Comprehensive Healthcare Simulation
Series Editors: Adam I. Levine · Samuel DeMaria Jr.

Christopher Strother
Yasuharu Okuda
Nelson Wong
Steven McLaughlin *Editors*

Comprehensive Healthcare Simulation: Emergency Medicine

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This book is dedicated to the hard working, often underappreciated educators out there without whom none of us would have the success we enjoy today. And to my children, Gannon and Beckett – who teach me as much as I teach them.

Christopher Strother, MD

This book is dedicated to my mother, Teruko Okuda, whose optimistic outlook in life and everlasting radiant energy taught me to believe in people, have faith in humanity, trust in myself, enjoy life, and be present in the moment.

Haru Okuda, MD

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Preface

> Education is not preparation for life, education is life itself. – John Dewey

Dewey was known for his pragmatism. We are hoping this text will be your pragmatic guide to all things emergency medicine simulation.

The complex nature of emergency medicine practice, and its reliance on teams and teamwork, makes simulation a natural and essential part of emergency medicine education. Simulation has grown rapidly in emergency departments and training programs. In 2003, approximately 29% of emergency medicine residencies in the United States used mannequin simulators, about 8% of them owned one. In 2008, those numbers were up to 85% using a mannequin simulator for training their residents, and 43% owning their own (Okuda). Today, this teaching methodology has become practically ubiquitous. Graduating medical students expect simulation to be part of their emergency medicine programs. Most medical schools are widely adapting this teaching method for their students as well (AAMC Survey). The next steps to grow will likely be focused faculty simulation for skills maintenance and in situ and interprofessional training in emergency departments.

There is a growing body of literature in articles and books describing simulation education theory and its effectiveness (McGaghie). For practical details such as: how to start your own simulation program, what if you have one for residents and want to know what's being done for medical students, what if nursing is asking for simulation in your department, we hope the answer is in this text.

Many of the authors in this text contributed to the original *Comprehensive Textbook for Simulation in Healthcare* (Levine et al.). In doing so, it was realized how much could be written specifically in the field of emergency medicine, and that there was a real need for a specific text focused on simulation for emergency medicine education and practice. We recruited emergency medicine simulation experts from around the country: dedicated educators, simulationists, and leaders in the field of emergency medicine and simulation. We asked our authors to keep their chapters practical, focused on best practice and application, with as many real-world examples of the successful application of simulation education as possible.

Our Approach

We've tried to take practical approach in this text with many tips and best practices to help your program grow and develop. We want to help you develop your emergency medicine program in a real way, help you avoid the mistakes that we've already made, and prevent you from having to reinvent the simulated wheel.

Parts of the Book

Part I: Introduction to Simulation for Emergency Medicine

These chapters are designed to give you the background, terminology, and theory needed to be a successful simulation educator. With a practical approach, we'll guide you through the theory, then teach you to build a case, work with your teams, and debrief like an expert to maximize your learners' outcomes. We'll also look at how to approach measuring outcomes for your simulation program, using it as an assessment tool, and how to use simulation as the powerful patient safety tool it can be. Be sure to check out Chap. 7, an excellent review of teamwork training. This chapter not only reviews how to create a team training program, but can be used as an approach to the creation, evaluation, and follow up for any simulation initiative.

Part II: Simulation Modalities and Technologies

With so many simulators and types of simulation out there, how do you decide which one to use? You want to integrate more task trainers, or standardized patients into your program, but what's the best way to do that? In this part we review specific types of simulation and simulators and how you might use them in emergency medicine simulation training. For example, this part might help a residency director decide what type of equipment they need to purchase for their much needed team training program, when they have only a small amount for funding, no upkeep support, and minimal technical expertise.

Each chapter will take the same general approach:

(a) Define and describe what it is
(b) Examples of what's currently out there and the similarities and difference between different types and categories of simulation relevant to EM
(c) Describe how it can best be utilized in emergency medicine education and training
(d) Tips and Tricks
(e) Cost, warranty, and maintenance considerations if available

We'll look at everything from live actors to screen-based simulations to the various basic and advanced simulators to make your experiential learning program work. How much fidelity do I need? What task trainers are out there or can I make my own? I love the idea of moulage, but how do I do it simply and practically? We'll explore all these questions in Part 2.

Part III: The Practice of Emergency Medicine

These chapters will be your guide to simulation programs with specific learners. What curriculums exist for resident simulation? How do I approach medical student education in emergency medicine with simulation? Find out in Part 3. We'll look at teaching residents and students, nursing simulation, and even an approach to pre-hospital providers and what has worked for them! Don't reinvent, review what has worked for others and apply it to your own program.

These chapters take the following format:

(a) Background – history, development, current state, and future uses of simulation in this area
(b) Best practices – describe successful or progressive programs and how they got there
(c) Sample curriculum – published or unpublished simulation curriculum that could be followed
(d) Integrating into existing education – ways to add or expand simulation seamlessly
(e) Challenges and solutions – common barriers and successful solutions

(f) Interface with regulatory bodies – ways simulation can help or harm you with program accreditation and credentialing

Part IV: Subspecialties of Emergency Medicine

Moving from learner types in Part 3 to subject types in Part 4, we give you examples and approaches that have been successful in using simulation to teach pediatric emergency medicine, trauma, ultrasound, and other "subspecialties" of emergency medicine.

Part V: Conclusion

Here Dr. Wong and Dr. Okuda take a look at the bright and expanding future of emergency medicine simulation. In his letter to future simulationists, he will inspire you to see the long-term future and value of simulation as an essential part of emergency medicine and medical education.

Following Dr. Okuda's chapter, you'll find a treasure trove of emergency medicine–based simulation cases (Appendix 1 and Appendix 2). Collected and written by our contributing authors, these will give you a great start to your case bank or inspiration for your own cases. Writing cases is one of the most fun and rewarding part of simulation, and we hope these cases will be useful to your learners for years to come.

We hope that you will find this book both complete and practical. We see it as an on-your-desk reference for teaching simulation, improving your own program, or adding a new aspect to your medical education in emergency medicine using simulation theory and practice. Thank you to all of our authors for their hard work, patience, and dedication to their craft!

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Part I

Introduction to Simulation for Emergency Medicine

A Historical Perspective of Simulation in Emergency Medicine

1

Paul E. Phrampus

Introduction

Since its inception, emergency medicine has needed to employ diverse educational strategies to ensure the development of competent emergency physicians with a knowledge that spans the entire practice of medicine. Additionally, the emergency physician needs to be able to expertly perform a significant number of procedures that range from simple and common to complex, time sensitive and rare.

The educational challenges within emergency medicine lie in the combination of the depth, breadth and diversity of medical knowledge that is necessary. Further, there are the complexities of initial skill acquisition and maintenance of competence over time. When looking at the historical perspective of simulation it is easy to recognize that since the beginning of emergency medicine some form of simulation has been inextricably involved. When one considers this diverse need for education it is clear that simulation will play an integral part into the future.

Looking retrospectively at this journey is complicated by the fact that the definition of healthcare simulation has changed over time. Currently, the term simulation encompasses a more inclusive position that recognizes multiple modalities, technologies, methods of teaching and assessment, that substitute aspects of interaction with the healthcare environment, and/or patients, with the actual practice of medicine.

Today's definition of healthcare simulation includes many modalities including part task trainers, anatomical models, computerized high-fidelity simulators, interactive computer software, human beings such as standardized patients, and/or standardize persons, as well as environmental replicas just to name a few. This is in contradistinction to the early to mid-2000's when the working vision of simulation in healthcare was essentially a newly created simulation center filled with high-fidelity simulators that had recently become prevalent, popular and more ubiquitously available.

A review of the medical literature provides part of the story of simulation in emergency medicine. However, as with many educational endeavors in the medical field, the historical documentation insofar as publications in peer-reviewed, scientific journals, are somewhat limited compared to the amount of training that has been accomplished. It is also complicated by the fact that many of the educational principles and foundational studies supporting simulation appear in the psychology and/or education literature primarily. This landscape is changing over the last decade as several new peer review publications, trade journals and scientific meetings have emerged that are disseminating information and best practices, as well as distributing results of traditional hypothesis driven research initiatives that are involving healthcare simulation.

Early Uses of Simulation in Emergency Medicine

One of the first published studies of the use of simulation in emergency medicine was ironically that of an administrative decision making exercise ostensibly aimed at developing competence of administrative leaders of emergency medicine in the 1970s [1]. Other emergency medicine early adopters/publishers reported simulation training associated with disaster training for students in emergency medicine programs [2].

It was in the late 1960s when the first Resuci-Annie and Andy manniquins (Fig. 1.1) were created that allowed wide scale disseminated training to ensure competency with mouth-to-mouth resuscitation as well as cardiopulmonary resuscitation (CPR).

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Fig. 1.1 A product information sheet from 1960’s for Resusci-Andy

Fig. 1.2 A replica of an early mouth to mouth resuscitation simulator

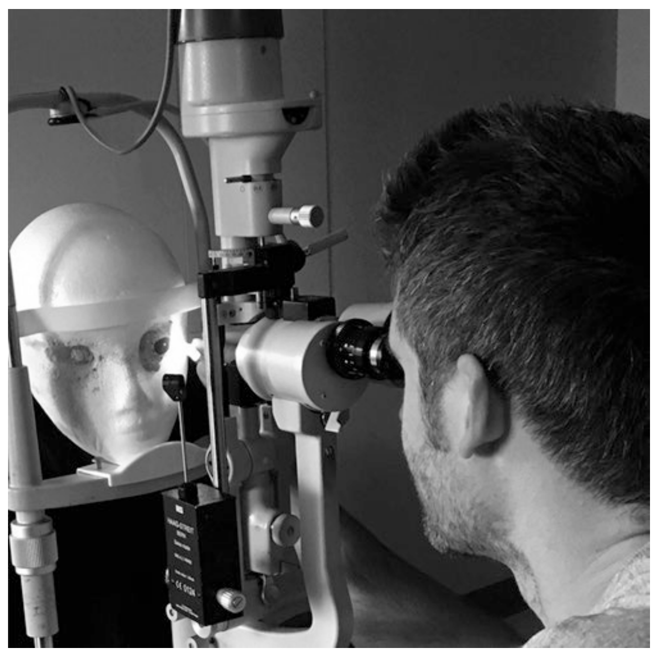

Fig. 1.3 Ocular foreign body removal using a porcine task trainer

Not surprisingly many of the earliest uses of simulation in emergency medicine training centered on acute resuscitation and airway management. This likely occurred secondary to the fact that there were some rudimentary airway models available as well as airway management being recognized as a key-skill in the curriculum of emergency medicine training.

In the mid-1970s this author had a first introduction to simulation while in elementary school. While taking a first aid course at the local YMCA a task trainer had been designed to demonstrate the procedure of mouth-to-mouth resuscitation of near drowning victims. Interestingly, a careful look will realize that the design afforded feedback to the participant along with the opportunity of deliberate practice for mouth-to-mouth resuscitation (Fig. 1.2).

Commercially available airway task trainers were also becoming a prevalent part of the training in emergency medicine focusing on bag valve mask ventilation as well as more complicated procedural skills such as endotracheal intubation.

Parallel to this emergence of early commercially available task trainers were other homemade models to reach needs that emanated from the ideas of innovative faculty members. One example was a porcine model of corneal metallic foreign body removal. Figure 1.3 as well as other bovine models for emergency airway procedural training (Fig. 1.4). Similarly, many emergency airway workshops focused on the training of emergency cricothyroidotomy by employing the airways of various large animals obtained from slaughterhouses as well as human cadaver labs. Some of these early innovative approaches are still used today in the training of emergency medicine residents.

In the early 1970’s the use of electrocardiogram rhythm generators connected to monitoring equipment allowed for the student to demonstrate competency with the dynamic interpretation of EKG rhythms during mock resuscitation events affectionately known as mega-codes (Fig. 1.5). Shortly thereafter several CPR mannequins were fitted with the electronics that could safely disseminate the energy from a defibrillator, thus affording live practice and the demonstration of competence using the equipment properly and

Fig. 1.4 Airway procedure training using bovine model of task training

Fig. 1.5 An early task trainer, EKG rhythm generator. (Image courtesy of Laerdal)

safely. These important early electronics were also able to give feedback to the EKG generating equipment to allow the automation of a preprogrammed event such as a recovery to normal sinus rhythm if the treatment was rendered correctly. While the term simulation was not used for this type of learning at the time, it is evident today that it easily fit within a more modern interpretation of the term scenario.

In the 1980s higher technology task-based simulation equipment began to emerge and was being rapidly employed into various training programs. This corresponded with the development of the American Heart Association's first advanced cardiac life support (ACLS) program which was first released in 1979 [3]. The development of such task training equipment was important and timely, as it corresponded with the recognized need to rapidly disseminate ACLS knowledge across the spectrum of physicians providing such care, but also to other members of the healthcare team such as critical care and emergency nurses, as well as paramedics to name a few. Looking back, it could also be argued easily that it was anecdotally demonstrating the power, effectiveness and scalability of immersive learning, when combined with traditional knowledge base learning that could help change the paradigm for emergency care learning methodologies and designs of the future.

In the late 1980s the American Heart Association released several courses related to Pediatrics including formal guidelines on pediatric CPR and the rollout of the Pediatric Advanced Life Support (PALS) initial formal curriculum [3]. This in turn, was accompanied by the development of many commercially available task trainers associated with pediatric resuscitation emergencies.

Additionally, in the late 1980s there was a proliferation of the personal computer which found its way into many academic institutions and businesses. During this timeframe, there were several interactive computer programs that were developed that allowed one to practice and receive feedback on their decision-making with regard to adherence to and treatment based the ACLS algorithm. Early programs were often text based cases combined with rudimentary graphics. It was nonetheless experiential learning that provided feedback as well as deliberate practice opportunities. This type of software can easily be argued to have been a precursor of more sophisticated virtual reality and virtual patient medical training systems of today.

In the early 1990s there was significant work from the discipline of anesthesiology related to simulation training aimed at patient safety in the operating room [4]. These efforts sparked significant interest into the development of human patient simulators. Several of these were full-body mannequins, with high-fidelity capabilities that allowed replication and control of numerous aspects of human anatomy and physiology. Features such as gas recognition and the inclusion of physiologic based hemodynamic trending that responded to therapy were becoming available.

The fact that many of the features in these early high-fidelity simulators developed for anesthesiology focused on airway management, acute resuscitation and critical procedures, as well as the management of hemodynamic emergencies made them very desirable for emergency medicine training. However, many of the early models were prototypes, exceptionally expensive, technologically complex to

Fig. 1.6 Early model of a lower-cost, portable, high-fidelity patient simulator set up in a hotel room for training emergency medicine personnel

operate, and harbored reliability issues which limited their ultimate scalability and widespread use early in their development.

Early in 2000 the SimMan® simulator was released and it incorporated patented technology developed at the University of Pittsburgh into the airway features of the simulator (Fig. 1.6). This created a simulator platform that incorporated low cost elements that brought together many of the features needed for education, training and assessment of emergency medicine. In comparison to the earlier high technology models, SimMan® was not physiologically modeled and was less complex but offered complete control of a limited number of physiologic parameters of the simulator to the educator.

The ability to replicate a significant number of airway pathophysiologic situations, perform several emergency procedures, detect ventilations, as well as cardiac compressions and display the hemodynamic parameters commonly available in the intensive care unit on the monitor made the platform ideal for emergency medicine training. Another critical feature that allowed for significant scalability and deployment was the price point was reduced from over $200,000 for the earlier simulators to approximately $45,000 per unit. Thus, a trade-off occurred between features and overall costs that allowed wider scalability.

The release of the human patient simulator platform created a competitive business development environment that resulted in several high-fidelity simulators mimicking many parts or actions of a human being. However, the development pathway shared by several companies continued to focus on acute resuscitation, procedural competency and emergency procedures which was ultimately a benefit to emergency medicine education programs.

The combination of the lower cost of the simulator units, the lessening of the complexity to operate them as well as the improvements in the underlying technological stability led to the development of many early pioneering simulation centers. Additionally, these factors allowed for implementation of innovative education curriculums into the training of emergency medicine for medical students and residents, as well as the training of prehospital care personnel.

The University of Pittsburgh had developed an anesthesia simulation center that grew rapidly and became multidisciplinary by 1997. Faculty members worked to creatively to integrate the technology into teaching methods that maximized the efficiency and effectiveness of utilization. Since 1997, simulation has been an integral part of the University of Pittsburgh medical student curriculum for emergency medicine. It was formally incorporated into the residency training program in 2001 with the introduction of mandatory simulation training program in emergency department airway management. The University of Michigan and the Massachusetts General Hospital were also early adopters of formal inclusion of simulation based training into programs for emergency medicine that began in the late 1990's and early 2000's [5].

Lastly, in the mid to late 1990's there was a growing interest in the medical education community in developing medical education training programs that allow practice in the development of competence with communication skills [6]. This resulted in another now common form of simulation technique known as standardized patients, or standardized participants (SP). This modality uses trained actors to play the role of patients, family members, and/or other roles within a simulation scenario. This helped to overcome some of the fidelity and realism limitations associated attempting a nuanced conversation with a mannequin based patient or family members.

Over the period discussed above, many of the foci of simulation efforts were on the educational accomplishments of individuals, often performing procedural skills, and/or demonstrating competency in adherence to algorithms and emerging best practices.

Rapid Recent Growth

From the mid-2000 timeframe to present there has been a rapid proliferation of simulation programs with a focus in emergency medicine training that has arisen from a variety of influencing factors. The first, has already been discussed in the earlier section regarding the availability of simulation equipment that became much more affordable, technologically reliable, as well as features that were often ideally aligned with emergency medicine.

In November 2000, the Institute of medicine released its sentinel report, To Err is Human, which outlined significant safety problems in the United States healthcare system healthcare system that lead to the death, and/or disability caused by medical error [7]. Specific findings included breakdowns in competence, inefficient use of technology as well as significant problems involving communications between healthcare providers as well as the ability to function, and work in teams. In this report simulation is cited 19 times as a potential methodology to help with a solution to many of the problems.

Commensurate with this heightened recognition of medical errors was an appreciation for the cost of medical mishaps and procedural failures that was receiving widespread attention. The cost of errors with care was being evaluated by payors such as medical insurance companies, risk management and malpractice insurance companies, as well as hospital systems that were becoming significantly more financially liable.

The attention of such groups with a direct financial interest in healthcare errors combined with the public appreciation for harm associated with medical care began to create another interesting opportunity for the spread of simulation. Situations requiring the practice on actual patients in the historical model of "see one, do one, and teach one" were beginning to undergo significant scrutiny by policymakers and payers as well as patients and their families. This is particularly true in areas where simulation has developed sufficiently to allow safe practice and competency demonstration that does not need to occur on actual patients. Some have deemed this need to incorporate simulation methods as an ethical imperative [8].

Additionally, the widespread proliferation of the American Heart Association programs found its way into recommendations of various clinical entities, and risk management programs requiring the training of thousands of healthcare providers to obtain advanced program certificates.

In 1999, the American Council for Graduate Medical Education (ACGME) and the American Board of Medical Specialties (ABMS) developed core competencies associated with the accreditation of graduate medical training programs. The requirements for residency programs in emergency medicine to develop the ability to document the education of and prove the attainment of competency in several of these core competencies required the development of additional, and innovative educational modalities. For this, simulation fit a niche need in several areas including teamwork training, procedural competence of skills, as well as communications. Some have evaluated the use of simulation in the assessment of individuals based on the ACGME guidelines [9].

In 2004 the emergency medicine journal *Academic Emergency Medicine* published an article entitled "See One, Do One, Teach One: Advanced Technology in Medical Education" which was a report of a consensus meeting of members of the Educational Technology Section of the 2004 AEM Consensus Conference for Informatics and Technology in Emergency Department Health Care [10]. One of the statements issued regarding mannequin based simulation concluded *"Emergency medicine residency programs should consider the use of high-fidelity patient simulators to enhance the teaching and evaluation of core competencies among trainees."*

In 2009 the ACGME and ABMS as well as many additional stakeholders further defined the need to develop a next generation training accreditation program that focused on specific areas of development and a more specific way of evaluating residents over the course of a residency training program. The program became known as the Next Accreditation System (NAS) and required that each medical specialty develop "Milestones" in core content areas aligned with the expected evaluation criteria would indicate a competence level that a resident should achieve for a given time in an accredited program. When considering the practice of modern emergency medicine that includes demonstration of critical thought process, the application of knowledge as well as the performance of procedures. It should come as no surprise that the original milestones drafted for emergency medicine list simulation as a suggested potential evaluation method in 19 of the 23 practice area milestones associated with emergency medicine training [11].

During this period the utilization of simulation in emergency medicine expanded significantly beyond the competencies of an individual, but began to include teamwork, team leadership training, communication skills as well as the use of simulation in systems assessment and systems design [12–14].

Technology has continued to advance and has led to the development of increasingly advanced simulators and task trainers are now become commonplace in the teaching of students and residents. There has been tremendous growth in systems focusing on training associated with the use of ultrasound as a point of care diagnostic and treatment tool for the Emergency Department (Fig. 1.7).

Thus, as this section indicates there is a multifactorial reason for the development of simulation programs associated with emergency medicine. However, there are still significant challenges that lie ahead when one considers factors such as overall costs, developing standards of assessment, as well as the complexities associated with true curricular integration that results in simulation efforts being incorporated into the mainstream of emergency medicine curriculums.

Fig. 1.7 High-fidelity ultrasound simulator for training Emergency Medicine Residents

Academic Development and History of Key Organizations

The continued growth and widespread acceptance of simulation in emergency medicine over the last three decades led to several collaborations between organizations that either contributed to or have benefited from involvement of the emergency medicine community in simulation.

The Society for Simulation in Healthcare

The Society for Simulation Healthcare (SSH) was founded in 2004 as a multidisciplinary organization with a goal of enhancing the value of simulation in healthcare. According to the SSH website they were founded *"by professionals using simulation for education, testing, and research in health care, SSH membership includes physicians, nurses, allied health and paramedical personnel, researchers, educators and developers from around the globe."* [15]

The SSH has developed the largest annual multidisciplinary meeting in the world for healthcare simulation. The meeting attracts thousands of people from around the world to engage in scholarly discussions, research presentations, networking and learning focused on simulation healthcare. The SSH also successfully launched the first peer reviewed, indexed journal devoted solely to simulation in healthcare. The SSH also launched the first multidisciplinary simulation accreditation program.

The emergency medicine community has played a crucial role in both the development of the SSH, as well as having been recipient of some of the fruits of the organization as a key community of practice stakeholder in healthcare simulation. Since the inception of the SSH emergency physicians have played a significant role in leadership, including a near continuous presence on the Board of Directors, as well as a past presidents of the organization.

There are many emergency physicians on the editorial board of the Journal, Simulation in Healthcare. Further, there has been a significant scientific contribution from the emergency physician community in terms of scholarly publications and presentations at both the international meeting, as well as the peer-reviewed journal. Two articles from emergency medicine authors were featured in the inaugural issue of the Society's journal [16, 17].

Emergency physicians have been actively participating in the SSH having formed an affinity group in 2006, a special interest group in 2008, and were one of the first groups approved by the SSH Board of Directors as a *section* in 2014. The significance of these milestones as an important part of the contributions of the community of emergency medicine by the fact that it takes continued active participation, demonstrating progress as well core number of dedicated members to continue the activities.

The Society for Academic Emergency Medicine

In May of 2008 the Society for Academic Emergency Medicine dedicated the annual meeting consensus conference to simulation for emergency medicine through a competitive process. The meeting was titled "The Science of Simulation in Healthcare: Defining and Developing Clinical Expertise." This grant funded consensus conference allowed a high level of networking between thought leaders in the emergency medicine simulation community to participate in a large audience consensus process with over 300 participants resulting in several key publications [18–21].

In 2009, members of the simulation community within SAEM were granted permission by the Board of Directors to form an Academy of Simulation. According to the SAEM website the purpose and function of the Academy provides a venue for SAEM members with a special interest or expertise to join to perform a number of functions. Among the purposes listed includes the ability to "Provide a forum for members to speak as a unified voice to the SAEM BOD as well as to other national organizations within their scope of special interest or expertise." [22]

In May of 2017 SAEM held a second consensus conference focusing on simulation entitled "*Catalyzing System Change Through Healthcare Simulation: Systems,* *Competency, and Outcomes"* to address critical barriers in simulation-based research [23]. A series of publications resulted from this meeting to continue to encourage scholarship and advancement of the use of simulation in a number of important areas of Emergency Medicine ranging from training, competency assessment as well as operations and care delivery.

Other Organizational Involvement in the Proliferation of Simulation

The American Association of Medical Colleges (AAMC) had previously founded a peer-reviewed computerized database that served as a repository for medical education materials. In the mid 2000's the AAMC undertook the development of a template and standardize review pathway specific to publishing simulation scenarios to help with high quality simulation scenario materials for sharing in and amongst its members.

More recently the American College of Emergency physicians (ACEP) has acknowledged the usefulness of simulation through including simulation-based workshops at the annual meeting as well as offering continuing education programs focusing solely on a simulation-based methodology.

The roles of the ACGME and the ABMS were covered previously in this chapter but should be thought of as to organizations who will likely contribute significantly to the need for simulation in the future as it relates to assisting with the assessment and demonstration of competency of individuals in accredited training programs.

The Simulation Literature and Emergency Medicine

An evaluation of the literature associated with simulation and emergency medicine demonstrates that the emergency medicine community has been forward thinking insofar as embracing innovative education into the training for emergency medicine. A search strategy combining the terms emergency medicine and simulation currently yields over 600 results. As one may imagine, the results are broad-based ranging from postulating the value of simulation to articulating specific possibilities for curriculum integration and modification of existing training efforts through the exploration of very specific modalities for very specific initiatives.

Some of the key publications authored by emergency physicians have also been used to appropriately enlighten others involved in the design of future undergraduate medical education programs as well as graduate medical education programs [24–26].

There are many efforts at postulating or trying to quantify the potential value of various modalities of simulation for utilization in the training of emergency medicine. Studies range from exploration of individual skills training efforts to those involving teamwork and communications.

Other studies have contributed to pushing forward the agenda to use simulation as a competency assessment tool as well as an educational method [9, 27–31]. Others had evaluated the concept and importance of accreditation form simulation programs relative to emergency medicine [32].

The emergency medicine community has also published literature suggesting strategies for implementation of simulation for competencies that have been identified as important in training programs, but have a history of being difficult to assess. Some of these include communication skills, delivery of bad news and other topics involving teamwork [30].

There have been recommendations published on how simulation may be useful as a rehabilitation or remediation tool for students and/or residents in emergency medicine training programs [33]. Emergency medicine authors have reported unique uses of simulation and the training of others for work in austere environments and special situations such as disaster management leadership training. [19]

Others from the community of emergency medicine look at simulation as a tool, one of many, to be embedded in areas that are critical to the future that likely involve changing of some traditional thought processes as well as multiple learning strategies. Examples such as this are demonstrated in efforts that describe the potential for incorporating simulation into an effective strategy to build an education agenda aimed specifically at error prevention in emergency medicine [34, 35].

There have been reports from the emergency medicine community that describe uses of simulation quite creatively. Okuda et al. describe a novel use of simulation that "allows the educator to watch the decision-making process of the learners as they manage simulated complex scenarios in a cooperative, competitive environment." [36] The net result of such efforts increases the visibility of simulation, can become attractive and somewhat fun for the participants, as well as provide those in educational leadership positions different vantage points for which to conduct assessments and/or evaluations of their programs and/or the individual participants of their programs.

Some reports from the emergency medicine community document simulation as a useful in-situ evaluation tool to further identify systems as well as individual latent threats and potential identification of issues that can help direct the resources and investment in further training/education programs for quality and patient safety initiatives [37].

Somewhat more recently, there has been an increase in demonstrating the usefulness of simulation as a part of a systems design and/or human factors tool. Such implementations have demonstrated effectiveness with studying the flow of emergency department patients in a simulated environment to attempt to identify inefficiencies that can be identified and remedied [38, 39]. Other systems design implementation for simulation describe using simulation to identify latent threats and hazards in new clinical spaces prior to their opening as well as in functional clinical patient care units.

Conclusions

The future for simulation in emergency medicine is bright. When one considers the multiple factors that have led to the significant increase in the number of simulation programs over the last few years it becomes apparent that these pressures will likely increase. The increased need to provide objective assessments of people in training programs as well as an appreciation for the advantages of experiential learning will continue to demonstrate value. A timeline of key events in the history of simulation is shown in (Box 1.1).

Patient satisfaction, throughput and expense reduction and other aspects of emergency department efficiency and quality will continue to areas that will benefit from simulation in planning new models of care for the future. Once planned and implemented, simulation holds great promise for ongoing evaluations of such improvement processes.

The reduction of unintended harm from medical care will continue to take center stage in improvement efforts moving forward and be more directly linked to educational and assessment programs involving individuals as well as healthcare teams, and environments. The financial pressures of penalizing systems for unintended harm and inefficiencies will continue to drive this forward and have a considerable effect on seeking out potentials that can mitigate such instances. It is quite natural that simulation will play a role.

Lastly, the tolerance for practicing on real patients will continue to decrease, and rightfully so as we identify appropriate simulation modalities and instruments that can minimize such practice until a plateau of competency is demonstrated by the healthcare provider.

Simulation in emergency medicine will continue to play an important role in various aspects of education, planning, discovery and defining the future of our practice. The greatest challenge lie ahead in defining the value and the most efficient and effective utilization of the many simulation based tools that are now available.

Box 1.1 A Brief Timeline of Historic Factor in the Development of Simulation from and Emergency Medicine Perspective

1960's	CPR task trainers Resusci Anne and Andy
1979	Administrative simulation for EM published
1980	First EM Board examination
1980's	Widespread adoption of ACLS task trainers and technology
1994	High technology, physiology based human simulators appear focusing on Anesthesia training
2000	Lower cost human simulators with features for EM focus come to market
2004	Society for Simulation in Healthcare founded
2008	First SAEM consensus conference on simulation
2009	ACGME milestones for EM recomends simulation
2010	High technology and virtual reality simulation equipment becomes more readily available
2017	2nd SAEM consensus conference on simulation

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Education and Learning Theory

2

James Kimo Takayesu, Nelson Wong, and James A. Gordon

Active Learning (AL)

The hallmark of simulation is learner engagement using a clinical scenario accompanied by debriefing that allows for reflection and re-engagement. These two elements – active engagement and critical reflection – align seamlessly with the operating principles of active learning. Active learning encourages learners to clarify, question, apply, and consolidate new knowledge. This process stimulates self-assessment in real-time as new knowledge is acquired and applied, encouraging learners to bridge the gap between their current competence and that just outside the leading edge of their performance. By engaging critical thinking skills, active learning allows for increased retention and encourages transfer of new information [1]. While not all active learning involves simulation, simulation is based on the foundation of active learning, requiring the application of knowledge in situations that mimic real life performance with opportunities to expand knowledge, skills, and attitudes through guided reflection. Simulation can contextualize new knowledge in scenarios that replicate actual clinical practice while also challenging or reinforcing heuristics that are central to emergency medicine practice. Emergency medicine is a specialty heavily weighted toward rapid clinical assessment in the midst of diagnostic uncertainty, which makes dynamic clinical simulation an effective teaching tool. Medical simulation has the dual ability to not only recreate clinical situations, including rare and critical cases, but also allows learning to occur in a protected time and space difficult to achieve in the typical Emergency Department bedside environment.

Beyond knowledge retention, active learning facilitates the formation of cognitive and emotional pathways for accessing and applying knowledge in clinical contexts. This application process expands and elaborates knowledge in ways that traditional passive teaching methods do not, leading to durable learning and retention (see Fig. 2.1). Because simulation learning is centered upon knowledge expansion through application, there is a need for some degree of basic knowledge prior to application to make the most of a simulation exercise. In this sense, simulation can be a particularly useful in targeting the higher levels of Bloom's taxonomy (see Fig. 2.2), after the acquisition of basic medical knowledge and principles that permit clinical reasoning and competent performance. Simulation does not replace traditional forms of pedagogy, but rather acts as an instrument for reinforcing, correcting, and

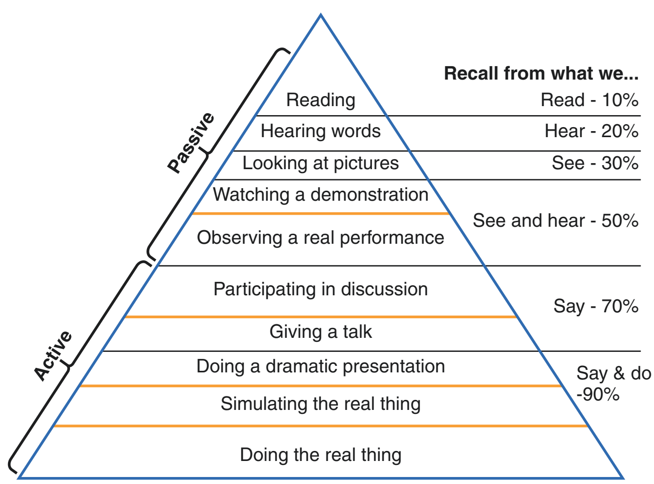

Fig. 2.1 Retention by teaching method pyramid. (Adapted from Dale [40].)

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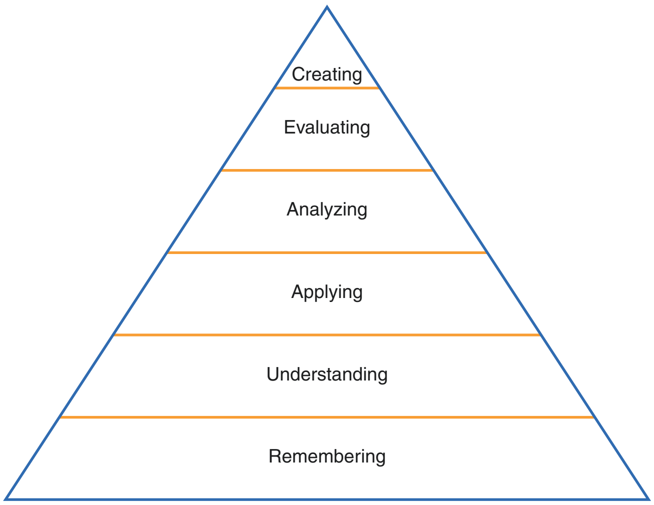

Fig. 2.2 Bloom's Taxonomy classifies levels of cognition reflective of effective learning. As knowledge is acquired, learners should be able to use it with increasing task complexity as they gain mastery. (Adapted from [38])

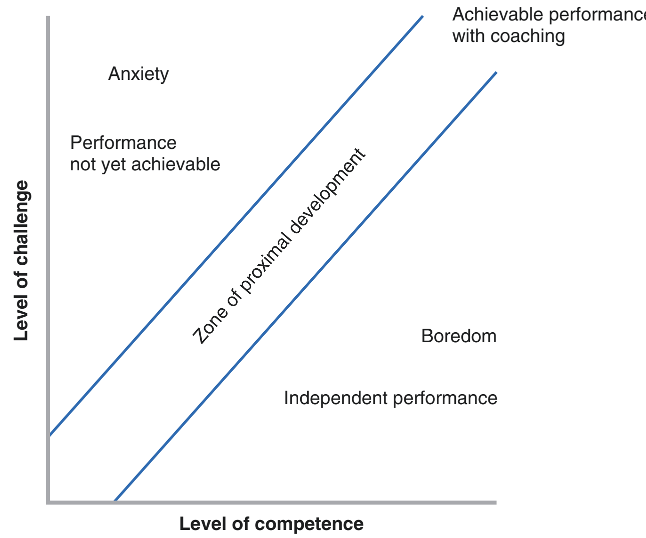

Fig. 2.3 The relationship between the Zone of Proximal Development (ZPD) and the Circumplex Model of Affect is commonly represented as a graph plotting competence against challenge. As the learner gains knowledge, new experiences create additional challenges that require application and extension. The level of the challenge should be difficult enough to emotionally active and cognitively engage the learner within their ZPD

expanding the types of knowledge that drive clinical performance. The simulationist's objective is less to disseminate knowledge, but rather to create an environment for active learning and ongoing clinical development.

Learning Theory

While an in-depth discussion of learning theory is outside of the scope of this chapter, it is important to review the most salient models of the learner and learning theories related to simulation. These theories and concepts are the underpinnings of sound simulation design and help to understand the limitations and, more importantly, the potential of simulation education in adult learning.

The psychological theory of **behaviorism** relies on a core assumption that stimuli create a reflexive response that is reinforced through reward or discouraged through punishment [2]. In its most basic form, simulation is a teaching tool meant to provoke a response and to promote specific behaviors through immediate feedback. **Constructivist theory**, developed by Piaget, challenges behaviorism, stating that learning is an active thoughtful process by which knowledge is constructed based on personal experience rather than reactions to reward or punishment [3]. This model of the learner underscores the importance of experience in driving learning. Looking outwards from the individual learner, **social constructivist theory** developed by Vygotsky emphasized the important role of social interactions in effective learning through instruction. This instruction provides the learner with a 'scaffolding' that helps the learner to grow by allowing them to elaborate upon their knowledge just outside of their current understanding, called the zone of proximal development [4] (see Fig. 2.3). This emphasis on the importance of instruction, gauged to the level of the learner in conjunction with new experiences, is a foundational theme to simulation educational practice.

Drawing from both Piaget and Vygotsky, Bruner further elaborated on constructivist theory by placing an even greater emphasis on the role of good **instructional design**, not just the engagement of instruction, as the scaffolding that helps the learner develop their knowledge structure in both content and complexity [5]. Thus, in addition to learner motivation and quality feedback, the design of the simulation exercise is critical to the learning process. As knowledge structures become more complex, new structures are adopted, replacing and subsuming the previous less-integrated structure. For example, the approach to acute chest pain and hypoxia in the emergency department may involve a relatively simple differential diagnosis for the novice, including pulmonary embolism, acute coronary syndrome with congestive heart failure, and pneumonia. With increasing case complexity, the content and differential diagnosis may be broadened to include rare entities such as atrial myxoma, post-infarction VSD, and papillary muscle rupture.

While these learning theories were primarily directed at explaining a theory of **pedagogy** for primary and secondary education, Malcolm Knowles characterized the essential characteristics of adult learners in his theory of **andragogy** [6]. Rooted in the psychological principles described by Maslow, andragogy has five assumptions which inform instructional design for an adult learner: (1) *self-direction* – adults set learning goals based on that which is immediately relevant to their lives and future direction; (2) *experience* – learning is influenced by the previous experiences a learner brings to the teaching encounter and is driven by new experiences which contextualize new knowledge; (3) *roles* – adult learning needs are set and prioritized by one's professional role and the demands this role places on them; (4) *immediacy* – adult learning is driven by the need to solve current problems encountered in daily life; and, (5) *motivation* – learning is internally motivated by a desire to succeed. For example, when teaching the principles of teamwork one could start by asking the learner about whether they have ever seen or run a code (establish self-direction); having them describe the experience including what could have been done better (anchor on personal experience); and prompting them to reflect on what they would need to do to improve the delivery of care for the next time (establish their own role, emphasize immediate application, and cater to intrinsic motivation). Simulation has a natural relevance to adult learning because of its experiential context. The importance of this context is classically described in John Dewey's theory of "learning by doing" [7]. These assumptions highlight the importance of setting appropriate learning goals, defining roles, and providing structured feedback that builds upon the learner's internal motivation to achieve.

David Kolb developed a model for adult experiential learning that directly informs instructional design. The **learning cycle** defines four sequential phases of learning based on four foundational learning styles, following the central tenet that "learning is the process by which knowledge is created through the transformation of experience" (see Fig. 2.4) [8]. A concrete experience first challenges the learner, forcing reflection on the learning needs required to meet the challenge. Abstract conceptualization denotes the next phase during which the learner elaborates on their knowledge and attempts to understand how the new knowledge will improve their performance. With a new knowledge structure comes active experimentation: applying the new knowledge in more complex and challenging contexts until a new challenge is identified. For example, a learner with a challenging case of a patient in cardiogenic shock may be compelled to understand more about the disease's management. Learning may take many forms (reading, learning from peers or superiors) but simulation is critically important as a means of providing opportunities for active experimentation that will permit the development of the procedural and conditional knowledge (see section "Metacognition") essential for improved performance. Kolb's learning cycle not only supports the utility of simulation experiences in the learning cycle, but also emphasizes the importance of good instruction in the form of debriefing and reflection as complementary and synergistic to the simulation itself.

Context and Transfer

Simulation learning experiences can range from paper-based exercises to full-scale mannequin-based simulations in realistic environments with standardized participants replicating a real-world clinical context. As such, simulation is not restricted to a specific setting or context other than requiring some form of experiential learning that aspires to replicate or approximate reality. **Fidelity** refers to the degree to which the exercise matches the appearance and behavior of the actual experience. The equipment and staffing requirements of a simulation exercise vary based on the experience level of the learner and the learning objectives of the session [9].

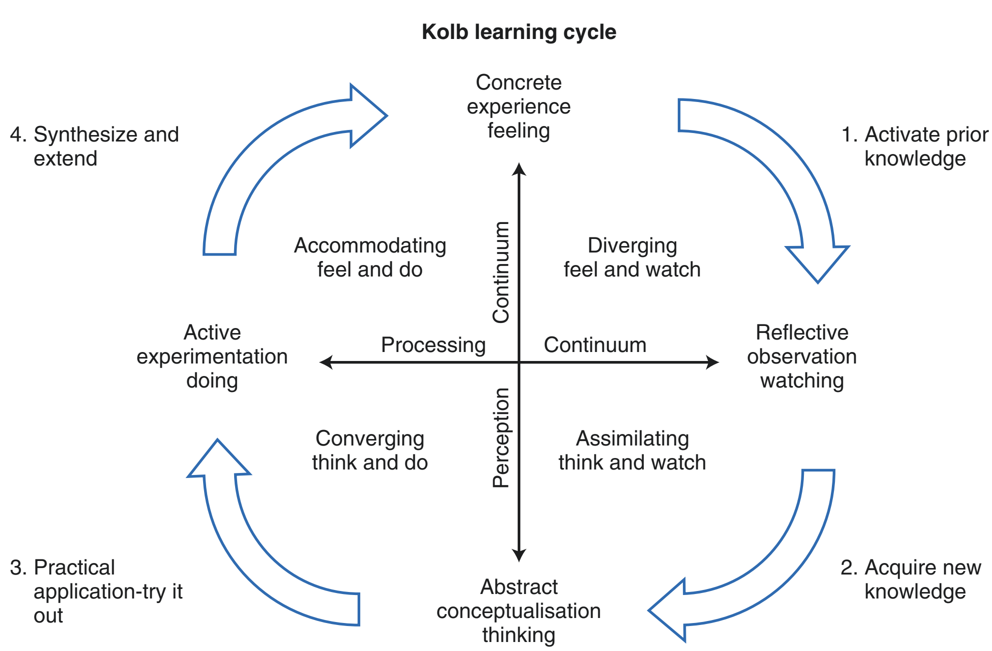

Fig. 2.4 The Kolb learning cycle [39] depicting the four phases of learning and the four learning styles of diverging, assimilating, converging, and accommodating. Learning activities should lead the learner through the entire cycle to ensure knowledge synthesis and extension through active experimentation

Teaching cricothyroidotomy to a first year resident requires much less design and resources than teaching a third year resident how to manage a complex trauma resuscitation.

The fidelity of a simulation can be understood in the context of the environment and the learner's experience of that environment. **Engineering and environmental fidelity** refers to the appearance and feel of the simulation environment, and its effectiveness in providing the learner with realistic sensory input during the exercise. **Psychological fidelity** is defined by the emotional and behavioral authenticity experienced by the learner during the simulated exercise. Higher fidelity simulations are useful in teaching and assessing more expansive non-technical teamwork and communication skills, such as those targeted by Crisis Resource Management (CRM) [10, 11], in addition to core technical and cognitive skills. Some work has suggested that psychological fidelity may even be more important than the engineering fidelity of a simulation in supporting performance gains [12, 13].

An additional aspect of psychological fidelity is the personal emotional response that the learning experience evokes in the learner. The **Circumplex Model of Affect** describes a relationship between emotional activation and deactivation in comparison to whether an experience is perceived as pleasant or unpleasant [14–17]. Based on the circumplex model (see Fig. 2.5), human emotion can be divided down into 4 major quadrants: pleasantly activated (happy, excited); pleasantly deactivated (calm, relaxed); unpleasantly deactivated (bored, sad); and unpleasantly activated (frustrated, anxious). Historically, much of traditional higher education has been experienced while learners are in a relatively deactivated emotional state (i.e., during routine lectures or readings); however, many of the most memorable events in an individual's life occur during a relatively activated state (i.e., a dynamic emotional experience). Immersive simulation seems unique in its ability to recreate a level of emotional activation that can support intense learning and retention in ways that parallel real-world experience [17].

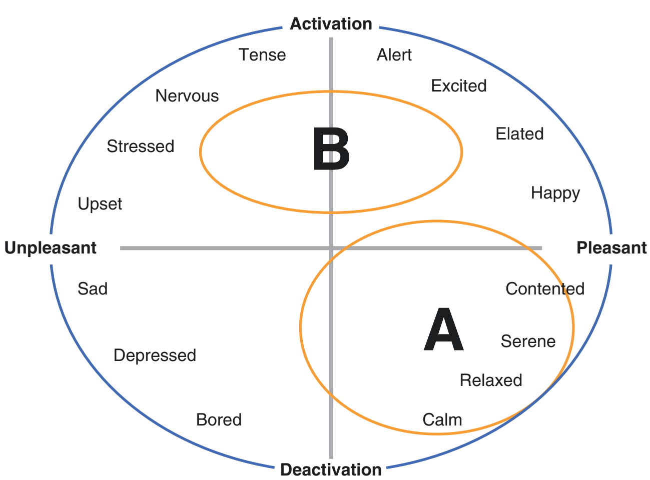

Fig. 2.5 Circumplex model of affect [14–17] as hypothetically applied to the medical learning environment. Area A represents the emotional state commonly experienced by learners during traditional pedagogic exercises (e.g., lectures, conferences, readings); area B represents the typical emotional state of learners during immersive simulation exercises. This dichotomy is thought to represent a unique and fundamental difference between simulation and alternative teaching and learning environments. Areas A and B of overlay on the core circumplex model represent a theory described by investigators at the Institute for Medical Simulation at the Center for Medical Simulation in Boston, Massachusetts. (Figure and descriptive legend text reproduced and updated with permission from the American College of Chest Physicians [17]. Core circumplex model, without areas A and B, reproduced with permission from Cambridge University Press [16].)

Because the reaction of the learner to a simulation experience can be titrated by the instructor, the educational experience can be customized and replicated in a safe, controlled environment. In this sense, fidelity is a characteristic of the simulation that creates realism for the individual to "buy into" the fiction of the case to a sufficient degree that they are engaged in the exercise. Increasing the affective complexity of a simulation in a way similar to the real world experience has proven valuable for developing certain procedural skills [18]; however, overwhelming the learner with excessively stressful environments (seen in the activated extremes of the circumplex model) has been shown to impede learning and retention [19, 20]. When designing a trauma simulation, for example, introducing a disagreement among consultants or inserting an inexperienced RN in the scenario may increase emotional complexity as part of an instructive encounter; however, having the patient subsequently become unstable and code in this setting might overshadow any learning of resuscitative principles. This underscores the importance of titrating fidelity to the level of the learner's cognitive and clinical abilities, balancing the affective learning with the psychomotor (technical) and cognitive learning objectives.

Cognitive load theory dictates that learners can only process a limited number of data points at a time based on their experience level [21]. There are three types of workload, intrinsic, extraneous, and germane. The intrinsic load relates to the task complexity and the expertise of the learner. A novice learning IV placement requires a much simpler task complexity, perhaps with lower fidelity needs, than a more advanced learner with real-world experience [12]. The extraneous load comes from processes that are not directly related to the learning at hand. When learning sepsis resuscitation, calming a panicked family member is not directly related to learning the principles of resuscitation. While such a distraction may be too challenging to the novice, it enhances the psychological fidelity of for the more experienced learner and can be an important secondary learning outcome for the simulation. The germane load refers to learning processes that are directly related to the intrinsic load such as task complexity (e.g. placing a chest tube in a patient with pleural adhesions) and context variability (e.g. placing a chest tube in a patient with hemothorax and hemorrhagic shock requiring an auto-transfusion setup). Combining the circumplex model of affect and cognitive load theory, one can derive a concept of learning that echoes Vygotsky's theory of the zone of proximal development in which the point of maximum learning occurs when the learner is emotionally activated and cognitively challenged to a point just outside of their comfort zone of performance (see Fig. 2.3).

The true test of learning is whether the exercise leads to real-world improvements in performance. A number of studies have shown that simulation learning is transferable to real-life situations [22–24]. High fidelity simulation provides significant advantages in unstructured "opportunistic" teaching. As such, it might seem that there should be a direct correlation between the fidelity of the simulation exercise and the quality of learning. However it is interesting to note that the use of high-cost high-fidelity simulations versus lower-cost low-fidelity simulations does not show a statistically significant difference in teaching cardiac auscultation, basic surgical skills, or critical care skills [25]. Applying the model of deliberate practice (discussed in section "Deliberate Practice") to the pursuit of expert performance in certain domains may thusly benefit more from the frequent use of lower-fidelity simulations rather than the limited use of higher-fidelity simulations.

Metacognition

Metacognition refers to understanding the process of thinking. Knowledge can be divided into three categories: declarative, procedural, and conditional knowledge. While the learning theories of behaviorism, constructivism and social constructivism attempt to explain how we learn, metacognition focuses on the actual qualities of the knowledge the learner is seeking to acquire. Metacognitive understanding can inform instructional design in ways that complement learning theory. Simulation experiences can aid the translation of declarative knowledge (what?) into procedural knowledge (how?) by requiring knowledge application rather than recall alone. As andragogy points out, adult learners have specific preferences in how they like to learn, with a common requirement of the new knowledge being immediately relevant to their real world needs [26]. Simulation meets this requirement by providing a learning environment modeled after actual practice.

Put simply, knowledge can be broken down into knowing simple facts (e.g. D-Dimer as a screening tool for PE); knowing how to accomplish a task (how to manage an airway); and knowing how to manage multiple tasks and inputs in an orderly fashion (knowing how to manage a trauma resuscitation from beginning to end). **Declarative knowledge** is factual knowledge. It can be conceived of as "inert" because it has yet to be applied, and is classically learned from a lecture or by reading a textbook. This knowledge can prime further learning since it sets the stage for performance through application. **Procedural knowledge** refers to knowing how to accomplish tasks using strategies, heuristics, and psychomotor skills. As one gains expertise, tasks can be performed with increasing degrees of facility. Complex thought processes become more fluid and lead to the development of heuristics. **Conditional knowledge** serves the executive function of knowing when and how to employ declarative and procedural knowledge as part of performing a a new task or role. Conditional knowledge permits learners to draw upon specific learning strategies to facilitate learning as well as to understand how to incorporate the new knowledge into their current knowledge structure in a way that improves performance, thereby gaining the experience required for expertise. Ideally, effective instructional design should address each of these forms of knowledge.

Cognitive apprenticeship is a metacognitive model of learning and instruction that makes "thinking visible" using a variety of methods to teach a complex task to a learner, or 'apprentice', by an expert or master at the task [27]. There are six components to the learning process, including (1) modeling of the task by an expert, (2) coaching the apprentice with feedback, (3) instructional scaffolding to help the learner achieve higher levels of performance, (4) articulation by the learner of their thought process and performance, (5) reflection on the gaps in performance between learner and expert, and (6) performance of the task in progressively more challenging environments. While many of these components (directed feedback, debriefing with reflection, and matching simulation complexity to the experiential level of the learner) are commonplace in simulation education, instructors can also maximize opportunities to model expert performance using a simplified "see one, do one, teach one" approach in the simulation environment. As example, the expert would demonstrate placing a central line on a task trainer, followed by the learner placing one on the same model using the observed techniques. With feedback and practice under direct observation—all in the simulation lab--the learner can improve their performance and subsequently demonstrate competence by describing the procedure and demonstrating it as if they were teaching another learner.

Deliberate Practice

The Dreyfus model of novice to expert performance, as well and Ericsson's model of deliberate practice [28], focus on the supposition that expertise is domain-specific and learning is guided by expert performance rather than an underlying universal theory of learning that applies across domains. The levels of performance achievement include novice, competence, proficiency, mastery, and expertise [29]. The emphasis on performance levels in the development of expertise thematically relates to Vygostsky's zone of proximal development, where staged levels of instructional complexity are required to support performance improvement. Planning successful simulations requires an understanding of the learner's current level of performance as well as feedback structured in a way that encourages the development of specific skills required to move to the next level.

The strongest evidence of the immediate and lasting impact of simulation on learners and patient care lies in its potential for **deliberate practice** [30, 31]. As introduced by Anders Ericsson and popularized by Malcolm Gladwell, deliberate practice is the process of obtaining and maintaining expertise within a domain. Nine sequenced elements of deliberate practice have been described by McGaghie and colleagues: (1) highly motivated learners with good concentration who address (2) well defined learning objectives or tasks at an (3) appropriate level of difficulty with (4) focused, repetitive practice that yields (5) rigorous, reliable measurements that provide (6) informative feedback from educational sources (e.g. simulators, teachers) that promote (7) monitoring, error correction, and more practice that enable (8) evaluation and performance that may reach a mastery standard where learning time may vary but expected minimal outcomes are identical and allows (9) advancement to the next task or unit [32]. McGahie et al. did a meta-analysis of twenty years of data and found that simulation-based medical education with deliberate practice was superior to traditional medical education for specific learning goals such as the acquisition of clinical skills such as advanced cardiac life support, laparoscopic surgery, cardiac auscultation, thoracentesis and central venous catheter insertion.

Colloquially known as the "10,000 hour rule," Ericsson defined a journey towards mastery requiring laborious repetition. Often forgotten in the popularized narrative however is the critical role of feedback in this process, a critical component in simulation education for effective learning [33]. The deliberate practice model relies on repetition with expert feedback followed by recalibration. Clinical simulation offers a space for understanding learner needs and level of performance, identifying performance gaps and teaching towards those gaps [34, 35]. Within the framework of a larger curriculum, simulation can provide opportunities for repetition required for mastery.

Ericsson specifically addresses the application of deliberate practice to the medical field [28], calling for simulation-based training not only for the development of expertise but also for maintenance of practice skills. Simulation can also provide systems-oriented opportunities for deliberate practice to clinical environments in the form of team training [24, 36] and quality improvement projects [23, 37]. Simulation-based deliberate practice is a means for guarding against a premature plateau in performance and the inevitable senescence of performance in practitioners without ongoing practice [28].

Conclusion

Simulation is a form of active learning whereby new knowledge and skills are acquired through experiences that mimic real life performance. Strongly rooted in constructivist learning theories, simulation provides opportunities for learners to grow within their zone of proximal development on the pathway from novice to expert. Fidelity creates both cognitive and emotional activation for the learner, enhancing the quality and durability of the learning experience. Ideally, these experiences should be repeated with sufficient frequency, and increasing difficulty, to permit deliberate rather than episodic practice (see "Appendix 1, Chapter 2 Supplemental Case Scenario").

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Simulation Scenario Development and Design in Emergency Medicine

3

Emily S. Binstadt, Gail Johnson, and Casey M. Woster

Simulation is a useful tool in emergency medicine, but key to its ultimate effectiveness is high quality scenario development and design. Simulation uses adult learning theory to teach new curriculum and skills in a memorable way, improve group dynamics and performance, practice rarely encountered procedures and problems without risk to patients, and can be used to improve systems level understanding and performance. However, no single simulation scenario will do all these things well. A simulator is merely a technological tool, and it requires the human user's creativity and preparation to allow it to function. Simulation scenarios perform best when they are thoughtfully developed with consideration of the available technologies, actors, and debriefing resources, but also the goals and objectives, the type of learner involved, and the ideal environment for the scenario. Historically, many simulators were stored, unused, because educators lacked the confidence and expertise to create relevant scenarios tailored to the goals of their users. Currently, several case banks of scenarios exist, but many simulation experts still develop scenarios de novo whenever they begin a new teaching or research endeavor. Referencing previously published scenarios on related topics can be helpful in generating ideas in the process of scenario design, but going through the process of de novo scenario development allows facilitators to optimize the scenario for their goals, learners, and environment. This process can be simplified by using a standardized template for scenario design.

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What Is a Scenario?

Simulation scenarios are case vignettes in which a challenging clinical situation can be replicated so that participants can demonstrate or explore their familiarity and mastery (or lack thereof) concerning the topic portrayed, without incurring risk to actual patients. Simulation scenarios aim to establish enough realism, or "fidelity", to allow participants to adequately engage in the case so that their thoughts, behaviors and actions are similar to how they might react in a real clinical situation. Although all participants know that their patient in the scenario is made primarily of plastic, run by a computer, and will not suffer as a result of their choices and performance during the case, the goal of the scenario is to help the participant "suspend disbelief". A short coaching session, often called "pre-briefing", can be useful to help achieve this state, when the participant is fully invested and immersed in the scenario enough to look past some unrealistic features and to be adequately immersed in the scenario enough to allow a cognitive state similar to a real clinical decision making scenario. Pre-briefing helps build trust by explicitly stating expectations for full participation, honest feedback, and safe questioning. Generally, simulation scenarios are designed to run to their completion based on the decisions and actions of the participants, without interference from the facilitator. The scenario is then followed by a debriefing, during which the facilitator encourages participants to discuss the case, guiding the discussion to ensure that the goals of the scenario are clearly conveyed. The main learning occurs during the debriefing, with the preceding scenario helping to "prime" the learner mentally and emotionally to be ready to learn and to retain learned concepts.

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Fidelity

Fidelity refers to the extent that simulation mimics reality [1, 2]. A literature search on simulation fidelity will return a large number of articles, but most refer only to mannequin fidelity. Rehmann, Mitman, and Reynolds proposed a multi-dimensional fidelity model that includes equipment, environment, and psychological fidelity [3]. Psychological fidelity refers to how realistic the simulation feels to the participant. A component of psychological fidelity, scenario fidelity, is also important, especially for experienced participants. Scenario fidelity means that the scenario, including patient and vital sign response to interventions, occurs in a realistic manner. Because experienced participants have mental models of how patients will likely respond to certain situations and interventions, they may disengage if that response doesn't occur in a manner consistent with what happens in actual situations. While all dimensions are interrelated, psychological fidelity is very important in order to dispel disbelief and get buy-in from participants [4]. Successful simulations also capitalize on the fact that events that are connected to emotions tend to be remembered [5]. Most simulation experts feel that unless we can help participants suspend disbelief, they are less likely to engage in the simulation and perform as they would in the real world.

Fidelity is described on a low to high continuum and can be further divided into functional and physical. Physical fidelity refers to how realistic something looks, whereas functional fidelity refers to how it responds, or the feedback that participants receive based on their actions. The scenario designer determines the level of fidelity needed based on participants and scenario objectives. A picture of a ventilator and ventilator tubing may suffice if participants do not need to manipulate buttons or settings. In contrast, it would be important to include an actual ventilator if appropriate responses to alarms or active ventilator management are objectives of the case. Similarly, in a scenario where the patient (mannequin) has a hemothorax, the scenario designer would need to determine the level of fidelity required for the management. If the focus of the scenario is teamwork, communication and leadership skills during a trauma team activation, then simulating the chest tube placement on a full-body mannequin may suffice. If however, an objective is demonstration of adequate skill in chest tube insertion, it would be important to incorporate a task trainer that provides a more realistic experience for this procedural skill. The following are common causes of decreased scenario fidelity: participants playing roles they don't know (i.e. nurse in physician role, resident in nurse role), scenarios that don't flow realistically, lack of moulage, and a patient's voice that is incongruent with their symptoms.

The level of fidelity required to maximize learning and performance has not been determined. Some would suggest that the highest fidelity possible should always be used while others would suggest that it is only necessary to achieve the illusion of reality [1, 6]. The scenario designer needs to determine what level of fidelity is necessary to realistically obtain buy in from participants and to meet the objectives of the scenario. Not every detail may be necessary to achieve a successful simulation for the participant, and too much focus on fidelity may actually distract a novice learner from the primary learning objectives of the scenario. Efforts to improve fidelity can also be quite costly, and may not be needed to achieve the learning objectives. Ultimately, "every simulation session must have enough realism for the participants to become fully engaged in the scenario. They must believe and act as if the patient simulator is someone for whom they are responsible and must provide appropriate care" [7].

Simulation Environments

While simulation activities often occur in dedicated simulation space, with planning, scenarios can be effectively and efficiently facilitated in any environment. It is important to include environmental considerations in the design phase of the scenario.Dedicated simulation space is becoming more common in hospitals and health systems. Simulation centers provide a safe place to practice and demonstrate proficiency for individuals and teams. Some simulation centers have dedicated rooms that replicate a room in the emergency department while others have more generic rooms that can be staged to resemble an area in an emergency department, such as a triage or trauma/resuscitation room, or even a field environment for EMS, international EM, and disaster response training. Many simulation centers have audio-visual recording capabilities and are able to stream live from a simulation room into a debriefing/classroom as well as provide playback for video debriefing. In addition to mannequins, simulation centers often have a number of task trainers (i.e. central line insertion trainers, lumbar puncture trainers, ultrasound trainers, surgical airway trainers) that can be incorporated into a scenario to add realism to clinically relevant procedures. In this type of dedicated space away from the actual clinical environment, it is possible to design complex scenarios, including those that may be emotionally charged, or scenarios created in response to an adverse outcome. This non-clinical environment may provide another layer of psychological safety and privacy and more time for adequate debriefing.

In situ simulation occurs within actual clinical or patient-care environments. Because it *is* a clinical environment, the environmental and equipment fidelity is high, and it may provide more realistic experiences for participants than a simulation center, optimizing both learning and performance [8, 9]. In situ simulation also allows analysis of current systems in place in the actual clinical environment. Along with these benefits, there are challenges and considerations with *in situ* simulation. When considering the design of *in situ* simulations for an Emergency Department, it is important to address any potential impact to patient care and safety [10]. To minimize disruption in workflow and patient care, if the simulation is occurring as part of the workday, scenarios for *in situ* simulations may be shorter than those that occur in a simulation center. The department may have an influx of patients when the *in situ* simulation is scheduled, resulting in no available staff or space for the simulation [8]. As part of the scenario design, it is important to develop a contingency plan and "no go" criteria. Finally, as part of the design phase, it is key to identify how supplies, equipment and simulated medications will be managed. There is benefit for staff to actually administer simulated medications, retrieve supplies and equipment and utilize them in the simulation. However, it should be pre-determined which supplies will be simulation/education supplies and which will be clinical supplies. If simulated medications will be used, where will they be kept? Will the actual medications in a code cart be replaced with simulated medications? Will the simulated medications be placed near a medication dispensing unit (i.e. Pyxis or OmniCell)? It is important to decide, perhaps in conjunction with hospital administration, how the simulated medications and supplies will be labeled and the process for ensuring that all simulated supplies and medications are removed from the clinical area.

Today, many high fidelity mannequins are wireless and have built in compressors to allow simulated breathing. This makes it possible to design and facilitate simulations that move from one area to another through the Emergency Department (ED), something that is difficult to replicate in a simulation center. For example, a scenario could involve triage, prioritization, rooming process, assessment and management of an infant with severe respiratory distress and anaphylaxis. A panicky *parent* (embedded actor/standardized participant) would carry her *baby* (mannequin) in respiratory distress into an emergency department waiting area and frantically ask a staff member for help. The scenario requires clinical judgment, decision-making, and procedural skills including IV or IO access and intubation. Multiple staff, providers would be involved as the patient is assessed and receives care. In this example, the scenario would include a list of supplies, medications and equipment required, and would differentiate the ED equipment/supplies used from educational supplies brought for the simulation. The scenario is designed to last 10 minutes and to occur during a shift. Participants can be pulled from their regular clinical duties to care for a "patient" in this type of a simulation, or additional clinical coverage can be scheduled. Although the simulation takes only 10 minutes, recall that debriefing is where the primary learning and reflection occurs, and time needs to be allotted for this important aspect of the simulation scenario as well.

In addition to single patient simulations, scenarios can be designed to test a department and/or organization's ability to respond to a mass casualty incident (MCI) or disaster. Preparation and training for disasters range from lectures to tabletop drills to computer simulations to full-scale immersive experiences with embedded actors and/or mannequins. The higher the fidelity of the disaster drill, the more the participants will be immersed in the experience, potentially resulting in a more realistic testing of the system [11]. A disaster simulation scenario should involve all stakeholders in the planning and design phases. Objectives and roles should be identified for all environments involved.

Though not as realistic as a simulation center or actual clinical setting, effective simulations can be designed for venues like auditoriums, classrooms, or conference rooms. Because observers are in the same room as the participants, the simulation pre-briefing should include additional behavior expectations. It is helpful to project the vital signs so all audience members can see them. Time for preparation with any simulation that occurs outside of a dedicated simulation center must be considered.

Types of Simulation Scenarios

Simulation scenarios are differentiated based on their underlying goals and objectives. Ideally, the objectives for the scenario are clear and measurable. These goals and objectives vary based upon the different learners involved, the various simulation environments in which the scenarios occur, and the outcomes that the scenario intends to achieve. Simulation scenarios can be focused on assessment or improvement of skills for individual participants, for group performance, or on a systems level. Scenarios can also be used for demonstration purposes to stimulate discussion about a particular topic, or to gather data for research questions regarding individual, group, or system performance.

Scenarios Focused on Individual Performance

To assess or improve individual performance, the scenario should be targeted to the participant's level of prior training, with appropriate cues and assistance to make success possible, but not predetermined. Simulation has been an effective and relevant way to educate and provide practice opportunities for healthcare students and professionals at all experience levels [12]. Simulation is now commonplace in medical and nursing education. In 2011, a survey by the Association of American Medical Colleges (AAMC) found that 92% of responding medical schools include simulation in the curriculum as do 86% of teaching hospitals [13]. Because of their lack of experience, participants in training programs may require more cues and/or more obvious cues in order to recognize a change in patient status and take action. In addition, it may take longer for students/novice clinicians to perform relevant tasks than it would for more experienced participants.

If there are multiple participants involved in a scenario, but the scenario's goal is to improve individual expertise, two main strategies can be used. First, the simulation facilitator can assign roles to each participant, usually including a team leader, but can also include other relevant roles, such as Emergency Medical Technician (EMT), nurse (RN), respiratory therapist, recorder, consulting physician (MD), pharmacist, admitting physician, etc. The participants do not necessarily have to serve these roles in reality but if there is an interdisciplinary group, it increases the overall fidelity of the scenario to have them play their actual clinical roles. Additional "extra" participants can be given an observation and even an assessment role: recording time stamps, critical actions, or being assigned in advance to assess a certain aspect of performance (e.g. communication, CPR quality), for which that person can then lead that aspect of the debriefing discussion. This method allows facilitators to choose roles for participants if desired, and quieter participants might be drawn in if encouraged to assume more vocal roles. The second option is to have all participants keep their actual clinical roles, and discourage them from choosing a team leader. In this circumstance, all participants share equally in the outcome of the case, and if they disagree with a proposed plan, they must speak up and state their concerns. If no consensus can be reached with discussion, the participants or the facilitator may call a "time out" for a simple vote on how to proceed. This strategy allows all participants to be involved and to perform according to their usual clinical roles, but may decrease the overall fidelity of the scenario somewhat. It works well when the goal of the simulation is to develop individual cognitive expertise in a specific subject area, but larger groups of learners are participating together in a simulation scenario. For example, it might be used with residents using simulation cases to learn core curriculum topics in depth because it allows the facilitator to hear their clinical reasoning and identifies uncertainties about the case, which can be discussed further in the debriefing.

Scenarios Focused on Team Performance

In scenarios where the goal is team improvement or assessment, crisis resource management (CRM) principles have been used to guide simulation scenario development. These were derived and adapted initially from simulations used in the aeronautics industry. The principles include leadership, followership, communication, teamwork, resource utilization, and situational awareness. From these principles, evidence-based teamwork systems have developed specific to simulation for medical teams. Interprofessional education (IPE) and Simulation-based team training (SBTT), have been successfully used to train teams using simulation [14–16]. During a simulation, a team can work together on appropriate clinical tasks, task coordination, communication, and teamwork [17]. Having different professions work together in simulation provides participants with "an opportunity to explore cognitive processes, underlying observed actions and assumptions, attitudes and other influences on team performance including environmental factors" [17]. Root causes of patient safety events such as medication errors, failure to recognize, failure to diagnose, and wrong site procedures can often be attributed to hierarchical-related communication issues. Designing a scenario that focuses on teamwork and communication may be an effective and safe way to illuminate and address communication issues related to hierarchy, "the presence of a significant gradient in authority between practitioners within a health care team" [18]. When exploring potentially contentious issues involved in teamwork debriefing, it is important to explore the various frames from which individuals are operating within that team, and the perceived context, motivation and rationale for their thought process and performance, rather than targeting an individual team member's specific actions or behaviors.

During the design of IPE, each different type of participant (i.e. physician, nurse, respiratory therapist, medical student) should have specific objectives identified and their role delineated in the scenario. It may be brief (i.e. a medical student's role in a cardiac arrest scenario may be to do chest compressions,) but it should be articulated. If not, it is easy to overlook some participants and they may wonder why they are there.

There are a number of published instruments used to assess team performance in simulation settings. One of the best-known examples is Team-STEPPS, which was developed by the Agency for Healthcare Research and Quality to improve patient safety [19]. Team-STEPPS emphasizes that teams need to be given more than one simulation scenario so that they can practice any weaker team behaviors identified on the initial scenario. Team-STEPPS also advises 3–5 events per scenario where teams can demonstrate the targeted team behaviors. The scenario should not be overly complex clinically. Team-STEPPS uses a checklist for observers to evaluate teams on aspects of teamwork, including: leadership, situation monitoring, mutual support, and communication. Certain behaviors and communication styles, such as SBAR (Situation, Background, Assessment, Recommendation) and closed-loop communication are desirable in teams [20]. Discussion of the frequency and quality of these behaviors can be the focus of debriefing when the scenario is focused on team improvement. An individual scenario focused on one or two aspects of teamwork behaviors is more likely to be successful, especially if time is limited.

Scenarios Focused on System Performance

When scenarios aim to assess or improve systems, *in situ* simulation scenario design can help achieve this goal. They can be performed real time in an active patient care area, or could be performed in an actual clinical space, but by a team specifically focused on the simulation and not also attending to other clinical duties simultaneously (i.e. if an ED decreases coverage overnight, the simulation could occur in an actual patient care room, but at a time when that room is not normally staffed). In situ simulation incorporates the constraints of the actual clinical environment, team and services available, allowing it to identify systems level barriers, errors, and opportunities for improvement. An example of an opportunity to use *in situ* simulation would be to develop an acute stroke scenario before introducing a stroke team in an ED. In situ simulation can help assess and improve new clinical protocols or policies, identify and analyze systems issues contributing to past critical events or cases identified by peer review, or when moving into a new clinical space to identify latent safety threats and reduce errors, and to optimize biomechanics and efficiency regarding placement of equipment. Systems-level scenarios could also include non-traditional participants. For example, the patient transport service could participate in a scenario to develop skills and assess competence related to patients with infectious disease precautions.

Some scenarios incorporate a combined focus on individual, teamwork, and systems improvement. An example of this type of scenario involves a parent (embedded actor/standardized participant) who brought her child (mannequin) to the emergency department with abdominal pain and extremity bruising. Components of the scenario design include roles and scripting for the parent, scripting for the child, detailed moulage with new and old injuries inconsistent with the parent's explanation of the event, and deterioration in vital signs and neurological status. In addition to assessment and management of the injured child, the objectives are to recognize possible non-accidental trauma and to follow the organization's suspected abuse policy. This scenario involves clinical staff as well as hospital security and social workers.

Reproducibility

Reproducibility, in simulation, is the ability to consistently run a scenario in the same way with little variability. If a scenario is designed and facilitated by the same individual, that same person is operating the mannequin, and the simulation will not be repeated, then the amount of detail regarding the set-up and flow is not crucial. There is no need for reproducibility and since the designer is also operating the mannequin, they can make changes occur "on-the-fly". If however, there will be more than one person facilitating the scenario, it will be facilitated by someone other than the designer, or the mannequin settings will be changed by another person, it is important to be as detailed as possible regarding participant cues, possible actions and corresponding mannequin changes. A detailed scenario is also important from a reproducibility standpoint. If a scenario will be repeated, it should flow the same way regardless of the individual facilitating or operating the mannequin.

Figure 3.1 shows the continuum between pre-programmed scenarios and those that are not pre-programmed, and the operator must control mannequin responses as the participants complete the scenario. The latter format is often termed running the scenario "on the fly". Some scenarios operate best when "running-on the-fly". This provides the most flexibility as the facilitator/operator can change the mannequin settings real time in reaction to what the participants do or don't do. It does require that the person operating the mannequin be a clinical expert, or to be very familiar with how the "patient" (mannequin) would respond to ensure scenario fidelity. In contrast, a facilitator can also use a pre-programmed scenario. This is where someone pre-programs the mannequin to respond certain ways based on the design of the scenario. Transitions can occur due to timing (i.e. after 2 minutes, ventricular fibrillation will occur) or based on participant action/lack of action. The scenario designer would still create the scenario and flow, but the critical branch points in the scenario would be programmed

Fig. 3.1 The continuum between pre-programmed scenarios and those that are not pre-programmed, and the operator must control mannequin responses as the participants complete the scenario

into the mannequin's computer, with appropriate resulting changes in mannequin states and vital signs. This is labor intensive initially, but may allow a simulation operator with a lower level of clinical expertise to operate the mannequin during the actual scenario. In the middle of this spectrum would be a detailed scenario script with a non-programmed or very minimally programmed mannequin. This level of scenario detail offers some reliability and reproducibility but still provides the flexibility if needed to modify mannequin response or the scenario based on participant performance.

Consistency is crucial if simulations are designed for high stakes simulations or summative evaluations, as well as for research studies. High stakes simulations are a type of assessment where the result of their performance during the simulation impact employment, academic advancement, receiving privileges, or have other significant consequences to the individual. Simulations designed for this purpose should have both the scenario and the assessment/evaluation instrument (or critical actions) vetted with reliability and validity established.

The Components of a Scenario Design Template

Scenario design templates are a commonly used method to facilitate simulation scenario development. Scenario templates allow some standardization of the scenarios produced and allow the writer to highlight certain parts of the scenario that she considers important or which might otherwise be neglected. Additionally, effective use of templates to guide the creation of a scenario take into account the environment for which the template was designed.

Several examples of high quality scenario development templates exist. Each template has slight variations in structure based on the needs of the institutions that use them. The template used for the cases in this book is presented in "Appendix 1, Chapter 3 Supplemental Case Scenario". Generally, templates include initial vital signs, initial history, a list of three to five critical actions, resulting consequences of those actions, and any specific moulage (make-up, costume, wounds, etc) instructions. It is also helpful to include debriefing points/questions and any relevant clinical pearls/policies. Templates vary somewhat depending on the target audience. If a simulation technician uses the template to make notes after discussion with an experienced simulation facilitator, more technical information and programming cues may be present in their template. In contrast, if a content expert is being asked to develop a simulation scenario for the first time, the template used may be less focused on simulation programming, and more focused on helping translate the subject expertise into a workable simulation scenario that simulation center staff can understand and act upon. For example, Hennepin County Medical Center's template includes debriefing hints embedded in it, and HealthPartners Clinical Simulation Template includes a list of available simulation equipment to help guide the novice facilitator in these facilities. Table 3.1 includes web links to multiple published simulation scenario templates from various centers.

Table 3.1 Links for published simulation case development templates

1. SAEM Simulation Academy's endorsed template	http://elearning.saem.org/sites/default/files/SAEM%20SIG%20scenario%20template%20RIHMSC%20rev%202.8.09.pdf
2. Hennepin County Medical Center – follow link to Simulation Scenario Template	http://www.hcmc.org/education/sim/sim-resources/index.htm?
3. MedEd Portal's guideline for structuring submissions for mannequin-based, standardized patient based, team-based scenarios, as well as assessment tools. These structures could be adapted or used as templates for case development in these areas as well	https://www.mededportal.org/submit/instructions/#faq-191140
4. Penn Medicine's download of its Scenario Planning Worksheet	http://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=2&ved=0CCkQFjAB&url=http%3A%2F%2Fwww.uphs.upenn.edu%2Fsimcenter%2Fprograms%2FPDFs%2FPMCSC_Scenario_Policy.doc&ei=xZglVJ-bD4akyAT434LwAg&usg=AFQjCNHneRNTECFBg81B5bta1wNXrYRXpg&sig2=hsllm2n2uy2KK1AM713GwQ&bvm=bv.76247554,d.aWw
5. University of Washington's Scenario Development Template. Also listed is a filled-out template	http://collaborate.uw.edu/tools-and-curricula/scenario-building-and-library.html
6. Duke University's template	http://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=11&ved=0CB0QFjAAOAo&url=http%3A%2F%2Fanesthesiology.duke.edu%2Fwp-content%2Fuploads%2F2014%2F01%2FSimTemplate0408.doc&ei=-I4lVNaHBIf0yAT4kYHYBQ&usg=AFQjCNF0kwncpPJ9GqjZl9dg4SeoU5dRAg&sig2=1udc1KH1Hyw33dE7XaCjOw
7. HealthPatners Clinical Simulation and Learning Center	http://www.hpclinsim.com/resources.html
8. The Template of Events for Applied and Critical Healthcare Simulation (TEACH Sim): a tool for systematic simulation scenario design	http://www.ncbi.nlm.nih.gov/pubmed/25514586

An alternative to using a pre-established template is to create a scenario using a stepwise approach. McLaughlin et al. outline eight steps of simulation design, a method which is used at the University of New Mexico [21]. These steps describe the important parts present in many simulation scenario development templates, and thus serve as a good introduction and outline for a discussion of the template components. The steps can be used to help guide development of a novel template for simulation scenario design. The eight steps are: defining objectives, considering the learners, creating a patient vignette, orchestrating the expected flow of the scenario, optimizing the environment (room, props, script) for the scenario, using tools to assess the results, debriefing the learners, and debugging the scenario for future changes and improvements.

Although different templates will vary slightly or emphasize different aspects of the simulation, most include many if not all of the above steps. We use several examples to discuss in detail the components of a standard scenario template. The starting point for a simulation case is to identify the topic of interest and the intended participants. For example, perhaps you learn that you have been tasked with introducing 2nd year medical students to simulation during their cardiopulmonary physiology course, and asked to make the subject area, including Frank-Starling curves and circulatory anatomy "come alive". Later that day, the ED program director asks you to develop a "chest pain" case for this years intern orientation, to help them mitigate some of the "deer-in-the-headlights" reaction when they begin their clinical rotation in the ED, and later your chair asks you if you have any ideas on how simulation might help with the 3 cases this month that have been noted to incur longer than desirable times to get patients with ST elevation myocardial infarctions (STEMIs) to the cardiac catheterization (cath) lab. We will focus on the intern-level case in most detail through our discussion here, but will mention the other scenarios briefly to highlight how widely varying template results can be.

Learning Objectives

The most critical step in scenario design is to define the learning objectives, as the rest of the template will flow from these objectives. Learning objectives are what we want our learners to take away from the simulation experience. They may focus on areas such as the management of a specific medical condition, effective teamwork or team leadership, demonstration of facility with a particular skill, procedure, or clinical protocol, or some combination of these [22]. While including multiple learning objectives will make for a more robust simulation, selecting three to five at maximum is ideal in order to keep the simulation focused and the outcomes achievable in the limited time frame of a simulation. For our interns, we might choose to emphasize ways to excel in their expected role in the clinical team, tips for efficiency and thoroughness with a chest pain specific history and physical examination, consideration of the life-threatening differential diagnoses of a patient with chest pain, and review of the Advanced Cardiac Life Support (ACLS) algorithm in a patient with cardiac arrest. The more clear and measurable the objectives, the easier it is to create a scenario that flows from them, and to do assessments afterwards.

The Participants

The second step of the eight steps is consideration of the learner's background and needs. It is worthwhile to explore the level of your participants' prior exposure to simulation in general, as well as to your specific topic before you begin. For our first scenario, we would want to introduce our medical student learners to the mannequin and to use the case we develop as a means to deepen their understanding of cardiopulmonary physiology and why it is important in making critical decisions for a patient with acute cardiac pathology. In contrast, for our delay to cath lab in STEMI example, the practicing RNs, MDs, and other professionals in the ED, are unlikely to be delaying definitive care based on lack of familiarity with cardiopulmonary physiology. Our first objective might be to observe and delineate the steps required to identify a STEMI and get the patient to the cath lab, with a second goal to determine which of these steps is most time-consuming. Lastly, we could choose to identify existing barriers to rapid achievement of each step.

Actions, Behaviors, and Outcomes

Flowing directly from our objectives, the facilitator should identify the actions, outcomes, or behaviors that the learners will be expected to complete. Ideally, these should be simple, and easily observable as well as recordable. This step is a deviation from the order of scenario development advised in the "eight steps" model. We chose to merge steps three and six from that model and to present them under this heading. To improve the strength of our scenarios as educational tools with proven efficacy, there is simulation literature that supports increased consideration of outcomes and assessment tools early in scenario development [23]. Because we feel it is important to identify desirable and observable actions and behaviors at the outset of developing a scenario, and because these are inextricably linked to the scenario's outcomes (often they are the same), we have modified the order for this discussion to include a discussion of scenario assessment here.

Possible actions in our sample scenario for interns could include: (1) asking the RN to place the patient on telemetry monitor, (2) communicating concern for cardiac etiology to ED team, (3) obtaining history including cardiac risk factors, (4) performing physical exam while noting important findings such as new heart murmur and signs of congestive heart failure (CHF), (5) obtaining electrocardiogram (ECG), (6) sending cardiac enzymes, (7) administering aspirin, (8) recognizing clinical deterioration into ventricular tachycardia, (9) initiation of cardiopulmonary resuscitation (CPR) and defibrillation following ACLS pulseless ventricular tachycardia/ventricular fibrillation (VT/VF) algorithm, (10) recognizing necessity of advanced airway management, (11) consulting Cardiology upon return of spontaneous circulation (ROSC). These actions could be developed into a Yes/No checklist for the facilitator to record performance during the scenario, especially when the list of desired actions is long as it is in this example.

Assessment tools include various behavioral checklists and global rating scales (GRS). Behavioral checklists can be used to record dichotomous 'hits' if a targeted critical response is observed [16]. A major benefit of the checklist is that it is simple and reliable, as the observer merely scores the presence or absence of specific actions. A GRS is more qualitative and subjective than the checklist, but has also been validated as an excellent assessment tool, especially when assessing group dynamics and for assessment of competence [24]. Timestamps can be incorporated as well if the timing to critical actions is important for the scenario. In the STEMI case looking at cath lab delays, the time to ECG, time to recognition of STEMI, time to IV placement, time to page cardiology and the time of return page, as well as time of transport to cath lab would likely all be important outcomes to record.

Flow of the Case: Creating the Story

These desired actions, behaviors and outcomes are next reviewed and assembled to create a vignette or storyline that allows the participants to perform them. Sometimes the storyline helps develop the actions and outcomes, and sometimes the reverse is true, but both should flow from the identified goals and objectives. At this point, it is helpful to identify the critical actions which influence the flow of the case. These actions are the ones that change the course of the case depending on whether or not they are performed correctly. For the medical student case, if the patient developed an acute anterior MI (AMI) in a first vignette, followed by a second patient scenario with an acute inferior MI (IMI), students could compare and contrast the physiology differences and ideal treatment in the debriefing. Recorded outcome actions might include (1) interacting directly with the mannequin rather than trying to talk to the facilitator about the mannequin, (2) teamwork tasks such as calling for help, communication regarding plan, and self-assignment of tasks (3) giving the AMI patient nitroglycerin (NTG), while giving the IMI patient intravenous (IV) fluids (possibly after NTG dropped the pressure), (4) giving both aspirin (ASA), and (5) considering vasopressors. Of these, the only critical action which will change the clinical course is the administration of NTG to each patient. In the first scenario with AMI, it will improve the patient's pain, and lower the blood pressure and heart rate. In the second scenario, NTG administration might make the patient hypotensive, requiring resuscitation with IV fluids. Identifying which critical actions will alter the flow of the case allows the facilitator to create "if/then" statements, which also can help guide scenario programming if desired.

The next component of the scenario template is crafting the case narrative. You have already determined who your learners will be, what their learning objectives are, and the critical actions that will form the backbone structure to the scenario. Now it is time to finalize the details about how the simulation will flow. Describe who your patient is (history of present illness, past medical history HPI, PMH, Allergies, Medications, etc), what is happening to him or her (vitals, exam), and what additional scenario branch points will occur. This is an opportunity to be creative and have fun with the scenario, but keep in mind that this effort is not necessarily key to the main learning objectives, and should not result in an undue expenditure of time and effort. Our interns' patient is an elderly male who has chest pain radiating to his shoulder and neck that occurred while shoveling. He has a history of hypertension and remote smoking, takes metoprolol and aspirin. He has vitals significant for hypertension and an unremarkable physical exam initially. His ECG shows hyperacute T waves anteriorly. He loses vitals and his cardiac rhythm becomes ventricular tachycardia as the case progresses. He requires advanced airway management. He obtains ROSC after receiving CPR, epinephrine and defibrillation. He goes to the Cardiac Critical Care Unit (CCU) or cath lab after cardiac consultation.

The Environment

The next component in our simulation template is the environment. This includes the room itself, any mannequin or task trainer being used, medical equipment or supplies, props, distractors, and scripting for standardized participants. Manipulating these environmental factors allows the facilitator to make the simulation more realistic. For the learners, the simulation often begins prior to entering the simulation room. A pre-briefing in which the behavioral expectations of the participants and the goals and limitations of simulation are discussed is recommended. A specific introduction to the mannequin may also be helpful, including listening to normal breath sounds, or palpating peripheral pulses. The participants may be provided with pre-scenario information, such as an Emergency Medical Services (EMS) run sheet, reported bystander history or triage note, which allows them to prepare for what is to come. Some simulation centers have different background scenes that they can use on their walls, allowing the environment to change. Less technologically sophisticated environmental factors can also be used to enhance the particular scenario. For example, a patient on a gurney replicates an emergency department resuscitation room, particularly when a cardiopulmonary monitor can be used, and a crash cart and airway equipment are available at the bedside. Scenario specific props such as a backboard and c-collar, appropriate clothing for profession or sport described in the scenario, or appropriate padding for obese or pregnant states can enhance the scenario. ECGs, printed or electronic lab results, and imaging studies further add to the fidelity of the environment. Our patient's ECG demonstrates hyperacute t-waves in the anterior leads with some questionable reciprocal changes, his troponin is slightly elevated.

The focal point of the environment should be the simulated patient. The patient can be achieved through verbal role playing, actors portraying standardized patients, partial-task trainers used for procedures, computer-based virtual reality patients, computer-controlled electronic mannequins designed to replicate real patient, or some combination of these [22, 25]. Although there are many options, high fidelity simulation most often refers to mannequin-based simulation. The use of moulage, applying mock injuries or accessories to the mannequin, can make the simulation much more realistic. Wigs can help match a male or female voice, makeup can highlight traumatic injuries, and commercially or locally produced injured body parts can be added. In our example, we might dress our patient in winter clothing as he was shoveling snow prior to the onset of his chest pain. Creative low fidelity efforts can also enhance the simulation. If a particular finding is not achievable using the mannequin's innate technology, creative low-tech interventions such as taping a photo of a rash to a leg, or placing a smartphone playing a video of nystagmus of the simulated patient's eyes allows the mannequin to provide information directly and the simulation to proceed without the participants "breaking character" to ask the facilitator for information. These types of solutions can also allow a healthy actor playing a simulated patient to acquire various disease states.

Along with the environment described above, various simulation personnel will be required for the simulation scenario. Your template should detail these players in advance. A standardized participant, or actor, portraying a friend or family member may be utilized to provide participants with pertinent history of present illness, past medical history, allergies or current medications. Standardized participants may also play the role of a nurse, family member, ED staff or other provider. A standardized participant provides the additional benefit of being able to steer confused participants towards specific teaching objectives, particularly when clinical expertise is limited. Detailed scripting for standardized participants and simulation operator can keep the scenario moving forward by preparing for potential complications that may occur if the learners go down the wrong clinical pathway. The scripting may also outline the optimal management of the scenario. These notes typically include tips to keep the simulation operator and standardized participant(s) following the same course of action and to increase the fidelity of the simulation. In our example, the script prompts the standardized participant to notice the large T waves on ECG if the residents initially agree with the computer generated "normal sinus rhythm" printed interpretation. The standardized participant may also be asked to provide distraction to see how participants cope with a distressed family member, irritating co-worker, or other role. The simulation operator is the person running the simulator, who will usually provide the voice of the mannequin while orchestrating any planned changes in patient condition, rhythm or vital signs. In our scenario, a standardized participant plays the role of RN to help administer medications, the simulation operator plays the patient and the debriefer portrays the voice of the consulting cardiologist over the phone. The debriefer may be watching from the control room, or could also be present during the simulation as a standardized participant. Finally, depending on how complicated the outcomes are, there may be an additional person present for assessing the learners on their performance of the behaviors, actions and outcomes.

Debriefing

Debriefing the learners after the simulation will be covered in detail in a different section of this text. A skillful debriefing typically requires preparation. Using the template, you may decide in advance if the debriefing will be individual or group, and whether any video or handouts will be used. Facilitating the discussion using good judgment, curiosity and respect is important for creating an effective learning environment. Focusing on the frames of the learners and not their actions is important [26]. Defining the key learning objectives in advance helps prioritize the topics to discuss during the debriefing. The debriefing process can also be a useful springboard into a discussion of pertinent recent literature or related topics. Using our example, after reviewing the outcomes and key learning objectives during our debriefing for our VF arrest patient, we could then discuss the utility of getting serial ECGs, the current evidence about therapeutic hypothermia and the utility and timing of coronary catheterization in this type of patient.

Table 3.2 Links to Published Case Banks

https://www.mededportal.org
http://www.emedu.org/simlibrary/
http://www.cordem.org/i4a/pages/index.cfm?pageid=3403
http://mycourses.med.harvard.edu/ResUps/GILBERT/pdfs/HMS_7607.pdf
http://www.mass.edu/currentinit/Nursing/Sim/Scenarios.asp
http://cms.montgomerycollege.edu/nursingsims/
http://sirc.nln.org/login/index.php
http://thesimtech.com/scenarios/

Debugging

After debriefing, the simulation is over but your work is not quite finished. It is now time for making any necessary revisions to further develop the scenario for use in the future [27]. This last component of the template is termed debugging. Was the size of the learner group ideal? Did you have enough personnel to run the mannequin, act as standardized participants, and effective debrief and evaluate the learners? Can you think of other standardized participant roles that would have been useful? Did you meet your learning objectives? Was the simulation appropriate for the participants' level of training? Having the learners evaluate their experience will provide additional feedback to help you make any necessary changes. With our example, we decided to have the standardized participant prompt getting a second ECG which would show developing STEMI in subsequent iterations of the case, and to include getting therapeutic hypothermia recommendations from the cardiologist as a recorded action on our checklist going forward after debriefing and learner feedback.

Resources and Summary

Several published case banks of simulation scenarios exist, which are usually searchable by topic. Reviewing case bank scenarios can help generate ideas when working on new scenarios. For instance, if you are writing a scenario about agitated delirium, and you see a case about cocaine toxicity, there might be parallels between the two scenarios. Alternatively, if you are developing a scenario focusing on interprofessional teamwork for acute decompensated CHF in the ED, you might be able to adapt a case on CHF which was originally targeted towards use with medical students. An organophosphate poisoning case developed for a simulation lab could be adapted for use with EMS providers in a mass casualty simulation in the field.

MedEd Portal is a catalogue of peer-reviewed simulation cases which have been published and are of consistently high quality. Additional national scenario case banks include those from the Council of Residency Directors (CORD) and the Society for Academic Emergency Medicine (SAEM), which were jointly developed into simulation scenarios from a set of oral boards preparation cases. These are also high quality, extensively reviewed and validated scenarios. Links to these and other case banks are presented in Table 3.2.

In summary, as you develop novel simulation scenarios uniquely suited to your goals, objectives, learners, and environment, it is wise to use all the resources that are available to you. Ultimately however, do not feel you must use a scenario from a case bank exactly as it is written, only because it was created by an expert in simulation, or because it has been peer reviewed. A scenario that is tailored to your specific needs will always perform better. Review and select the best of the scenario development resources and materials available to you, and adapt them to meet your own needs. If you are developing a novel scenario for the first time, we recommend using the following summary. First, identify your goals and objectives, then use these to guide development of your critical actions and outcomes. The more clear and measurable these can be, the better. Next, identify the initial vital signs and how they will change with performance or nonperformance of your critical actions. Last, choose a scenario template, tweak it to meet your specific needs, and fill in the rest with creativity and a sense of humor.

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4 Debriefing in Emergency Medicine

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Case Vignette

You are a simulation educator in the Department of Emergency Medicine (EM) at a large teaching hospital. Key institutional stakeholders have targeted the management of severely head injured patients who require emergent airway management for interprofessional and multi-disciplinary simulation training. In addition to planning simulation scenarios as part of this curriculum, you see several options for the debriefing component of the simulation experience. Your curriculum will include events that bring the whole team together, but also sessions to help prepare individual learner groups.

EM resident physicians and EM nurses participated in the pilot run of this scenario, with the future plan to involve other involved specialties and learner levels. You noticed a few things during the case that you want to address in the debriefing: (a) the team followed a highly systematic approach to trauma assessment; (b) despite a GCS of 6 upon arrival in the Emergency Department (ED), the decision to intubate was not made until 10 minutes into the case; (c) the patient presented with asymmetric pupils, hypertension and bradycardia; however no osmotic agents (e.g. mannitol or hypertonic saline) were given during the case; (d) shortly after intubation, oxygen saturation dropped precipitously from 97% to 80% and remained 80% for nearly 1 minute before the team responded; (e) team members lacked a shared understanding about priorities and did not use communication strategies such as summarizing and closed loop communication.

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Goals of this Chapter

We have several aims with this chapter. First, we outline the important role of debriefing in simulation-based education as well as the creation of a supportive yet challenging learning environment that enable effective debriefing. We present general considerations for debriefing for the process of debriefing, including various strategies educators can apply deliberately to help achieve intended learning outcomes. These include traditional post-event forms of debriefing, but also within-event debriefing that has shown great potential. Also, while debriefings have classically been facilitated by a simulation educator, recent work has shown some promise for learner- or peer-led debriefing. Then we explore approaches to align simulation-based learning with the demands of emergency medicine. Specifically, we address several factors that impact debriefing in emergency care settings, including learner characteristics, debriefer characteristics, and debriefing strategy. We also explore how debriefing promotes acquisition and maintenance of clinical skills in various performance domains (cognitive, behavioral, and procedural). We use trauma team management of a patient with severe head injury as a case study to illustrate these points.

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Healthcare Debriefing: General Considerations

Although at times used interchangeably, we differentiate the terms ***feedback*** and ***debriefing***. Feedback is "specific information about the comparison between a trainee's observed performance and a standard, given with the intent to improve the trainee's performance" [1]. Whereas f**eedback** is *information,* **debriefing** represents an interactive dialogue or *conversation* in which educators and learners explore and reflect on key aspects of performance [2]. Experiential learning theories emphasize the essential role of reflection in promoting learning [3]. Debriefing helps transform learners' experience into learning through reflection [4]. Importantly, debriefing may also integrate critical performance feedback for learners. In this chapter, we refer to all simulation participants as "learners" irrespective of career stage or training level. We use the term "educator" to indicate the individuals who designs simulations, create supportive learning environments and moderate the debriefings; "instructor" or "facilitator" are alternate terms that are part of the simulation discourse, however, we prefer to use "educator" here.

An emerging body of evidence outlines what makes debriefings effective [5–7] and how to assess debriefing quality [8, 9]. Debriefing conversations include key elements: [10] (a) learners' *active participation* rather than just receiving feedback passively; (b) a focus on *learning and improvement* rather than simply a performance review; (c) a discussion of *specific events*; and (d) use of input from more than one source, e.g. educators, peers, video review, performance data. A successful debriefing is not a goal unto itself; the debriefing takes place to enhance future clinical practice. While guidelines to promote debriefing effectiveness exist, educators' debriefing practice is highly variable [11] and may not reflect the ideal [6]. As an example, although learners value an honest, non-threatening approach [5], educators frequently hesitate to provide performance feedback they perceive as "negative" to avoid being viewed as harsh [12, 13], and their concern for potentially harmful effects on learners [14–16]. Supportive learning environments help mitigate perceptions about potentially negative effects of performance critique.

Establishing a Supportive Learning Environment

A challenging yet supportive learning environment forms the basis for successful simulation-based education and debriefing [17–21]. A supportive context makes difficult conversations possible. Psychological safety promotes a sense that learners will not feel rejected, embarrassed, or punished for speaking up with questions or concerns or making mistakes [22], helping learners take risks [23] and accept challenges [24] during the learning process. *The groundwork for a successful debriefing is laid before the simulation even begins*. Educators work to instill a sense of psychological safety, mutual respect, and trust through several important steps: [18, 21]

- Perform introductions for all parties who have an active role in the simulation session, including educators and learners.
- Provide a session overview so learners know what to expect.
- Discuss ground rules including the important role of confidentiality and mutual respect between all participants and educators.
- Orient learners to simulation environment—particularly important when the simulations occur outside of the clinical area.
- Explain how learners access essential information for the simulated case (e.g. how they elicit key physical findings that are difficult or impossible to assess on the simulation mannequin such as capillary refill time, the simulated patient's general appearance, etc.).
- Outline the importance of the debriefing process, how it will take place, and that the discussion will address aspects of performance that worked well ***and*** those that need improvement; highlight the important role of feedback in helping learners improve.
- Emphasize that the goal is not perfect performance during the simulation; areas that could use improvement can serve as valuable springboards for learning.
- If a pause and discuss debriefing approach will be used, let learners know up front to expect pauses at various points during the simulated case for a few minutes at a time in order to reflect briefly on how they are doing and receive feedback before resuming the case. 'Pause and discuss' strategies promote successful practice of clinical skills.

"How to Debrief": The Process of Healthcare Debriefing

Debriefing has clear benefits for performance improvement [10], although no standard framework exists. Various frameworks have been developed to provide educators with an overarching structure for the debriefing. Some examples include:

- Debriefing with Good Judgment [12]
- GAS (Gather-Analyze-Summarize) [25]

- 3-D Debriefing Framework (Diffuse, Discovering, Deepening) [26]
- DEBRIEF: military after-action review contextualized for healthcare debriefing [27]
- Blended approaches and frameworks
  - PEARLS blended debriefing framework [28]
  - TEAMGains [29]

While these and other debriefing frameworks differ, we seek to highlight common elements of an organized debrief. Traditionally, debriefing after a simulation event follows a clear structure (reactions, description, analysis, summary) [17, 18, 28, 30] during which learners may receive performance feedback. See Table 4.1 for an overview of debriefing structure and function, as well as pitfalls to avoid. Debriefing scripts, when used by novice educators, promote learning outcomes in terms of knowledge and team behavioral skills [31]. We include a basic debriefing script here to support post-event debriefings (see Table 4.2). This basic debriefing script includes key structural elements of the debriefing with a simple, easy to use learner self-assessment strategy. Basic learner self-assessment strategies such as the SHARP technique are especially helpful when time is limited [32]. In nearly all instances, the analysis phase comprises the bulk of the debriefing. To prime learners, key issues can be sign-posted at the beginning of the analysis phase (e.g. "For most of the debriefing I would like to focus on aspects of the clinical decision-making as well as the teamwork and communication surrounding the intubation. Are there other issues you would like to discuss?"). Debriefing topics will also be informed by emergent issues and questions that learners raise. Educators should probe to explore important content, communication or process areas in order to discover the learners' underlying cognitive routines, thought processes or mental models [12, 17]. Further, an important part of the debriefing includes broadening or generalizing the discussion beyond the simulation case to relevant concepts that apply to clinical practice.

In general, educators may employ three broad categories of educational strategies during debriefings [28, 33]: (a) prompting learner self-assessment [32, 34–36]; (b) facilitating focused discussion to promote reflection and explore understanding of events [12, 29, 30, 37]; and (c) and providing information through directive feedback [38, 39], and/or focused teaching [11, 12, 17, 37] as knowledge gaps emerge. See Table 4.3 for an overview of educational strategies used during debriefings with examples of specific models. Educators may blend these three broad educational strategies within the general debriefing structure depending key factors, such as how much time is available, type of learning

Table 4.1 Debriefing structure and function and key pitfalls for each phase

Phase	Function	Pitfalls
Reaction	Ideally immediately after the scenario Serves emotional washout and venting and prepares learners for later analysis Surfaces key topics that are important to learner for integration later in the debriefing	Skipping this portion may lead to unexpected reactions later in the debriefing (frustration) Avoid delving into one person's reactions before giving all team members an opportunity to vent
Description	Serves to establish a shared understanding of the case; important for both educator(s) and learners Educators invites learners to share a brief summary of the case from a medical point of view and main issues *from their perspective* ***OR*** educator provides an overview of the facts of the case May be brief if team members had clear shared understanding of the key issues	Failing to clarify main issues of the case upfront may leave learners confused and negatively impact the debriefing since educator(s) and learners may not be on the same page Avoid a time consuming blow-by-blow of events of the case since it can be inefficient and places a focus on what happened rather than on thought processes, and sense-making of the scenario and what it means for clinical practice
Analysis	Discussion of key learning points related to case objectives Can be quite helpful to frame the discussion if the educator is explicit about key topics for the debriefing Three broad categories of educational strategies • Educator prompts learner self-assessment • Educators facilitates a discussion to explore key aspects of the simulated case • Educator provides information in the form of directive feedback or teaching as appropriate ***Ultimate goal is to generalize the discussion away from simulation case to application of principles and their relevance for clinical practice***	Avoid focusing on one or only a few individuals if a team scenario Focus on exploring thought processes in order to understand the learners' perspectives in order to diagnose learning needs ***before*** facilitating discussion or providing solutions Avoid getting lost in the minutiae of the case at the expense of generalizing what it means for real clinical practice
Summary	Allows learners to state take home messages and how lessons learned apply to real life clinical practice Educator may add final comments to augment essential points	Plan to leave enough time for this part of the debriefing Often rushed, even though giving learners an opportunity to articulate take home messages is an essential step in the learning process

Working through all phases is most appropriate for a **Post-event Debriefing** (after the simulation has ended)

Table 4.2 Basic Debriefing Script[a]

Before the simulation	
1. Introductions & session overview 2. Orient learners to simulation environment including how to access essential information 3. Review ground rules (a) *"Everyone is capable, does their best, and wants to improve"* (b) Role of error: *"No one is perfect, our goal is learning"* (c) *"Everyone has something to contribute"* (d) Confidentiality: *"What happens here, stays here"* 4. Overview of the debriefing process: *"During the debriefing we will explore both aspects of patient care that were working for you and aspects you would change."*	
Debriefing	
Setting the stage	"We will spend about [X] minutes debriefing. I hope you share what was on your mind at various points during the case."
Reaction	"How are you feeling right now?" ***OR*** "Initial reactions?"
Description[a]	"I am interested in your perspectives of the case. Can someone summarize what the case was about to make sure we are all on the same page?"
Analysis	"From your perspective, what worked well ***and why***?" "What would you change next time, ***and why***? *Consider probing/facilitating focused discussion around key topics (ie. "What was going through your mind when you first noticed xxxx?") and providing relevant feedback/information*
Any other burning issues before we start winding down?	
Summary	What are you taking away from this experience for your future clinical practice?

Modified after Eppich and Cheng, in press
[a]***Educator can state main issues of the case for participants if limited time or obvious (unusual)***

Table 4.3 Three broad categories of educational strategies used during debriefing[a]

Approach	Description	Examples/key elements
Ask learners to self-assess	The educator **asks** participants to self-assess their own performance by asking what they think	Plus-Delta (+/Δ) What they did well (Plus) What they would do differently (Delta) SHARP technique What worked well ***and why***? What would needs to change ***and why***? Easy-challenging What was easy about managing the case What aspects were challenging?
Use focused facilitation strategies to promote discussion	The educator **facilitates** a discussion surrounding around key events and helps learners reflect on key aspects of the simulated case and generate learning points	Advocacy-inquiry Guided team self-correction Circular questions Alternatives and their pros and cons
Provide information in the form of directive feedback and/or teaching	The educator **gives** participants directive feedback based on what he/she saw the individual or team do (i.e. their actions) and tells them what to do differently next time if their performance was lacking	Share specific observations, rationale for why this is important, and suggestions for what to continue doing in the future or how to improve Teaching to close clear knowledge gaps as they emerge during the debriefing

[a]Educational strategies apply during **Post-event Debriefing** (after the simulation) or during **Pause & Discuss** (case is paused for brief discussion before resuming the case)

objectives, level of learner, where the simulation and debriefing takes place, etc. Unifying characteristics of a blended approach include learning that is learner-centered [40, 42] actively engages learners, and promotes collaboration and self-directedness [41]. For example, educators can prompt self-assessment by querying learners what they think went well in the simulation as well as what they would change about their performance using a plus/delta technique [34, 36], what went well/not so well ***and why*** (e.g. SHARP technique) [32] or what aspects were "easy"/"challenging" [35]. Although self-assessment is imperfect [42, 43], learner reflection serves a starting point and often provides a segue for additional discussion.

Educators can probe deeper into issues uncovered with self-assessment strategies by using questions and facilitation techniques. These techniques promote active learner participation, with an ultimate goal of helping learners' reshape their underlying mental models [12, 13, 29, 44, 45]. For example, advocacy-inquiry represents a conversational strategy that helps uncover learners' rationale for action or mental models, also known as "frames" [12]. With advocacy-inquiry, educators begin by sharing a specific, concrete observation, then explicitly stating their point of view, *before* inquiring about the learner's perspective using an open-ended question [12, 17]. Additional advanced strategies for focused facilitation add value to explore team interactions, such as guided team-self correction [44] and circular questions [45, 46]. Through focused facilitation methods, educators help reveal learners' frames of mind, mental models, and/or thought processes, in order to make sense of the simulation and diagnose learning needs [17]. When learners and educators share their mental models, they can work collaboratively to reframe their thinking in a number of key ways related to decision-making, teamwork, extraprofessional collaborative practice, or systems integration [17, 18]. As appropriate, educators should offer information, e.g. clear directive performance feedback [39] and/

or focused teaching [37] conveyed using an honest yet non-threatening approach [5, 9]. A blend of strategies may be quite appropriate depending on the learning objective or learner types [28]. All three educational strategies will often play a role during a debriefing in blended fashion, for example: global self-assessment first, then focused facilitation about clinical decision-making, then providing information based on demonstrated learning needs. This type of blended approach to debriefing has become known as the PEARLS debriefing method [28], for which a faculty development guide exists [47].

In PEARLS, the choice of educational strategy depends on a number of factors. These factors include: amount of time available, performance domain, learner insight and clinical experience, and educators' debriefing expertise [28, 30]. For example, educators may use a brief self-assessment followed by directive feedback and teaching, when time for debriefing is limited. This approach works well for more novice learners, or for cases with many technical components, and when the knowledge gaps are already clear. However, educators may use focused facilitation to discover and reshape learners' frames, particularly with more available time, more advanced learners, or cases focused on complex clinical decision-making [28]. Across all strategies, several important principles promote discussion and enhance debriefing effectiveness (see Table 4.4). Recent work has demonstrated the potential for assessing debriefing quality. Both the Debriefing Assessment for Simulation in Healthcare (DASH) [8] and the Objective Structured Assessment of Debriefing (OSAD) [9] offer valuable frameworks for not only assessing debriefing quality, but providing a common language within simulation programs for faculty development purposes and simulation educator certification.

Most debriefing approaches described above are facilitator-led, i.e. a simulation educator moderates the debriefing conversation. Recent work highlights the potential for peer-led debriefing [48, 49]. Boet and colleagues demonstrated similar outcomes for crisis resource management and behaviors when teams debriefed themselves using a predefined template to guide their discussion [49]. Another promising approach called "pause and discuss" [50, 51] leverages the power of shorts bursts of debriefing that occurs 'within-scenario'. These pauses can explore rationale for action, discuss appropriateness of decision-making or team processes, and/or provide performance feedback—either in the form of an affirmation of what is working or what needs to be improved—before resuming the scenario. Through within-scenario debriefing, learners have immediate opportunities to integrate feedback and practice what they learned, thus optimizing tighter cycles of experiential learning. Both post-event debriefing and within-scenario debriefing approaches such as "pause and discuss" foster reflection-on-action [52] *after the fact.* Hunt et al., in a highly structured form of pause and discuss termed "rapid cycle deliberate practice" (RCDP), found significant improvements in pediatric advanced life support skills for pediatric residents [51]. In this important study, Hunt et al. afforded learners scenario-

Table 4.4 General principles to promote discussion during debriefings

Use ***open-ended questions*** to allow for a range of possible answers
Pose questions that ***invite multiple responses***—in this way, more than one person can contribute to the discussion; avoid questions that seek ***a single answer***
Invites multiple responses*: E.g. What is your approach to an acute fall in oxygen saturation in an intubated patient?*
Seeks a single answer: *E.g. What is the acronym guides your approach when there is an acute fall in oxygen saturation in an intubated patient?* (answer: DOPE for displacement, obstruction, pneumothorax, equipment failure)
Avoid questions that ***suggest*** an answer since they may limit discussion
E.g. Do you think it would have been a good idea to start bag-mask ventilation when the oxygen saturation fell below 80%?
Listen carefully and actively: build in learners' responses when formulating subsequent questions or comments (i.e. use the learners' words)
Be flexible to flow of the debriefing conversation; avoid following a rigid agenda to the exclusion of topics that learners find important
Use silence to give learners time to think and formulate a response
Turn questions back to the group rather than answering them yourself (*i.e. "Thoughts on that?")*
In team debriefings, ***direct questions to the group*** to open up discussion rather than focusing on individuals
Seek to be ***honest yet non-threatening*** by sharing your point of view and striving to be curious about the learners' valuable perspectives; learners generally want to talk about challenging aspects of case
Be clear about what you would like to talk about at various points in the debriefing to frame the discussion; this strategy also signposts the direct of the conversation especially if you are changing topics
E.g. I'd like to talk about managing acute oxygen desaturation in an intubated patient
Share ***specific observations***, clearly state your ***point of view*** or personal reaction about what you saw, and invite learners to share ***their perspective***.
Speak from the first person perspective, i.e.
"I noticed… I didn't notice…"
"I saw…I didn't see…"
"I was thinking….my impressions was….my sense was…I was worried about…I liked that strategy because…"
"I am curious about…."
E.g. I saw the oxygen saturation fall abruptly from 97% to 80%, I was worried that the oxygen would continue to fall and the patient might become bradycardic and arrest without an intervention. I am curious how you experienced that?
Balance discussion and teaching to knowledge gaps as the need arises; avoid switching into "teacher mode" too early and talking too much
Remain mindful of the important role of ***non-verbal cues*** (body position, eye contact, seating arrangement, tone of voice, etc.) and their influence on discussion
If desired, integrate brief ***video segments*** by letting learners know what they should be looking for to prompt self-reflection and discussion

based opportunities to acquire and practice basic skills such as bag-mask-ventilation in a repetitive and deliberate manner. In RCDP, learners start with a lower-complexity case requiring basic skills, then debrief and receive feedback on their performance. Subsequent scenarios include these basic skills but also build on them in cases with increasing levels of complexity. When learners do not perform basic skills perfectly, the educator pauses the scenario to provide feedback and the scenario 'rewinds' to give learners the opportunity to practice again. Sequential cases follow this pattern of integrating prior skills with increasing clinical difficulty and amidst higher cognitive load (e.g. performing basic life support including bag-mask ventilation, managing asystolic cardiopulmonary arrest, working through reversible causes for pulseless electrical activity, treating ventricular arrhythmias including electrical therapy). Again, tightening the cycles of experiential learning through "pause and discuss/rewind" promotes just-in-time feedback, reflection and repetitive practice to achieve well-defined performance goals. Given the importance of advanced pediatric and adult cardiac life support (ACLS) in emergency medicine, RCDP has great potential to accelerate the learning curve and prepare individual learners and teams for situations of cardiac and respiratory arrest. Additionally, feedback and debriefing structured to promote mastery learning [50] help learners progress especially for skills with clear performance standards, such as ACLS [53]. In mastery learning approaches, learners achieve uniform outcomes; what varies is the amount of time learners need to achieve those performance standards [54].

Making It Count: Aligning Simulation with Learning Needs

The alignment of simulation with clinical practice is of utmost importance to promote maximal performance gains in clinical settings such as emergency departments (ED). Simulation educators should strive to generalize lessons learned in simulation to actual clinical environments. In doing so, educators should tailor debriefings to the unique needs of emergency clinicians in order best advance their patient care skills. We also consider how several factors impact debriefing: (a) learner characteristics (b) types of learning objectives for individuals, teams, and systems-based practice; and (c) issues of context as they relate to debriefing for emergency providers, whether in simulation centers or at the point of care.

Learner Characteristics

When preparing for debriefing, educators should consider who comprises the learner group. Key factors include the participants' level of training, the composition of the team, and their degree of experience with simulation. Undergraduate medical and nursing students, by virtue of their stage in training, likely have less background knowledge and clinical experience to draw upon than postgraduate learners such as residents or practicing healthcare professionals (physicians, nurses, respiratory therapists, etc.). Pre-existing knowledge and previous experience impacts the development of clinical reasoning skills and the mental models used in clinical problem solving [55, 56]. In general, we prefer learner-centered debriefing approaches [57] that take these factors into consideration and promote discussion of issues participants identify.

Irrespective of learner level, educators should explore the underlying rationale for action [12, 28]. Although more experienced clinicians often use pattern recognition and other intuitive processes in their clinical reasoning [58, 59], they can often explain their reasoning behind complex decision-making. Thus, for groups of experienced clinicians, focused facilitation methods will feature prominently in the analysis phase. Junior learners with limited clinical experience, on the other hand, follow ruled-based and analytical strategies [58] before they develop sophisticated cognitive routines. A higher proportion of the debriefing time may therefore need to be spent in an educator-centered approach where directive feedback or teaching is delivered to this learner group, often based on the scenario learning objectives. However, focused facilitation strategies which explore the rationale for their actions such as advocacy-inquiry [12] remain valuable in gaining their perspective and diagnosing learning needs before providing directive feedback or offering teaching points. Knowing that novice learners are less facile with self-assessment [43, 60], educators must balance learners' self-assessment with their own direct observations when deciding how to allocate time in the debriefing. Further, educators should keep in mind that these novice learners, given their analytic decision-making approach, benefit most from facts, rules, and algorithms to guide their future behaviors [58]. Only after learning an algorithm itself can novices then work on refining their application of the algorithm depending on the appropriate situation. In our experience, a shift from learner-centered to more educator–centered approaches occurs during the course of a debriefing based on learners' responses and demonstrated learning needs.

Group composition also influences debriefing decisions. One key consideration is whether the group is composed of more than one profession (i.e. an interprofessional group) versus a homogenous group of learners composed of one profession only (i.e. a group of nurses). When debriefing teams, one must also consider whether the group comprises of a natural clinical team who works together regularly and/or a heterogeneous group that includes individuals with varied clinical expertise and experience. When debriefing inteprofessional groups, it can be helpful to have educators representing the various professions involved to promote discussion by focusing on topics relevant across professional boundaries rather than emphasizing profession-specific topics [61]. For example, imagine a physician and nurse or paramedic debriefing a scenario together. This form of co-debriefing lends itself to debriefings with interprofessional groups. When learning issues arise that apply primarily to one professional group (i.e. programming an intravenous pump for nurses), others may lose interest. Educators can engage the whole group by emphasizing how such issues impact teamwork and communication while at the same time promoting mutual understanding of team member roles. Shared understanding of roles and thought processes across professional boundaries builds better teams and can be viewed as an important learning outcome from interprofessional simulation events. If needed, profession-specific challenges or questions can be addressed after the debriefing to allow for in-depth discussion less applicable to all participants.

Knowing whether team members work together in normal clinical practice also plays a role in how to approach a group—either interprofessional (i.e. physician, nurse, tech) or multi-disciplinary (i.e. emergency medicine, trauma, critical care, anesthesiology). Usually, established clinical teams participate during in situ (in an actual clinical setting at the point of care) simulation, whereas teams form more arbitrarily during a course at a simulation center. The level of familiarity among team members has particular relevance, since teamwork and communication comprise very common topics during healthcare simulation debriefing [62]. Not surprisingly, many teamwork and communication issues apply universally for both established or ad hoc teams. Established teams may have an extensive history of working together and therefore have developed unique communication styles and group norms that may not be obvious to facilitators. Of course, this potential also exists for less effective team processes. In these situations, educators do well to harness their curiosity about an established team's cognitive routines and generalize the discussion to situations encountered in clinical practice. For example, prehospital care providers (e.g. paramedics) or physician-nurse dyads who have worked together for years and have well-established role clarity may not explicitly discuss workload distribution. For these groups who know each other well, we also recommend a more learner-centered approach, exploring their perspectives, discussing best practices, highlighting the advantages and potential pitfalls of implicit assumptions especially in instances when a new member joins their team.

Finally, heterogeneous groups that include individuals with varying degrees of clinical expertise and experience (i.e. junior resident – attending physician – nurse – tech teams) present unique challenges. Those with less experience may feel less confident to speak up or share their thoughts. Debriefers must remain vigilant and invite more junior clinicians to join the discussion as needed. On the other hand, those with significant experience or expertise may manifest two patterns of engagement: (a) partially engaged in simulation training and thus less likely to participate in the discussion, or (b) keen to answer all questions, drive the conversation, and teach other learners. Educators will need a repertoire of approaches to balance the debriefing discussion among learners.

Learning Objectives Inform the Debriefing

Clear learning objectives inform not only simulation scenarios [63] but impact the debriefing. The notion of *performance gaps* is important for individuals and teams: a performance gap represents the difference between desired and actual observed performance. In this setting, these gaps focus on areas that need improvement (but can also represent areas of performance that exceed standards) [17]. A line of questioning in the debriefing that is unrelated to the scenario objectives can emerge from observed gaps in performance. An important tenet about debriefing relates to covering the main case objectives; at the same time, unplanned yet worthwhile discussion may also emerge. Educators should be open to exploring unexpected performance gaps they observe during the simulation or other potential learning points that come up in the debriefing. The balance between having a plan while remaining flexible contributes to the art of debriefing. On the one hand, educators should not get so derailed by learning points or performance gaps identified during the case that they do not debrief the original objectives of the scenario; on the other hand, educators should not adhere to a rigid agenda at the risk of neglecting potentially high-yield topics. To keep the debriefing focused and time-efficient, educators need to prioritize identified performance gaps for discussion that cover original learning objectives. Another important aim of debriefing is to help learners develop self-reflection skills [64]. Reflective practice [52] encompasses both (a) reflection-on-action—which occurs after the event, similar to the debriefing, but in an independent fashion; and (b) reflection-in-action—which occurs in the midst of the situation—during future clinical encounters or activities.

"What to Debrief": Debriefing Issues of Clinical Decision-Making and Problem Solving

Educators should consider performance domains, as they inform debriefing approach. These include:

- Cognitive (e.g. knowledge, clinical decision-making)
- Technical (e.g. procedural skills)
- Behavioral (e.g. teamwork, interprofessional collaboration, leadership, communication, etc.)

During the debriefing, educators should align educational strategy and performance domain of the learning objectives [28]. As a general rule of thumb, cognitive learning objectives related to clinical reasoning or diagnostic decision-making can be explored using focused facilitation methods [28], e.g. advocacy inquiry [12] and alternatives with their pros and cons [35]. As Rudolph and colleagues outline [12], clinical decision-making is influenced by learners' pre-existing frames of mind, or their underlying thought process or ways of thinking that leads learners to perform, or not to perform, certain actions or make certain decisions. Frames of mind can be influenced by a number of factors, including knowledge base, feeling/attitudes, situational awareness, and prior experiences.

Exploring frames of mind represents a fundamental aspect of debriefing. Educators should strive to moderate a discussion that allows learners to share their frames of mind related to specific events during the case, e.g. "I did not speak up about the possible medication error since I was not sure if it was right or not and I did not want to appear like I don't know what I am doing". For cognitive or behavioral learning objectives, simulation educators strive to help learners recognize which cognitive routines or frames of mind are working for them, and which frames of mind might need "reframing" for the future [12, 17], e.g. "I need to speak up even if I am not sure about something especially if patient safety is at risk." For example, in the trauma case vignette, a significant performance gap is that neither mannitol nor hypertonic saline was administered for the patient who had a unilateral blown pupil and other evidence of impending herniation. In the debriefing, the educator might initiate discussion of this topic using advocacy inquiry as follows: "I am interested in exploring how you approached this patient with a severe head injury and signs of increased intracranial pressure (ICP). I did not see the team give osmotic agents. I know that lots of factors play into the decision whether or not to give them. What was your thinking on that?" Any number of reasons could explain why the patient did not receive osmotic agents, all which may be unclear to the educator at the end of the simulation case. Several examples include: (a) the learners did not recognize that the patient was herniating; (b) they did not know the correct medications to use; (c) they were prioritizing other strategies to mitigate increased ICP; or (d) other factors played into the decision-making. Importantly, educators should keep in mind that a perceived inaction may reflect a failure of their own observation during the simulation---the team may actually have given an osmotic agent and the educator simply missed it. During the debriefing process, educators can work to surface the learners' frames of mind or rationale for action (i.e. why they did or did not take action) through genuine curiosity and the use of questions [12]. Once the rationale for action emerges, educators can facilitate a focused discussion with the team of learners to reinforce elements of the performance that worked well and catalyze change for those that need improvement [17].

At times, learners need specific information in the form of directive feedback and teaching to improve [28]. Here, educators could speak from their perspective and share their expertise: "Here are the factors that influence my decision about whether to use osmotic agents….". This brief didactic input from the educator (2–3 minutes maximum) could be followed up with a provocative question or statement to frame a dilemma that the educator has also faced in order to prompt ongoing reflection and discussion.

When exploring issues surrounding clinical decision-making, it can be useful to outline cognitive processes clinicians use to make decisions, namely intuitive vs. analytic decision-making [59]. As we have highlighted, more junior learners tend to be more rule-based or analytic in their approach, thus slower and more deliberate. With increasing experience, clinicians rely on intuitive processes such as pattern recognition which is faster and more efficient, yet prone to cognitive biases or errors [65]. While experienced providers rely on intuitive processes in routine practice, they also recognize deviations in established patterns and then deliberately adopt a slower, more analytic approach that enhances thoroughness and reduces risk of error [58, 66].

During the debriefing, educators collaborate with learners to explore whether their problem solving and clinical reasoning were intuitive vs. analytical processes, or a combination of the two. Particularly for more novice learners who tend to rely on analytical thinking, the simulation and debriefing conversation can highlight features of clinical cases that promote the development of illness scripts [67] or discrete 'packages' of clinical information (e.g. patients with severe head trauma with bradycardia and asymmetric pupils likely need immediate management of increased ICP including intubation, positioning, osmotic agents, and neurosurgical intervention as brain imaging dictates). The development of robust illness scripts helps learners progress on the continuum of novice to expert.

In our trauma vignette, learners did not move to intubate the patient until 10 minutes into the case. To address this issue during the debriefing, the educator might proceed as follows: "When you first encountered this patient, he appeared have altered mental status. I am keen to hear what was going through your mind at that point in the case." The educator may then uncover that the learners have not encountered many patients with altered mental status who require intubation; analytically they were working through a list of differential diagnoses in order to identify the etiology of altered mental status prior to performing intubation. In the debriefing, the educator can then help learners close this performance gap by generalizing the discussion to those situations when patients require emergent airway management as a prerequisite to further diagnostic work-up (e.g. labs and imaging). In addition, discussion and teaching can promote learners' abilities to identify key patterns that allow them to shift from analytical to more intuitive modes of thinking, i.e. the combination altered mental status, a blown pupil, associated with hypertension and bradycardia indicates that a patient with traumatic head injury or intracranial hemorrhage with impending brainstem herniation requires emergent airway management to secure the airway and to treat ICP.

Highlighting the pitfalls of cognitive biases during debriefing—and using normalization as a strategy to emphasize that these are common—can be a particularly powerful strategy to promote metacognitive skills [68, 69]. Ultimately, the desired transfer to clinical practice is for learners to engage in reflection-in-action, i.e. pressing pause and switching from intuitive to analytic processes in order to avoid cognitive errors [70]. Emergency medicine clinicians are prone to a number of cognitive errors since they must make efficient decisions at times based on limited information. These cognitive errors include premature closure, anchoring bias, search satisfying, and confirmation bias; see Croskerry for an overview [68]. By exploring, discussing, and labeling certain types of cognitive errors, learners may be more likely to appreciate these phenomena during their clinical practice. Better understanding these errors help learners anticipate and identify them when they occur and minimize them through cognitive forcing [71, 72] or debiasing strategies [69]. A concrete strategy would be to use simulation events to practice actively avoiding errors of premature closure and fixation through workplace practices such as shared team reflection [73] (i.e. summarizing events), inviting team members for input by asking "Are we missing something?". For example, during the debriefing of the trauma vignette, learners may share that they stopped working through other differential diagnoses when the patient's passive breathalyzer value was elevated. At this point, educators might facilitate an enlightening discussion about premature closure, manifested by the thinking that the patient was "only inebriated" and leading to a missed diagnosis. Simulation and debriefings can also highlight that diagnostic decision-making and treatment decisions reside not within a single person or profession, but emerge from shared understanding and mental models [73–75]. During debriefing, decision-making can be viewed as a team sport.

"What to Debrief": Debriefing Issues of Teamwork and Communication

When dealing with behavioral objectives, focused facilitation approaches also help discover learner's rationales for action [12, 28]. Behavioral objectives are frequently multifaceted and nuanced issues; the underlying rationale for action is essential in order to understand the learner's performance. Teamwork and communication are exceedingly important in all aspects of medicine, particularly emergency medicine. Regardless of the local team training or crisis resource management frameworks utilized, the underlying principles for teamwork and communication are similar. Linking the debriefing discussion to local team training practices and principles can provide valuable context (see Chap. 5 for an overview). In the trauma scenario, the lack of closed loop communication might have led to confusion about when certain medications had been given. As some learners may not be as familiar with these specific team training concepts, educators need to identify key behaviors (presence or absence thereof), describe and name these behaviors, discuss the behaviors' benefits, and when they should be used in clinical practice. In debriefing the trauma case, educators might frame the discussion by noting, "I would like to spend a few minutes talking about the communication surrounding the medications before the intubation. It seemed like there was some confusion at times about what medications had or had not been given, which I think has the potential for medical error. How did you experience that?". Ideally this line of questioning affords an opportunity to label and define closed loop communication, often after learners have explored their concrete experience during the case. The educator could then facilitate further discussion to generalize concepts of closed loop communication, through group discussion and problem solving, as a way to improve future communication. Instances of effective leadership, communication, and teamwork strategies deserve exploration as well in order to reinforce these positive behaviors.

We prefer interprofessional co-debriefing for running interprofessional education (IPE) simulation sessions that include learners from multiple professions, such as resident physicians and nurses [61]. While using a similar overall debriefing structure, it can be helpful to have both a physician lead and a nurse lead in the debriefing working together in a collaborative and respectful fashion. When facilitating a co-debriefing, it is important to establish a game-plan with ground rules between the co-debriefers ahead of time. Such ground rules might include: (a) having a plan for sharing 'lead time' and contributions in the debriefing; (b) agreeing to avoid interjecting during the other person's lead time without first touching base to "add something"; (c) sitting in positions where both debriefers can make eye contact and use nonverbal cues with each other; (d) planning for other ways to structure the debriefing and transition the lead role back and forth in a smooth and collaborative manner through explicit open negotiation [61]. A brief "huddle" before the debriefing helps ensure that both debriefers are on the same page after watching the scenario and can prevent issues from arising during the debriefing. Options for this huddle include: (a) on the walk from the control room to the debriefing room, thus preventing learners from venting independently before the debrief, or (b) run the scenario in a steady state for an extra 1–2 minutes at the end of the case, during which learners have already made significant decisions, in order to allow the debriefers a minute or two to collaborate on their debriefing plan. A few other tips for running a successful IPE debriefing are (a) having the learners sit interspersed with each other (i.e. don't let all of the physician learners sit together on one side and all of the nurse learners sit together on the other side), and (b) avoid phrases like "from a physician perspective" since this invites only one professional group to comment. Nurses may then feel they are not able to comment on the medical management on which they may have valuable perspectives.

"What to Debrief": Debriefing in Procedural Skill Training

Procedural skills are viewed in relation to individual learners, although many procedural skills also require elements of effective teamwork and communication. A key issue when incorporating procedural skills into simulation scenarios is whether performance of the procedural skills will be embedded within a complex scenario using mannequin-based simulation or practiced separately on partial task trainers. With procedural skills nested within complex scenarios, the debriefing varies based on scenario objectives. For example, in a "can't intubate, can't ventilate" scenario, the learning objectives may be in the cognitive domain and related to the decision-making leading to a cricothyrotomy rather than the actual procedure itself. In this instance, the debriefer would spend time exploring the mental models surrounding airway management and much less time discussing the cricothyrotomy technique unless suboptimal performance of the procedure warrants further discussion and teaching. However, if the case objectives relate to performing a cricothyrotomy using correct technique, then more debriefing time will focus on the procedural skill. For example, a robust curricula designed for procedural skill training decreased central line-associated bloodstream infections (CLABSI) using mastery learning and deliberate practice [76]. This research program demonstrates that deliberate practice for central venous catheter insertion benefits both learners *and* patients [77, 78]. Similarly, Hunt et al.'s RCDP approach treats adherence to advanced life support algorithms as a procedural skill [51]. These approaches highlight how to promote skill acquisition by providing specific feedback on challenging aspects of the task coupled with repetitive practice while working toward well-defined performance standards [79].

"What to Debrief": System-Based Processes

System-based processes are an increasingly important component of successful emergency departments, and can also be practiced, trained and debriefed using simulation [80–83]. Simulation scenarios can address system issues in a number of ways [84, 85]. For example, scenarios can be developed for providers to practice using a new piece of equipment, to test a process employed in the ED (i.e. decontaminating a patient with organophosphate toxicity), or to test an overall process that involves other areas of the hospital (i.e. a patient with an acute myocardial infarction requiring activation of and transfer to the cardiac catheterization lab). As another example, ineffective handoffs can compromise patient safety through loss of critical information during transitions of care [86]. Many individuals and institutions seek solutions to these problems, which may include standardizing the handoff process [87]. Simulation can be a useful venue to test or practice a chosen handoff method. Having your learners give or receive a handoff during the simulation and incorporating discussion of this into the debriefing can meet important educational objectives. When debriefing system-based processes including handoffs, the same overall debriefing structure is used as discussed previously, but one focus of debriefing is improving the system. By using systems-based simulations, we can generate many quality improvement (QI) ideas, identify latent errors and patient safety threats [80, 83], and develop methods for troubleshooting future issues in the clinical arena [82].

In addition to center-based simulation, in-situ simulation offers additional opportunities as well as challenges. Among the opportunities are the ability to train in actual clinical environments and integrate elements of systems-based practice and systems testing [84]. Additionally, in-situ simulation also allows participants to identify systems issues that could impact actual patient care (e.g. logistics of where medications or equipment is stored). Simulation facilitators should have a mechanism for documenting these issues to ensure that personnel in the involved clinical areas address these latent safety threats before patient harm occurs. In-situ simulations present challenges such as finding space and time for the scenarios to occur. This is particularly true in busy emergency departments. Similarly, finding physical and temporal space for debriefing can present a challenge since the clinical area is not ideal for in-depth conversations and reflection. In-situ facilitators should expect and plan for interruptions by actual patient care emergencies, as when participants are called away in the middle of a scenario or debriefing. In addition, cross contamination of simulation equipment with real patient care supplies represents a real risk [85]. Strict policies will help prevent this potentially harmful intermingling of supplies.

Caring for multiple patients simultaneously is another aspect in EM that could be emphasized and discussed within the context of simulation and debriefing. Designing, running and debriefing multi-patient simulation cases for EM providers will help trainees and providers learn and refine the skills needed to carry out this task in the ED. When debriefing a multi-patient simulation session with 2–3 patients, debriefers should explore thought processes surrounding each simulated patient in addition to the overall coordination of care and resources. However, when debriefing a simulation session with many patients, such as a mass casualty scenario, more debriefing time will need to be spent discussing (a) recruitment, allocation and coordination of resources, (b) prioritization of patients, tasks and next steps, (c) overall communication and teamwork both regarding the immediate ED team as well as the extended team of providers who may not yet be present, and (d) situational awareness of the entire environment. Depending on the amount of time available for the debriefing, aspects of individual patient management could be discussed, especially if themes are identified regarding aspects of care that were not adequately addressed on multiple patients within the scenario.

Simulation Modality Impacts Debriefing

Simulation modalities run the gamut from relatively simple low-fidelity task trainers to more complex systems such as high-fidelity mannequins, standardized or simulated patients, and hybrid simulations which combine two or more elements, e.g. mannequins and simulated patients. The intricacies of modalities are covered elsewhere in this book; however, two points highlight how a simulation modality may impact debriefing. First, embedded simulated persons (ESP) or standardized participants prepared to portray caregivers or other healthcare providers [88–91] can serve several valuable purposes. For example, in pediatric emergency scenarios, simulated parents can give essential information in terms of history needed to manage the case as well as relaying important physical findings (e.g. "his face is pale", "his feet are cool", or "she is so sleepy", or "she is so pale") that are not possible to assess on a simulation mannequin.

Second, simulation scenarios may include communication with the ESP as a primary objective of the scenario, such as dealing with situations that require an apology and disclosure [92], or even repairing a laceration while interacting with the patient [93]. With preparation [88, 94], an ESP can participate in the debriefing, offering learners invaluable insights and critical performance feedback on the content and process of patient/family-centered communication. If simulated parents/caregivers/healthcare providers participate in the debriefing, they should be coached to share their points of view in the debriefing from the first person perspective [88], keeping in mind that the actual simulation is over and feedback to the learners' should not include any added emotion that was portrayed during the scenario.

Summary

We have explored various aspects of healthcare simulation debriefing, including specific elements with specific relevance for emergency care settings. The overall debriefing structure should generally include reaction, description, analysis and summary phases, with a focus on the analysis phase. However, the specific framework and approach can vary, and should be informed by participant group, learning needs, and predetermined learning objectives while leaving space to explore unplanned yet fruitful debriefing points. The discussion should also highlight the unique features of emergency settings, including individual cognitive demands, unique logistic factors, and the interprofessional and multidisciplinary nature of ED team-based care. One size does not fit all, and debriefing various components of any one simulation scenario are not mutually exclusive, as educators may debrief some individual thought processes, some teamwork, and some systems issues, all in one debriefing session. Debriefing is an essential element of healthcare simulation and we hope the information provided here assists educators in developing and implementing an informed strategy.

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Crisis Resource Management

5

Martin A. Reznek, Charles Lei, Michael D. Yashar, and Rebecca Smith-Coggins

Introduction

The work environment in emergency medicine (EM) is one that is prone to crises where demands outstrip resources. In order to effectively and efficiently manage crises in the emergency department (ED), health care professionals must execute highly organized, team-based approaches to care. A team has been defined as "two or more individuals with specialized knowledge and skills who perform specific roles and complete interdependent tasks to achieve a common goal or outcome" [1], and teamwork has been defined as "a collection of behaviors and attitudes that promotes efficient processing of information and ultimately leads to timely and proper actions carried out by various team members" [2]. In order for the ED team to function optimally as a unit, training as a unit is likely to be beneficial. This is supported by research by Salas et al. from which the authors conclude that team training "is a viable instructional strategy for optimizing teamwork in healthcare settings" [3].

Similar crisis-prone work environments exist in anesthesia and aviation. A number of teamwork training strategies exist, however crisis resource management (CRM) is well accepted in these fields as an effective team-based approach for averting and managing crises. In fact, CRM principles may be even more important for EM given the particularly chaotic environment of the ED and the relatively high number of individuals with differing special skills functioning together at one time.

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History of Crisis Resource Management

Aviation

Crisis resource management is a relatively recent term in healthcare, but it has a long history in the aviation industry. Originally called Cockpit Resource Management, the concept was developed to address safety issues related to the "application of human factors in the aviation system" [4, 5]. Following the introduction of more reliable turbojet airliners between 1960 and 1980, the National Transportation Safety Board found that flight crew errors led to more than 70% of aviation accidents, eclipsing intrinsic aircraft, maintenance, or weather related causes [4]. Deeper investigations of crew operations and "pilot error" by NASA found that accidents and incidents were more likely to be due to failures in team communication and coordination than in the more technically focused and traditionally emphasized "stick and rudder" proficiency [4, 6]. Specifically, common error domains included "deficiencies in communication, workload management, delegation of tasks, situational awareness, leadership, and the appropriate use of resources." As a result, NASA provided an open forum in 1979 for government representatives and experts in aircrew operations and training from major airlines to discuss their research and training programs [7]. Shortly thereafter, United Airlines introduced the first comprehensive and iterative resource management training program [6]. With time, there was a shift in concept to the team-based approach, leading to a change in name from Cockpit to Crew Resource Management.

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Anesthesia

CRM was first adopted by Gaba and his colleagues in anesthesiology at Stanford University in the late 1980s [8]. Dr. Gaba and others recognized parallels between aviation and anesthesia, noting that dynamic decision-making, interpersonal behavior, and team management were important to overall safety [8, 9]. Gaba, et al. found that during a standardized multi-event scenario, errors most frequently were related to human factors such as fixation errors rather than equipment failure [8]. It was recognized that, similar to aviation, traditional training in anesthesia focused on the technical aspects of patient management, and not on the behavioral aspects of crisis management. To address this, Gaba, Howard, and colleagues developed and implemented the first Anesthesia Crisis Resource Management (ACRM) course in 1990 which was centered on adult learning theory and the tenets of crisis management [10]. ACRM has been well-received by anesthesia [11, 12], and more recently, CRM-type curricula have been implemented in other medical specialties as well as in nursing, dentistry, pharmacy, and other allied health professions [8].

Crisis Resource Management in Emergency Medicine

Following the success of crisis resource management programs in aviation and anesthesia, several high-risk medical specialties, including EM, began to evaluate the potential impact of CRM training on medical team performance. In the 1990s, the US Department of Defense developed the MedTeams program with the goal of introducing formal teamwork training to emergency medicine. A retrospective review of ED risk management cases found that 43% of the errors were due to teamwork failures, and over half of the deaths and permanent disabilities were judged to be avoidable with appropriate teamwork [13]. In the prospective phase of the project, researchers adapted aviation CRM training concepts to the ED environment and developed a didactic curriculum known as the Emergency Team Coordination Course (ETCC). EDs that completed the ETCC and implemented formal teamwork structure and process had statistically significant improvements in the quality of team behaviors and reductions in observable errors [14].

Recognizing the potential benefits of teamwork training in EM, several groups introduced simulation training into their CRM courses and studied the effects on medical team performance. In 2003, Reznek and colleagues developed a simulation-based CRM course for EM residents (EMCRM), using ACRM as a template and adding principles unique to EM [15]. In this pilot course, residents participated in a didactic training session that introduced key crisis management behaviors of EMCRM and then practiced implementing these principles in high-fidelity simulation-based scenarios. The participants rated EMCRM very favorably and believed that the crisis management skills gained would be beneficial in their practices.

In 2008, Hicks and colleagues conducted a needs assessment to identify specific cognitive and teamwork skills important for a successful ED resuscitation [16]. Their results validated the use of ACRM principles in EM team training and highlighted the importance of including unique elements of ED crisis management, such as interdisciplinary communication, triage and prioritization, and the management of multiple patients. They developed and implemented a simulation-based CRM curriculum for EM trainees in Canada resulting in non-statistically significant trends toward improved team-based attitudes and improved performance of non-technical skills [17].

While EM educators and trainees exposed to CRM have embraced it as an important educational tool for optimizing teamwork, the connection between CRM training and improved patient outcomes in EM has not been proven. Demonstrating correlation or even causality of adverse event reduction due to CRM would be difficult, if not impossible, in EM. It would likely require large, complex multi-center coordination to capture sufficient adverse event data and therefore is probably not feasible. The aviation industry faces similar research difficulties, and there is no definitive evidence proving that CRM saves lives or aircraft [9]. Nonetheless, CRM, is federally mandated in aviation based on face validity and expert consensus. Given that anesthesia and aviation, both with extensive experience in CRM, support it as a best practice, it stands to reason that CRM should be emphasized similarly in EM training given our similar work environments and teamwork challenges.

Key Principles in Emergency Medicine

The primary purpose of utilizing CRM in EM is to prevent adverse patient outcomes which generally do not result from single, discrete events but rather result from multifactorial and often complex combinations of latent factors, systems failures and human actions or inactions. Reason described a model of "accident causation" in his text, Human Error [18]. The general idea of this model is that there are weaknesses in every step of accident prevention, similar to the holes in Swiss cheese slices [19]. Without proper prevention, a unique set of cheese slices may line up in such a fashion as to allow a straight trajectory of an accident progression to pass through a hole in each of the preventative measures and ultimately lead to an adverse outcome. While the inevitability of weaknesses of preventative measures (or holes in the cheese slices) may seem daunting at first, the optimistic implication of the model is that there are multiple opportunities to intervene within a potential adverse event progression to prevent harm from ultimately coming to a patient.

ED crisis resource management focuses primarily on the period of time that bedside providers can intervene effectively in the progression of an adverse event. The key principles taught in CRM are designed to: (1) facilitate earlier detection of adverse outcome progressions and (2) empower bedside providers to intervene more effectively when progressions are identified.

Crisis management principles include systems-based strategies as well as individual strategies. While it would be ideal to prevent every adverse event with system fixes, the reality is that flaws remain in our current system of healthcare delivery and humans often must intervene [20]. Sound medical knowledge is necessary but not sufficient for providers to be effective in preventing adverse events. Providers must also be adept in crisis management behaviors, as listed in Table 5.1.

Table 5.1 Key crisis management behaviors in emergency medicine

Anticipation and planning
Become familiar with the location and operation of ED equipment.
Identify the strengths and vulnerabilities of the work environment.
Establish roles of team members
Establish department- and institution-wide disaster plans.
Communication
Deliver clear, direct, and respectful communication.
Close the loop: obtain confirmation that the message was received and understood.
Encourage the open exchange of information between team members.
Leadership
Establish clear leadership.
Balance confidence and humility.
Think globally about the "big picture."
Empower team members to speak up.
Awareness and utilization of all available resources
Activate all helpful resources including additional personnel and equipment.
Recognize the usefulness and limitations of each resource.
Utilize cognitive aids.
Distribution of workload and mobilization of help
Call for help early. More help is better than less help.
Assign specific tasks to team members based on their abilities.
Continually reassess the workload of team members and redistribute responsibilities if there is task overload or inability to complete a task.
Routine re-evaluation of situation
Re-evaluate the situation after each intervention to determine if further actions are needed.
Remain flexible and adapt to novel and dynamic situations.
Awareness and utilization of all available information
Monitor and utilize multiple sources of information.
Verify the accuracy of the information before acting on it.
Triage and prioritization
Assess and prioritize the criticality of each task.
Employ pre-determined triage protocols.
Efficient management of multiple patients
Maintain situational awareness.
Form specialized teams to manage each patient or set of patients.
Effective coping with disruptions and distractions
Avoid getting fixated on non-urgent distractions.
Designate one or more team members to monitor for, avoid, and manage disruptions and distractions.
Monitor for task saturation.

Anticipation and Planning

In EM, we pride ourselves in being able to handle "anything that comes through the door" with our broad knowledge of disease states and injuries. In that regard, we anticipate and plan well, but our formal training does not prepare us as well for non-clinical issues. For example, what do you do if there is a power failure in your ED? What should be the priorities for your team? What equipment has back up batteries? Will the ventilators need to be reset or even work at all? The "what if" list is long.

The culture of planning in EDs appears to be improving perhaps as a result of recent large-scale terrorist and weather related catastrophes. In fact, disaster plans are now mandated by hospital accrediting bodies [21]. However, continued work on institutional and individual advanced planning is essential to prevent patient harm. Anticipation and planning techniques range from those as simple as being familiar with ED equipment to establishing institution-wide disaster plans.

Communication

Communication is critical to the success of any team. Messages must be delivered and received without losing information. Communication should be **clear**. In other words, messaging should include all the pertinent information, but nothing additional. Verbal communication should be loud enough to be heard by all intended recipients, but not so loud as to be disruptive. It also should be fast enough so it does not delay other activities, but not so fast that it is not easily understood. Communication should be **direct**. Ideally, the communicator should look directly at the intended recipient and address them by name and/or title. Communication should be **respectful**. Disrespectful communication can serve as a distractor, and it also may erode future team interactions. Finally and perhaps the most important, effective communication should include mechanisms for **loop closure**. Recipients of communication should repeat back to the sender what they understood to ensure that the proper message was received [22].

Leadership

Effective teams require effective leadership. While there are a number of specific leadership tasks that are essential in crisis management (discussed in subsequent sections), this section focuses on global qualities that leaders should exhibit to be effective crisis managers. First, a leader should **balance confidence and humility** so that they are able to make calm and timely decisions while recognizing their team's and their own limitations. A leader should not only be **open to feedback** but should actively solicit it. A leader should **think globally** about the "big picture" and avoid fixating on isolated details. A leader should be **adaptive** so that they can manage novel and dynamic situations. Finally, a leader should be **adept at prioritization**.

It deserves mention that an effective leader requires an effective team. Effective "followership" may be as essential as leadership, although it often gets less attention. Effective team members should be keenly **aware of their role** within the team. This may come from preparation or may be facilitated during a crisis by the leader. Team members should **recognize their skill sets** and be willing to communicate if they are being asked to perform duties above their skill sets (or below, if their expertise may be better used to help the team during a crisis). Team members should **focus** on their assigned task(s) but also **constantly survey** to ensure that changes related to their task(s) or the global crisis are communicated to the leader and other team members. Team members should feel **empowered to speak up** with information that they feel is possibly pertinent to averting a crisis progression [22].

Awareness and Utilization of all Available Resources

Resources for the effective management of an ED crisis are plentiful, but the team must be aware of those resources. Resources can be divided into five general categories: personnel, equipment, pre-planned procedures, cognitive aids, and oneself. ED equipment and usual staff (nurses, ancillary staff and other ED providers) are generally apparent, but identifying non-traditional resources may require resourcefulness. For example, it may be uncommon practice at a particular institution for a provider in the ICU to come to the ED, but in a true crisis, the extra expertise and set of specialized hands may be a key factor in best managing such a situation. Being aware of all the resources both within the ED and the institution (as well as the community-at-large for large-scale crises) is essential. In addition, it is important to understand the usefulness and limitations of each of those resources.

Often people may not consider themselves as a resource. Just like the four other resource types, it is essential for one to be aware of one's own "usefulness and limitations." One's own knowledge and skills are perhaps the most valuable assets during a crisis, but they do have limitations. Human performance in a crisis may be hindered by physical limitations such as fatigue or psychological limitations such as arrogance or insecurity. In addition, humans are limited by how many items to which they can pay attention effectively at one time [22].

Distribution of Workload and Mobilization of Help

During a crisis, work should be distributed to all available team members. Ideally, a significant portion of role and task distribution may be predetermined. Well run trauma teams are a classic example of role pre-planning; each member has a specific role assigned prior to the arrival of the patient. However, in the heat of a true crisis, pre-planning may not be sufficient. During a crisis, the team leader should continually reassess the workload of team members to ensure that none are overloaded in volume of work or performing tasks beyond their skill set. If it becomes apparent that the team is limited in knowledge-base, skills or man-power, the leader should enlist help early from outside sources.

Routine Re-evaluation of the Situation

Continual re-evaluation of the situation is essential during a crisis. Team members and especially the team leader should reassess the patient both on a regular basis, as well as after every intervention. W. Edwards Demming, considered by many to be the father of modern quality control, espoused the **"plan, do, study, act"** cycle for quality improvement [23]. This cycle is also valuable during crisis management since one must quickly devise and implement a plan to thwart the crisis. Soon after each intervention, it is essential to re-evaluate the situation to determine if further actions are necessary.

Awareness and Utilization of All Available Information

In evaluation and re-evaluation of a patient, there are multiple sources of subjective information including feedback from co-workers, patients, and family members, in addition to objective information such as vital signs or lab values.

During a crisis, it is important to assess data quickly and verify that they are correct before acting on them. The balance of speed of decision-making and depth of verification will depend on the unique requirements of the crisis and the importance of each piece of information.

Triage and Prioritization

While caring for multiple acutely ill patients is not unique to emergency medicine, it is a common occurrence for the specialty. Numerous triage protocols have been developed for mass casualty incidents [24]. Pre-planning is essential to ensure that all team members are aware of these procedures and have access to cognitive aids. Single patient crises may have numerous tasks that require prioritization. Quickly assessing the criticality of each task and prioritizing them is essential.

Efficient Management of Multiple Patients

In the case of crises involving multiple patients, crisis management behaviors become more complicated and difficult. Ensuring effective communication and situational awareness becomes even more important to avert adverse events. The principles remain the same with the possible added need for forming and coordinating multiple teams to manage the crisis.

Effective Coping with Disruptions and Distractions

Managing distractions during a crisis is essential. Non-urgent distractions should be minimized. A quick and accurate assessment should be made regarding the urgency of the distraction to determine if attention to it can be safely delayed or delegated. In the case of distractions originating from people, the goal is to quickly avert the distraction, and above all, avoid escalation. Whenever safely possible, care should be taken to ensure that individuals involved in the distraction understand that the team is aware of their concerns and needs, and that the team's assessment is that the situation at hand must take priority. In addition, those involved should be reassured that attention will be paid to their concerns and needs in a timely fashion following the crisis. If a brief intervention in a human driven distraction is insufficient or the crisis dictates that no attention can be paid to it safely, the team should be aware of other resources that can assist in de-escalation. Ideally, but only as safety permits, a record of concerns and needs arising outside of the crisis itself should be kept so that the loop can later be closed on each.

Curriculum Development – Practical Considerations

Needs Assessment

Crisis resource management provides a framework for teams to perform optimally during crisis situations. Although recurring themes can be identified in CRM programs across various industries, specialties and institutions, there is no universal list of CRM principles. Even in aviation, where CRM was initially described, the training of flight crews varies from airline to airline. One size does not fit all. In developing a CRM curriculum, individual training programs may choose to emphasize certain CRM principles over others. Additionally, the scope of a CRM course may be influenced by financial or institutional constraints, such as the availability of funding, simulation space, and faculty. Thus, before designing a CRM curriculum, it is essential to first perform a needs assessment to highlight the most critical teamwork and crisis management competencies for a particular learner population and practice environment [25].

The needs assessment should identify and characterize the problems that need to be addressed, which helps to focus a curriculum's goals and objectives. This can be accomplished by reviewing and understanding the contributing factors to critical events and near misses in the ED. For instance, an in-depth analysis of several trauma cases that resulted in suboptimal outcomes might reveal that there was no identifiable resuscitation leader and that members of the trauma and ED teams were interrupting each other and placing contradictory verbal orders. In this example, it is clear that a CRM course at this institution should provide training on effective team leadership and communication.

Emergency care providers interact with many other clinical specialties, often at times when effective team behavior is vital to patient safety and survival. As such, EM is uniquely positioned to take advantage of multi-disciplinary CRM training opportunities. A multi-disciplinary and interprofessional approach to teamwork training provides learners with the richest and most realistic simulation experience possible and offers valuable insight into the individual biases and mindsets that prevent effective teamwork. The composition of the learner population of a CRM course should reflect the makeup of the real-life ED resuscitation team as much as possible. Using the above example, the targeted learners should ideally include EM physicians, trauma surgeons, as well as ED nurses and ancillary staff.

Incorporating CRM into Scenario Design

After the needs of the learners have been made clear, a curriculum that systematically addresses each of the targeted CRM principles should be created. It may be tempting to develop scenarios that test many CRM competencies at once, especially if the time and resources for simulation training are limited. However, teamwork is a dynamic process involving the coordinated interactions of multiple individuals and the implementation of numerous skills and behaviors. It is too complex to train the full spectrum of teamwork competencies in any one scenario. Instead, specific scenarios should be designed to address specific CRM principles. By focusing on a defined subset of CRM concepts, instructors can shape a scenario to maximize learning and convey a clear message to trainees about optimizing these team performance behaviors. Because the scope of any one scenario is limited, a set of scenarios should be developed in order to effectively train the entire set of targeted CRM principles [26]. We describe steps to creating these scenarios and provide some examples below.

The next step in CRM curriculum development is to define specific and measurable learning objectives for each of the targeted teamwork competencies. The development and prioritization of specific learning objectives allow for further refinement of the curricular content and guide the construction of the simulation scenarios. Learning objectives should clearly communicate to others, such as trainees, instructors, program directors, and department chairs, what the curriculum addresses and hopes to achieve. Learning objectives also provide the framework for debriefing and feedback, and should therefore be measurable to enable the assessment of the targeted learners. Measurability also allows course faculty to demonstrate the effectiveness of the curriculum and to continually improve the curriculum to meet the intended educational goals [25].

In simulation-based education, the events of the scenario serve as the content of the training. Trigger or critical events should be embedded throughout the scenario to provide learners with structured opportunities to practice and demonstrate specific teamwork and crisis management skills. These trigger events are predefined changes in the trajectory of the scenario (such as an alteration in the physiology of the simulated patient, a change in the performance of a standardized participant, or the arrival of new clinical information) that are designed to elicit a set of targeted responses or critical actions. The critical actions should be objective, measurable, and linked to the predetermined learning objectives of the scenario. The ability or failure to perform the expected critical actions indicates whether the learners possess the targeted CRM skills [26].

When crafting a simulation scenario that trains CRM competencies, one should construct a case in which the medical management is challenging but not mysterious. If the medical aspects of the case are too complex, learners will spend valuable course time reviewing their medical decision-making rather than focusing on how they can function as an effective team. The tendency to train both teamwork and task skills in the same training session should be avoided. The most effective CRM courses provide learners with the opportunity to practice teamwork competencies rather than teaching new clinical or technical skills [27].

CRM training requires a time investment from both learners and educators. Most team training courses start with a didactic session that reviews the principles of crisis management, followed by a series of simulation sessions that allow the learners to develop and implement these cognitive and behavioral skills in a setting that is similar to their work environment. Effective teamwork training cannot be accomplished in a single session or simulation exercise; it requires a continuous cycle of practice, evaluation, and refinement.

Anticipation and Planning

Built-in "down time" before the arrival or clinical deterioration of a simulated patient provides trainees with the opportunity to explicitly practice their anticipation and planning skills. For instance, at the start of a trauma scenario, paramedics can call the ED to report that they are en route with a critically injured victim, with an estimated time of arrival of 10 minutes. This waiting period enables the team to designate specific roles, prepare for resuscitative interventions (such as airway management, chest tube placement, and rapid blood transfusion), and call for additional resources (such as a radiology technician and trauma surgeon). Standardized participants can help to reinforce the importance of establishing a plan during a crisis situation. Before an intubation, an actor playing the role of the supervising physician might ask the resident to verbalize his airway management strategy, including his plan for an unsuccessful first attempt, second attempt, and so on. Alternatively, an unforeseen error during a scenario (such as oxygen tubing not connected to the oxygen source) can be left uncorrected to help learners appreciate the consequences of failing to anticipate and plan (such as increasing hypoxemia).

Communication

Before the start of a simulation session, instructors should review the elements of effective team communication (clear, direct, and respectful with mechanisms for loop closure). Learners should also be reminded and encouraged to practice "thinking out loud." This involves clearly and directly verbalizing team priorities, management goals, and clinical observations. Distractors, such as ambient noise, frequent interruptions, and disrespectful team members, can be embedded throughout a scenario to assess the team's ability to maintain effective lines of communication. Commonly encountered examples of ineffective communication include statements such as "someone should be calling the radiology technician" and "let's give a liter of normal saline." To illustrate the potential consequences of these vague commands, two nurse standardized participants can respond by either duplicating the tasks or not performing the tasks at all, with each nurse assuming that the other is responsible.

Leadership

Simulated crisis situations provide excellent opportunities to train and assess leadership behaviors. High complexity medical cases with dynamic needs challenge the leader-in-training to orchestrate a multidisciplinary team, adjust to shifting priorities, and maintain a grasp of the "big picture." Carefully designed trigger events can be used to explore a number of interesting questions related to leadership. If it is determined that the leader is the only individual with the skill set to perform a necessary procedure (such as endotracheal intubation), should they then hand off the leadership role to another team member? How well does the leader handle input from other team members regarding patient management? Do they actively solicit feedback? If the patient's clinical status continues to worsen despite their efforts, does the leader have the humility to recognize their limitations and ask for help? As more personnel arrive to assist with the resuscitation, how does the leader utilize these individuals? If the leader is adequately coordinating the resuscitation, how do they respond when a more senior physician arrives and attempts to take over the leadership role?

Awareness and Utilization of All Available Resources

Before the start of each scenario, provide learners with information regarding the availability of personnel and equipment in the simulation environment. An ED that is part of a Level 1 trauma center and that has access to a catheterization lab has very different medical capabilities than one that is located in a small, rural hospital where the emergency physician is the only in-house physician. Encourage learners to carry and utilize their cognitive aids (including pocket cards, handbooks, and smartphones) during simulation training. Stock the simulation environment with the same cognitive aids that are available in the real-life ED, such as ACLS cards, the Broselow tape, and any institution-specific emergency manuals. Throughout the course of training, offer learners ample opportunities to experience both the usefulness and the limitations of different hospital resources and cognitive aids.

Distribution of Workload and Mobilization of Help

Scenarios that call for the simultaneous completion of multiple tasks provide learners with the opportunity to practice distributing the workload and mobilizing additional resources during crisis situations (such as the patient in cardiac arrest who requires chest compressions, airway management, and vascular access). Standardized participants can help to reinforce the importance of continuously reassessing the effectiveness of each team member. For example, an actor playing the role of an ED technician might gradually perform slower and shallower chest compressions as he becomes fatigued. This trigger event should prompt the learners to redistribute the workload and replace the technician with another team member. Over the course of simulation training, learners should be assigned to cross-fill the roles of physician, nurse, technician, pharmacist, and so on. This provides the trainees with insight into the strengths as well as the workload limitations of each member of the ED resuscitation team.

Routine Re-evaluation of Situation

Sudden, unanticipated deteriorations in the status of a simulated patient can be used to assess whether learners are performing routine patient re-evaluation. These changes can be predetermined to occur during a vulnerable period in the patient's ED course (for instance, in the radiology lab, during a procedure such as a laceration repair, or while the telemetry monitor is disconnected or not functioning) and can be left unnoticed by "unsuspecting" standardized participants. The patient would continue to worsen until the learners recognize the change in condition and initiate the appropriate interventions.

Awareness and Utilization of All Available Information

Simulated patients who are confused, unresponsive, or otherwise unable to provide reliable information offer trainees the opportunity to practice collecting and synthesizing data from other sources, such as paramedics, relatives, companions, and witnesses. Simulation scenarios also allow instructors to "plant" erroneous information to train learners to crosscheck data streams, identify mistakes and inaccuracies, and prevent adverse outcomes. For instance, the sudden loss of cardiac activity on the telemetry monitor due to disconnected leads might prompt one team to immediately start chest compressions, while triggering a different team to recognize that the patient is still awake and to first check for a pulse. The addition of these critical events to scenarios helps to reinforce the importance of constantly gathering and verifying the validity of information to avoid fixation errors and improve patient safety.

Triage and Prioritization

Simulated mass casualty incidents with multiple critically ill patients allow learners to practice triage and prioritization skills, utilizing already well-established triage protocols. These concepts can also be trained and assessed in a single-patient scenario. For example, in a high-complexity case, resident trainees might order a wide array of diagnostic studies and therapies. These simultaneous orders can easily overwhelm the capabilities of the nurse standardized participant, just as they would in a real-life situation. The nurse can ask the learners to prioritize their orders, which should prompt them to consider the relative importance of each of their interventions and to recognize the need to mobilize additional resources.

Efficient Management of Multiple Patients

Multiple-patient scenarios are excellent for challenging learners to optimize their implementation of the full spectrum of CRM principles. When designing these scenarios, it is important to avoid overwhelming the capacity of the medical team to the extent that the team structure disintegrates and each learner is functioning independently without interacting with other team members. This would prevent the learners from practicing important CRM behaviors such as leadership, communication, and workload distribution. One strategy is to introduce patients into the scenario in a staggered fashion to provide trainees with the time to evaluate each patient, make triage decisions, call for help, assign roles, and perform routine reassessments of the situation.

Effective Coping with Disruptions and Distractions

A wide variety of distractions can be embedded within a scenario to simulate the chaotic ED work environment. Human distractors, such as intoxicated patients, grieving relatives, and disruptive consultants, provide learners with the opportunity to practice de-escalation techniques and to practice leveraging potentially useful skills of non-clinical ED staff (including guest services, social workers, and security staff). Other distractors, such as the loss of electrical power, challenge learners to maintain effective teamwork behaviors and mitigate medical errors.

Debriefing

Debriefing is an essential component of simulation-based CRM training (see Chap. 4 for additional information on Debriefing). While some learning takes place during a scenario, significant additional learning and reinforcement occur when the case is discussed in detail. Debriefing should immediately follow each simulation scenario. Effective debriefing of teamwork competencies requires adequate time. As a general rule, the time allocated to debriefing should at least be equal to, and ideally greater than, the time taken for the scenario.

The role of the debriefer is to facilitate the discussion and to direct the flow of discussion topics. The debriefing should be structured to minimize discussions of task work and focus instead on team behaviors. Whenever possible, the facilitator should link discussion points back to specific CRM principles and learning objectives, and they should encourage learners to extrapolate their observations from the scenario to behaviors and events encountered in their real-life work environment. The debriefing facilitator may allow some flexibility in the trajectory of the discussion but should set aside enough time to review all of the critical actions of the scenario. This may involve a period of instruction within the debriefing that emphasizes demonstrations of effective teamwork and addresses any overlooked areas for improvement. The tendency to direct the debriefing solely toward the subset of learners who participated in the simulation should be avoided. One strategy is to provide observers of a simulation with a task to perform during the scenario, such as recording the instances in which the simulation participants displayed a specific crisis management skill. This technique transforms passive observers into active observers and empowers them to contribute during the debriefing.

If available, the use of video playback during debriefing allows instructors to replay the actual sequence of events in a simulation, providing learners with objective feedback of their performance. This is particularly useful in CRM training as it allows learners to visualize subtle non-technical aspects of the case and triggers rich discussion on strategies to improve teamwork behaviors. (Please see Chap. 4 for a more detailed review of debriefing.)

Conclusion

In order to effectively and efficiently manage crises in the ED, health care professionals must execute highly organized, team-based approaches to care. Crisis resource management (CRM), originally developed for the complex and high-stakes field of aviation, is being adopted as an effective team-based approach for averting and managing crises in multiple fields within healthcare, including EM. Optimal crisis management in EM focuses on ten key crisis management behaviors. The simulation environment is an ideal setting to train clinicians in these behaviors and reinforce their importance. Development and implementation of simulation-based, CRM curricula including scenario design and debriefing strategies should ensure that the ten behaviors are systematically learned, practiced and reflected upon by learners.

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6 Interdisciplinary Teamwork Training

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Introduction

It has been long (if not widely) acknowledged that teamwork is fundamental to the delivery of safe and high quality care. A growing body of evidence from diverse sources supports this notion [1]. Teamwork failures are an independent cause and cross cutting theme in systems breakdowns leading to preventable patient harm. In contrast, effective teamwork can be a powerful source of resilience [2]. It is a way to catch errors before they translate into harm, to provide effective, supportive and helping behaviors to colleagues, and to manage interpersonal relationships in complex and stressful environments. Consistent with the general teamwork literature, a growing body of research in healthcare indicates that interventions targeting improved teamwork in care delivery settings can be effective [3, 4]. However, as with all efforts to change behavior in organizations, success of teamwork training is not guaranteed. Many factors can influence whether or not a specific team training program will achieve its aims. Fortunately, decades of research and practical experience have provided a wealth of theoretical and empirical guidance.

The purpose of this chapter is to make this team training knowledge base accessible to people developing team training programs in Emergency Medicine. Specifically, we will provide a brief and practical overview of the science of teamwork and team training for application in Emergency Medicine. To this end, we will address three central objectives. First, as teamwork remains a somewhat recent topic of interest in healthcare, common terminology remains a challenge; therefore, we will provide some key definitions and an overview of teams and teamwork rooted in the decades-long research tradition of teamwork training. Second, we will introduce a systems-based framework for the factors influencing team training effectiveness. This broad perspective considers management of the curriculum, organizational and training environments, scenarios, performance measurement, feedback, and continuous improvement. Third, we will summarize critical issues and best practices for designing, delivering, and evaluating team training. These will focus on key tasks before, during, and after a team training activity.

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Teams and Teamwork: Some Key Definitions and Frameworks

Emergency Medicine involves highly interdependent work and high quality outcomes depend on more than the sum of the clinical expertise of individuals. The outcome is affected by how team members manage interdependencies, communicate and collaborate. As mentioned above, team training in healthcare literature is plagued with inconsistent terminology. Terms like non-technical skills, soft-skills, team management, and interprofessional competencies can be used to refer to the same, or different, constructs depending on the context. Therefore, it is worth clearly defining what we mean by these fundamental terms: team, teamwork, team performance, and team competency.

The most basic definition of team includes two central components: *interdependence*, and *shared goals* [5, 6]. First, a team comprises two or more individuals, each of whom rely in some way on their team members to reach their objectives. This central component differentiates a team from a collection of individuals. Second, all the members must work toward a shared goal. Team members may have some unique goals, but they have shared responsibilities for achieving something they all value.

The vast majority of team research uses some form of an Input - Mediator (or Process) – Output (IMO) framework. As depicted in Fig. 6.1, this framework informs our definitions of teamwork, team performance, and team competencies [7]. Team Inputs are relatively stable attributes of a team, the goal of the team, and the environment. Inputs include such things as team composition (e.g., who is on the team; what are their roles, expertise, personalities, and other attributes), organizational culture, characteristics of the technology, and tools team members must use to complete their work. Team Mediators or Processes transform these inputs into outputs. They are the interactions of team members such as coordination, leadership, communication, and back-up behavior. Team outputs are the end products of a performance episode including task outputs (e.g., efficiency, safety, quality) and team member outcomes such as learning and team member satisfaction.

Teamwork refers to the behaviors (e.g., communication, leadership, back-up behavior), cognitions (e.g., shared mental models) and affective states (e.g., mutual trust, collective efficacy) that enable team members to achieve their collective goals. It includes team processes and is differentiated from taskwork, which is the work each individual team member completes in isolation from others. Just as any component of taskwork (e.g., a specific clinical task) can be defined in terms of the knowledge, skills, and attitudes (KSAs) required to successfully complete the task, teamwork competencies are the KSAs involved in teamwork. Team performance is the sum of both teamwork and taskwork, and team effectiveness is an evaluation of the team's

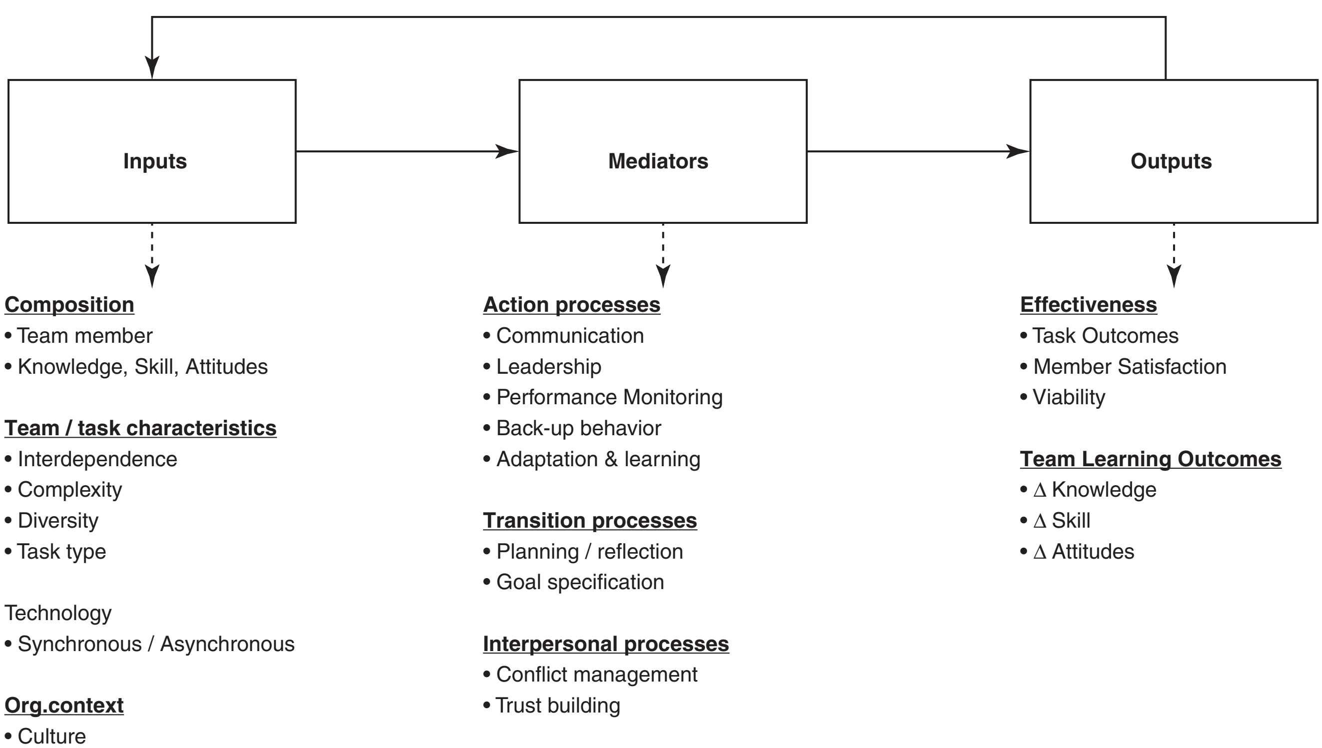

Fig. 6.1 The input, mediator, output model of team performance

outcomes (i.e, task outcomes, learning, and viability—the ability of the team to perform in the future). Additionally, multi-, inter-, and even trans-disciplinary or professional teams have become common terms in the literature.

Methods for Improving Teamwork

Team training is a systematic approach to improving teamwork competencies. Specifically, it is a theory-driven strategy and set of instructional methods designed to improve the members' knowledge, skills, and attitudes (KSAs) underlying effective teamwork and to provide opportunities for team members to experience using these critical KSAs.

There are many established techniques for conducting team training, including guided team self-correction, cross-training, and crisis or crew resource management training (for a review, see Chap. 5). For example, guided team self-correction uses team debriefs focusing on a clearly defined framework of teamwork to support a team's evaluation of their own communication, cooperation, and coordination processes during a given scenario [8]. The critical elements of this strategy are: (1) a debriefing structured around a conceptual model of teamwork, rather than a linear discussion of events, (2) a discussion of both positive and negative instances of teamwork, and (3) adoption of learning orientation (i.e., what did we do), rather than a performance orientation (i.e., how did we do). Cross training strategies allow team members to experience the roles and responsibilities of fellow team members. This helps to build role clarity and a shared mental model, both of which facilitate coordination. Crisis or crew resource management (CRM) focuses on training team members how to recognize cues and red flags, as well as strategies for adapting their coordination strategies and resource allocation patterns based on such cues.

Team training provides an opportunity for healthcare providers to learn, refine, and practice different strategies for improving teamwork competencies. Reviews of the team training evaluation literature indicate positive learner reactions, learning (i.e., knowledge and attitude change), as well as behavior change on the job [3, 4, 9]. These strategies can help individual team members develop teamwork competencies (e.g., knowledge, behaviors, and attitudes) that can be generalized across different teams. These strategies can also foster team-specific learning through shared experimentation, reflection, and codification of both shared and unique knowledge.

In addition to training, organizational change strategies are increasingly used in healthcare to facilitate the transfer of trained skills into daily work processes, such as organizational structure interventions (e.g., team composition, work process, and task re-design), standardized communication protocols (e.g., handoffs, huddles, briefings and debriefings), recurring team self-correction debrief sessions, peer feedback and coaching, and formal audit and feedback processes. While each of these strategies have growing evidence to support their efficacy as independent interventions, the true opportunity lies in aligning training with broader organizational change efforts to maximize the application of teamwork competencies acquired in learning environments to clinical work.

A Systems-View of Team Training

When designing a learning experience, we have a tendency to focus on the event itself, and on what happens in the simulation we're creating. This is no doubt important, but if our ultimate goal is to improve the quality of teamwork in actual care delivery contexts, we need a broader perspective. Many factors occurring before and after a given formal learning opportunity can dramatically impact what is learned and what is applied on the job.

The system view of teamwork training contains six core components: curriculum management, organizational and training environment management, scenario design and management, performance measurement, feedback, and continuous improvement [10, 11]. As summarized in

Table 6.1 Summary of the major components of a systems approach to teamwork training

System component	Description	Key tasks
Curriculum Management	Provides the 'big picture' for the training program by listing the high level training objectives and connecting them to training activities and organizational needs.	1. Identify the needs the training program is addressing for the facility (e.g., what problem is it solving?). 2. Specify global training objectives and link them to the identified needs. 3. Specify the training delivery methods and learning activities used to meet each of the training objectives.
Organizational and Training Environment Management	Provides tools for understanding and preparing the environment for SBT teamwork training.	1. Assess organizational factors and ensure sufficient levels of leadership support and material resources. 2. Assess staff perceptions of SBT and teamwork training.

(continued)

Table 6.1 (continued)

System component	Description	Key tasks
Scenario Design and Management	Provides a set of standard processes for developing and managing individual scenarios to meet the global training objectives.	1. Identify and clearly articulate the teamwork training objectives for the scenario in a measurable way. 2. Identify an incident, event, or clinical context that can be used to provide opportunities for practicing targeted teamwork behaviors. 3. Develop an event set (i.e., opportunities to perform) associated with targeted teamwork behaviors and a script for the scenario. 4. Pilot-test and refine the scenario.
Performance Measurement	Provides the overarching measurement framework (i.e., what are we measuring and how are we measuring it?), process for developing new measures, and specific tools in use.	1. Develop measurement tools that focus on critical events in the scenario and expected teamwork behaviors. 2. Train observers. 3. Monitor inter-rater reliability.
Feedback	Provides a set of tools, procedures and a staff development process for ensuring a high quality team debriefs.	1. Develop expert debrief facilitators through training and evaluation. 2. Incorporate performance measurement and technological tools to help scaffold the debrief process.
Continuous Improvement	Provides a method for evaluating the effectiveness of the training program as a whole and its components with a focus on increasing learning and transfer. This feeds into a process for continually improving (1) the trainees' learning, (2) the quality of instruction (i.e., debrief facilitation), and (3) the quality of the training itself (e.g., the scenarios).	1. Assess and improve the *training content* (i.e., elicit trainee reactions and incorporate lessons learned; use results of training evaluation). 2. Assess and improve *trainee learning* (i.e., maintain a historical record of performance over time). 3. Assess and improve *training delivery* (i.e., provide an assessment and feedback mechanism for trainers).

Table 6.1, each of these components is a set of tasks and tools aimed at meeting a specific goal. Curriculum management focuses on maintaining overall organization of the training and connections to organizational needs. Organizational and training environment management involves assessing and preparing the organization and trainees to ensure the training has the best potential for success. Scenario design and management entails ensuring that the training activities provide the appropriate opportunities to learn. Performance measurement is important for assessing improvements over time as well as helping to structure debrief sessions. Feedback focuses on methods for providing corrective feedback through facilitated debriefings. Continuous improvement involves systematically evaluating and improving the quality of training program as well as the staff member's teamwork skills.

Best Practices and Tips for Training Multidisciplinary Teams

As described in the systems view above, effective teamwork training involves much more than the actual learning session. To maximize the impact of our training, we need to focus on what happens before, during, and after the actual simulation session. Below, we briefly describe some key practices to focus on at these different times.

What Happens Before Training?

Conduct a Team Training Needs Analysis

The first step in interdisciplinary team training is to conduct a team training needs analysis (TTNA) [12]. This is perhaps the most critical process in the team training cycle as it influences the design, implementation, and evaluation of team training. A good TTNA will sensitize training developers to potential obstacles that can be avoided or managed before they derail the program. There are three concurrent phases to a TTNA: (1) organizational analysis, (2) team task analysis, and (3) person analysis. First, training developers must determine the strategic objectives of the organization and level of organizational support for the training endeavor. Specifically, what organizational need is the teamwork training program addressing? What problem is it solving? For example, teamwork training can help meet regulatory and educational requirements. Understanding the organization's strategic objectives helps establish training priorities that align with organizational goals, which is important because the need for team training can be marketed to leaders as essential to the organization's mission. Without organizational support, team training won't take off. Training developers should identify key stakeholders and determine whether the organization is prepared to invest in team training. To this end, training developers can also look into previous cases of when team training worked (or failed) to better understand the external conditions likely to influence training. Finally, it is worth considering whether team training is even the most viable solution to redress organizational problems. Perhaps improved procedures or additional staffing are more practical alternatives. Beyond academic Emergency Medicine where team training programs can be aligned with the aims of resident education competencies and broader interprofessional education programs, team training programs can be aligned with operational needs for efficiencies (e.g., throughput).

The second component of the TTNA is the team task analysis, which specifies when teamwork matters and the competencies that underlie effective team performance. The team task analysis should identify tasks that are the most common, challenging, and significant to the organization. For each of these tasks, a key understanding of the roles, responsibilities, and degree of interdependency will inform the KSAs needed for effective performance, and in turn, what should be targeted in training. Common tasks targeted for teamwork training in Emergency Medicine include basic and advanced life support and trauma response. These represent opportunities where a more in depth team focus can be added to existing training requirements.

The third phase of the TTNA considers the characteristics of the individuals that will be trained. Individuals vary in their learning styles, motivation, and skill sets. Factors such as these must be considered before implementing team training to ensure the benefits of training are realized for all learners and that the lessons learned during training actually transfer to the job environment [13]. For example, some learners may need prerequisite skills before more advanced topics are introduced. In other cases, the person analysis may reveal that potential learners hold negative perceptions of training from prior experiences, which impacts training motivation and outcomes [14]. Thus, mechanisms to improve or enhance motivation should be incorporated into the training program (e.g., making the learning environment engaging, encouraging learners to set practical goals) and a positive team-training climate should be encouraged.

A variety of resources are available to collect data in support of the TTNA. Examples include interviews with staff, observations of teams in action, and reviewing organizational records (e.g., accident reports, job descriptions). Additionally, a training development team should be formed to align the design, delivery, and evaluation of team training with the requirements of the job and strategic goals of the organization. Ideally, this team should include clinical experts (i.e., front-line staff), training or health care education experts, and organizational leaders. Members of this team, which includes the organization's workforce, can also function as champions to promote the value of team training to others in the organization [15].

Create a Climate That Fosters Learning

Team training cannot flourish unless there is strong commitment to the endeavor from all levels of the organization; buy-in of organizational leaders and front-line staff is vital. Leaders set the tone for establishing the values of an organization and can send positive messages about the importance of team training to staff, model desired team behaviors, and can even take an active role in team training through attendance, participation, and instruction. Similarly, the time and availability of learners must be respected. Common challenges for teamwork training are the simple logistics of scheduling a time and place where a multi-disciplinary team can meet to be trained. In our experience, in situ simulations are a valuable approach to overcoming some of the logistical constraints for staff scheduling in Emergency Departments. There are, of course, well documented tradeoffs between in situ and center-based simulation, but our [EH, JK] experience has been that announced and unannounced in situ simulations can not only reinforce teamwork skills, but identify any work system (i.e., policy, process, inter-departmental communication, equipment) issues that will impact how successful a team can be. Managing this challenge requires commitment of leaders from each of the disciplines. One way to achieve buy-in from all stakeholders is to explain how team training can help the organization better achieve its goals, how learners can personally benefit from participation, and ultimately, the potential impact of team training on safety and performance.

The training environment itself must also foster the learning experience. Learners should feel comfortable asking questions and open to receiving feedback from others. Both the positive and negative aspects of performance should be embraced during team training, with errors being framed in a positive way rather than a point of criticism. In fact, encouraging learners to make errors and explore solutions can improve the extent to which the KSAs acquired during training transfer to the job environment [16]. Making an error offers a point for self-reflection. Errors also provide opportunities to practice recovering from mistakes in a safe environment where consequences do not jeopardize patient safety.

Create Conditions That Support Transfer of Teamwork Skills

Simulation-based training is a foundational and highly effective method for building teamwork competencies. However, transfer of training (i.e., the application of competencies acquired in learning environments to the targeted performance environment) is always a challenge for learning and development programs, and may be particularly difficult for teamwork skills. Estimates of the overall amount of application of competencies acquired in formal training and education to the work environment vary widely. Examples of learner, training environment, and organizational characteristics that influence transfer of training [13, 17] are provided in Table 6.2. It is important for teamwork training designers to consider each of these factors and what can be done to maximize the likelihood that learners will apply what they learn in patient care areas. Anecdotally, integrating teamwork training concepts and principles into an ongoing review of actual trauma cases can be a powerful method to sustain the effects of teamwork training. As part of a multidisciplinary trauma team training and overall quality improvement effort, one of the authors was involved in a project where trauma cases were recorded and one was selected for review as a group. The same teamwork measurement tools used in simulation were used for these video reviews to reinforce the concepts, identify ongoing learning needs, and drive improvement.

What Happens During Training?

Ensure Content Is Team Focused

A teamwork simulation must provide clear opportunities to practice targeted teamwork competencies. This may seem like an obvious point, but designers of teamwork training programs do not always clearly map scenario events to learning objectives and teamwork competencies. As discussed above, a TTNA should provide the raw materials for designing teamwork-focused scenarios. These analyses of team tasks can feed into event-based methods for designing simulation. Event-based methods provide a way to ensure that a given scenario provides opportunities to practice targeted teamwork behaviors [18]. In general, this process involves defining a teamwork competency model (i.e. CRM from

Table 6.2 Summary of factors influencing transfer of training and points to consider for teamwork training

Factors influencing transfer of training		Things to consider for teamwork training (TT)
Learner Characteristics	**Self-efficacy.** Judgments learners make about their own ability to perform a given task.	What are learners general level of comfort with teamwork? Will learners be able to master TT scenarios?
	Pre-training motivation. A learner's level and intensity of desire to acquire competencies BEFORE attending a training session.	Have you effectively presented the case for (value of) TT? Are there local incidents that support the need for TT?
	Perceived utility. Learner's valuation of learning opportunity based on an evaluation of the credibility that competencies will improve performance, a recognized need to improve performance, belief that applying new skills will improve performance, practicality of applying new skills.	How is TT being messaged to learners? Have teamwork competencies been clearly connected to clinical outcomes? What is your communication plan for TT?
	Career planning. Degree to which learners create and manage specific plans for their development	Is TT a part of larger career development plans? Is TT integrated with continuing education?
Training Characteristics	**Learning goals.** Explicit communication of desired performance, conditions under which performance will occur, and the criterion of acceptable performance.	Do learners understand what is expected of them in TT? Do the learners perceive the training as 'assessment' focused, or developmental and learning focused?
	Content relevance. The degree to which learning opportunities correspond to the job environment and require consistent responses from learners across these settings.	Do the scenarios selected for TT reflect real task situations learners perceive as important and realistic? Do TT scenarios clearly emphasize teamwork?
	Practice and feedback. The degree to which cognitive and behavioral rehearsal strategies are used in conjunction with feedback, reinforcement, and remediation.	Have debrief facilitators been trained to be effective? How will you use measurement to drive systematic feedback and remediation?
	Error-based examples. A strategy of systematically sharing 'what can go wrong' when learners fail to effectively apply what they are currently learning.	Does TT provide clear and realistic connections between teamwork breakdowns and adverse clinical outcomes?
Organizational Characteristics	**Transfer climate.** The situations or consequences in organizations that facilitate or inhibit transfer; a positive/supportive transfer climate includes: presence of cues that prompt learners to use new skills, consequences for using skills and remediation for not using skills, social support from peers and supervisors (incentives, feedback, etc.).	Are there work process changes that can reinforce TT behaviors? Structured communication tools? Huddles? Briefings and debriefings focused on teamwork? Can you embed reminders to use TT skills on the job? Cognitive aids? Tip sheets?
	Supervisor support. Presence of supportive behaviors from leaders including: discussing new learning and how to use it, involvement in training, coaching and use of positive feedback and encouragement.	How are you engaging leaders prior to TT? Have you provided leaders with common language and tools for reinforcing targeted teamwork behaviors?
	Peer support. The degree to which colleagues facilitate the application of new skills, including networking with peers and sharing ideas about the learned skills.	What is your plan for peer coaching? Can you provide a forum for people to debrief on their experiences after attending TT?
	Opportunity to perform. The degree to which learners have opportunities to use what they've learned on the job.	How can you ensure clear opportunities for learners to use their new skills on the job? In situ sims? Coaching?

Chap. 5 or TeamSTEPPS), identifying and clearly stating the teamwork learning objectives, identifying an incident that can provide the opportunity to meet the learning objectives (i.e., a situation that requires the targeted teamwork behavior to manage effectively), developing an event set and list of associated expected teamwork responses, and pilot testing, refining, implementing, and continuously evaluating the scenario. For example, in BLS (or advanced protocols) simulation scenarios, we operationalize the teamwork competency of mutual support (i.e., asking for and providing task assistance when needed) in very specific terms relative to the BLS protocols (e.g., getting backboard or step stool, lowering bed rails, monitoring for chest compression quality and offering assistance when performance degrades). Most aspects of the BLS protocol provide an opportunity for team members to practice mutual support, but only if their team members need it. A high performing team may not display much mutual support if the individual team members are highly proficient in each of their roles. More junior learners may need mutual support as they are less proficient in their roles, yet also not display mutual support behaviors because they are unable to detect when they or their team members actually need assistance. Therefore, a measurement, feedback, and debrief cycle for junior learners may focus on missed opportunities to provide mutual support (e.g., reviewing where team members were struggling in the code simulation, and discussing how that could have been managed as a team). For more expert learners, deliberate events may be need to be inserted into the code simulation to ensure the team has opportunities to practice mutual support (e.g., use of standardized participants to display poor chest compression performance; introduction of equipment malfunctions like a nonfunctional defibrillator or missing airway equipment).

Use Appropriate Delivery Methods

At a high level, training delivery methods can be classified as information-based (e.g., didactics, readings and other forms of providing static information to learners), demonstration-based (e.g., providing visualizations of effective and ineffective performance), and practice-based (e.g., creating conditions where learners enact targeted competencies) [19]. This chapter focuses on practice-based methods for teamwork training as it has proven to be a powerful approach to learning, particularly for teamwork skills. However, classroom methods (i.e., information-based) have also shown to be useful [20]. Ideally, a variety of delivery methods will be combined in a teamwork training program to produce the best outcomes. For example, information- and demonstration-based methods may be useful for building familiarity with concepts and creating a common vocabulary in new learners before they come to a simulation session in order to maximize value of time spent together as a team in practice activities.

In healthcare, simulation occurs in dedicated centers as well as within care settings (i.e., in situ simulation) [21]. Center-based simulation is a more controlled environment, but may be more difficult logistically if the center is not physically close to work settings. In situ simulation provides some added realism and the opportunity to evaluate work system related issues, but can introduce the opportunities for unexpected events or distractions. There is no one best choice in location, but ideally, these two are blended in a teamwork training program. For example, having initial trainings in center-based simulation can provide the structure and control needed to ensure team members develop basic competencies. These can be reinforced and elaborated upon during in situ simulations over time.

What Happens After Training?

Evaluate Teamwork Training Program

Without evaluation, it is impossible to quantify whether teamwork training goals and objectives have been realized. A blueprint for assessment is needed even before training begins. At this stage, training designers must consider what team competencies to measure, how they should be measured, and who will be involved in assessment. Clearly, this process requires significant consideration and planning. Measurement tools cannot be arbitrarily selected; measures must elicit information about specific teamwork competencies in order to inform whether learning objectives are achieved (i.e., those informed by the TTNA). There are also pros and cons to different measurement techniques [22]. Self-report surveys are valuable for capturing information about team-related attitudes but are subject to biases of those providing responses. Observation provides a more objective account of team behaviors, but can be resource-intensive as they require dedicated staff time to provide ratings, train raters, and monitor their reliability over time. In reality, multiple forms of measurement should be leveraged to provide a comprehensive account of performance.

The evaluation plan should incorporate both process and outcome measures of teamwork. Outcome measures help explain *what* has happened by targeting information related to the quality and/or quantity of performance (e.g., treatment intervention was timely and appropriate). Conversely, process measures capture information about specific KSAs to explicate *why* a particular outcome took place (e.g., engaged appropriate support personnel, effective team decision-making in response to crisis). Training effectiveness must also be evaluated at multiple (Kirkpatrick) levels, including: reactions, learning, behaviors, and results [23]. Reactions consider whether learners enjoyed or disliked the training experience whereas learning refers to whether there were changes in knowledge or attitudes as a result of training. The assessment of behaviors, though, is concerned with whether learners transfer and apply the skills that were developed in the training environment to the actual performance environment. Finally, results specify whether the organization achieved a return on investment as a result of training.

Last, evaluation must occur at multiple points during the teamwork training cycle (i.e., before, during, and after teamwork training). Measuring performance before and after training allows training designers to demonstrate quantifiable differences as a result of the intervention. Incorporating measurement during the intervention may inform whether adjustments need to be made before it is too late.

Ensure Teamwork Training Transfers to the Job Environment and Endures Over Time

The overall impact of the training program has minimal value if the KSAs developed during training do not translate into improved performance on the job. The transfer and sustainment of teamwork training is concerned with establishing the conditions for continued success [17]. Consequently, training developers must also invest resources to promote the positive transfer and sustainment of KSAs following teamwork training. For instance, learners need opportunities to use the skills they practiced during training or institute the practice of clinical debriefing. Though seemingly superficial, the realities of emergency medicine (e.g., scheduling, unpredictable tasking) may preclude structured use of trained skills or the application of teamwork skills to a variety of contexts following training. Additionally, organizational leaders can facilitate a climate for enduring success by ensuring employees have adequate time to use learned skills, modeling desirable teamwork behaviors, and by providing encouragement and recognition of effective teamwork. Continued feedback is also recommended as a mechanism to foster and reinforce skills.

Sustainment initiatives should also incorporate continuous measurement and learning opportunities. Recurrent assessment of KSAs may highlight areas where performance is deficient relative to others and suggest where additional teamwork training is needed or if the training itself requires modifications to redress shortcomings. Additional learning opportunities also help ensure skills don't decay overtime. The teamwork training life-cycle is ongoing. Organizations may adopt new policies, procedures, or new personnel may need to be immersed in training content. Consequently, teamwork training needs must continuously be assessed in light of the organization's strategic goals and modified to address new demands.

Concluding Remarks

Teamwork matters in healthcare and specifically in Emergency Medicine where high levels of time pressure, uncertainty, and complexity make coordination all the more important. Simulation-based teamwork training can be a powerful tool in building expert, high-functioning teams. To get the most out of the time devoted to these learning opportunities, it is necessary to think beyond the scenario and simulation session itself. These are important, but issues of curriculum design, organizational and training environment management, and performance measurement matter as well. It is an exciting time to develop and implement teamwork training in Emergency Medicine. There is a solid basis of evidence and practice available, but there is also an opportunity to explore, innovate, and evolve this field.

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7 Simulation-Based Measurement and Program Evaluation: Demonstrating Effectiveness

Rosemarie Fernandez, Adeyinka Adedipe, Elizabeth D. Rosenman, Scott Compton, and Steve W. J. Kozlowski

Introduction

The delivery of emergency medical care is a dynamic and complex process that requires a high level of practitioner competency. Simulation offers the opportunity to both train and assess practitioner skills including decision making, diagnosis, teamwork, procedural skills, and interpersonal skills in a realistic and relevant context [1]. This chapter covers two important and distinct topics. In Part 1, we discuss the use of simulation for learner *assessment*, focusing on evidence-based simulation assessment design and implementation processes. In Part 2, we discuss simulation-based training *outcomes,* i.e., simulation program evaluation. Figure 7.1 highlights how our discussion fits into the larger educational process. This education context shapes the overall focus of this chapter; however, the process outlined here is applicable to using simulation for assessment of systems, environments, and organizational practices.

Assessment science has advanced considerably in the past decade, and a single chapter such as ours will not address every nuance and detail. Rather, we strive to give the reader a general approach and some best practice guidelines with meaningful examples and references to more detailed source information.

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Simulation-Based Assessment

Overview

The role for simulation in medical education is increasing, largely due to the mandate for competency-based, objective evaluation of healthcare trainees. This is evident in emergency medicine, where it is necessary to assess clinical competency in (a) rarely performed lifesaving procedures, (b) the diagnosis and treatment of infrequently encountered disease states, and (c) complex team-based situations. Such competency assessments should reflect actual clinical performance, not just knowledge recall. It is not surprising that simulation is well represented in the Accreditation Council for Graduate Medical Education (ACGME) assessment toolbox [2] and is considered an American Board of Emergency Medicine-approved mechanism for maintenance of certification [3].

The medical education literature demonstrates multiple advantages of using simulation to assess individual, team, and unit-level performance. Properly designed simulations provide a standardized way to objectively evaluate a number of clinical skills [4]. Additionally, simulation provides a "synthetic environment" that can re-create part or all of a patient care experience, thus allowing educators and researchers to better understand the effect of different interventions or stimuli (e.g., noise, sleep deprivation, and training) on performance.

While the early adoption of simulation-based assessment within emergency medicine is exciting, one must proceed with caution. As alluded to above, when simulations are *properly designed and applied*, they can create a realistic, reproducible, reliable assessment "platform" supported by evidence of validity. Although there may be no single "right way" to create simulation assessments, there are principles that should be used to guide their design and implementation. The objective of Part 1 of this chapter is to provide a practical overview of simulation-based assessment. We will discuss each component of a simulation-based assessment

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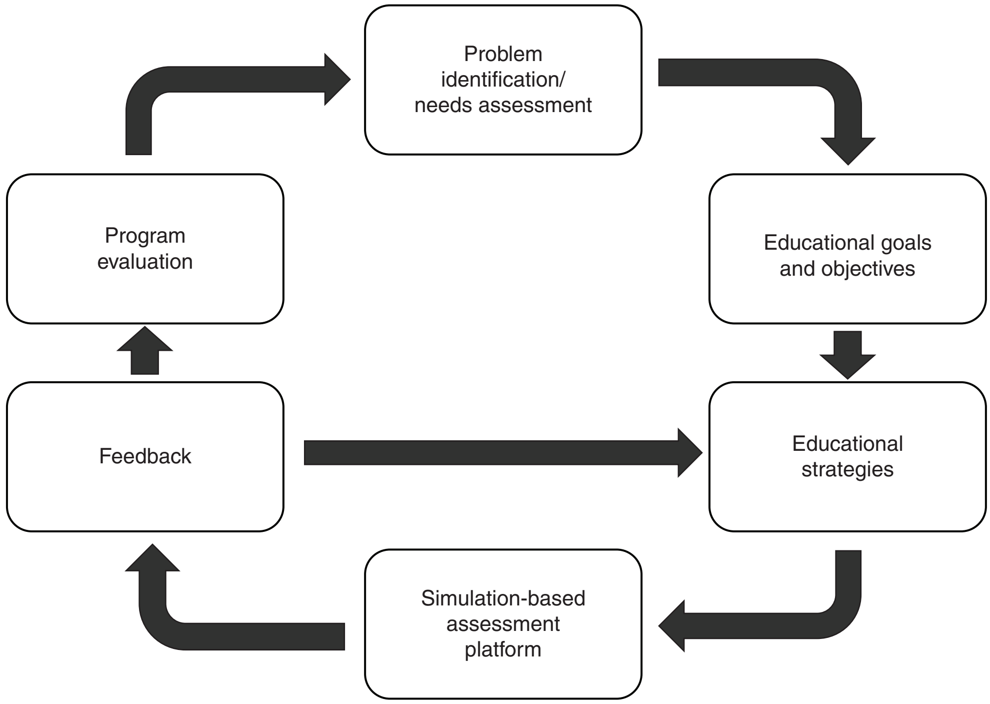


Fig. 7.1 An overview of simulation-based assessment embedded within a curricular design framework

platform (assessment objectives, scenario(s), metrics, and coders/raters) and we will highlight guiding principles that can be applied independent of the simulation modality being used. We will also briefly cover special topics of interest (team assessment, systems evaluation, blended simulations). Overall, we strive to provide a practical primer that includes recommendations and examples to help guide the development of your assessment portfolio.

Simulation-Based Assessment Platform (Fig. 7.2)

When implementing simulation-based performance evaluations, educators and researchers should view the assessment as a platform that purposefully prompts critical behaviors that are then observed and recorded using well-designed metrics. One does not simply apply observation-based metrics used at the bedside to a simulated case. Rather, each component of the assessment is carefully constructed and integrated into the platform to ensure that the simulation is appropriate for the assessment objectives and provides the opportunity to observe and capture critical behaviors.

It is also important that the purpose of the assessment ultimately drives the design process. That is, one should keep in mind whether the goal of the assessment is formative versus summative. While we feel that all assessment should provide meaningful feedback to the learner and the program, if there is a summative assessment goal, this needs to be reflected in the design decisions. Ultimately the result is a simulation assessment platform that provides reliable, diagnostic measurement of complex performance that directly relates to educational objectives and goals [5]. Rosen, et al. [6] describe an approach to simulation-based assessments tied to the ACGME core competencies (SMARTER) and Grand, et al. [7] present guidelines for simulation-based measurement. The methodology we present below is in line with the SMARTER approach but considers a wider application of simulation-based assessment across multiple education and research endeavors.

Assessment Objectives

Setting clear assessment objectives is a critical first step when developing any assessment tool, as the objectives will drive the design of the other simulation platform components [8]. With simulation-based assessment, this is particularly important, as one must ensure that simulation is, in fact, the appropriate method of assessment. Objectives can come from multiple sources, including formal needs assessments, programmatic mandates, or research aims. Once in place, it is important to closely examine the objectives to ensure that they are appropriate for simulation-based assessment [9]. Simulation provides the opportunity to view complex, dynamic behaviors in a clinically relevant setting. Objectives should be clearly defined as well as reflective of performance and behaviors (e.g., "Demonstrates correct approach to rapid sequence intubation in a patient with spinal cord injury"). Objectives that focus on pure knowledge testing (e.g.,

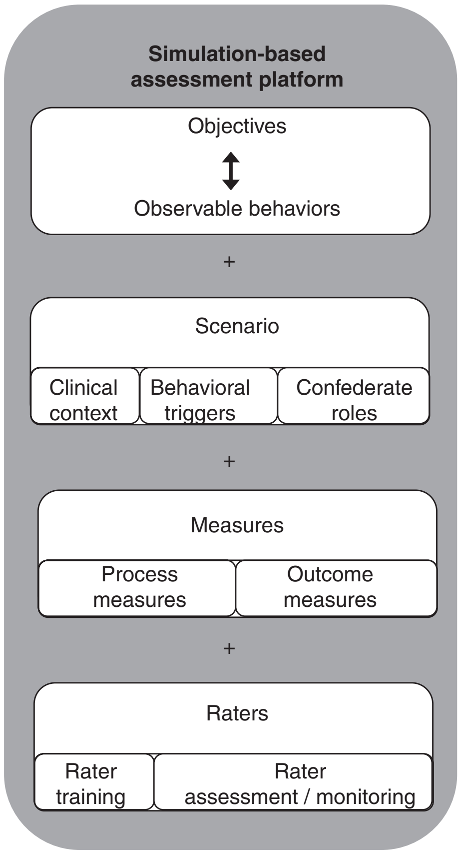


Fig. 7.2 Components of a simulation-based assessment platform

"Knows the different types of paralytics used for rapid sequence intubation.") may not be well suited for simulation-based assessment.

Principle 1: Assessment objectives should be clearly defined and appropriate for simulation-based assessment.

Once objectives have been defined, it is important to consider how those objectives might translate into observable behaviors. If the goal of a simulation is objective performance assessment, it is critical that the simulation provide opportunities for trainees to demonstrate the desired behaviors. This means that eudcators must define the clinical context (e.g., apneic cardiac arrest patient with difficult airway) and consider how your objectives would translate into observable actions within that context (e.g., uses airway rescue device, prepares for surgical airway).

Principle 2: Translate assessment objectives into observable behaviors within a clearly defined clinical context.

Simulation Modality

Scenario-building for assessment first and foremost must follow good design principles so that the modality of simulation and the flow of the scenario prompt the behaviors that one wishes to assess (see also Chap. 3) [10]. Table 7.1 lists various simulation modalities along with respective advantages and limitations. While we strongly advocate for keeping things as simple as possible, we recognize the value of combining multiple types of simulation and encourage faculty to consider how blended simulations could advance their assessment needs. If the primary purpose of an assessment is to measure provider-patient communication, standardized participant (SP)-based simulation might be more appropriate than mannequin-based simulation [11]. To assess complex patient care activities such as resuscitations, mannequin-based scenarios are likely more appropriate. Blended scenarios may offer the best of both worlds by incorporating two or more types of simulation (e.g., SP and mannequin) to allow the observation of a wider range of clinical skills. Combining a task trainer with a mannequin provides the opportunity for both complex diagnostic assessment supported by the mannequin and procedural assessment supported by the task trainer. The task trainer is often brought into the scenario when the trainee verbalizes the desire to perform the procedure. The trainee performs the procedure on the task trainer, but continues to manage the "patient" using the mannequin. Similarly, an SP and mannequin-based simulation would allow trainees to encounter family members or other standardized healthcare team members while caring for a critically ill "patient." In this case, SPs are often referred to as actors or "confederates." Scripted actors serve several roles: (a) provide fixed, consistent cues within a scenario and from one scenario to the next, (b) simulate behaviors that increase the psychological fidelity of a scenario, and (c) decrease performance issues related to a lack of familiarity with equipment. Properly integrating scripted actors into a simulation is vitally important to ensuring reliable assessments. Pasucci, et al. provide some guidelines regarding the recruitment, training, and integration of SPs into mannequin-based simulations [12].

Principle 3: The goals and objectives of the assessment should drive the decision of which simulation modality, if any, to use.

Scenario Design

As mentioned, it is critical that the assessment objectives drive the scenario flow, i.e., the order of events encountered by the trainee. To highlight this concept, we provide the following example:

> You are interested in evaluating the ability of your resident to care for a patient with severe intracranial and cervical spinal injuries from blunt trauma. You wish to specifically evaluate the following critical actions: (a) recognition of the need for intubation in patient with depressed level of consciousness, (b) proper execution of intubation, including maintenance of spinal precautions, (c) ATLS-guided evaluation of unstable patient (d) recognition of neurogenic etiology of shock, (e) treatment of neurogenic shock.

Table 7.1 Advantages and limitations of different simulation modalities

Simulation modality	Advantages	Limitations	Example
Standardized Patient (SP) *Actor trained to portray a patient, family member, or member of the healthcare team. May or may not have a role in providing learner feedback.*	Capable of realistic communication Offers “emotional” fidelity Offers opportunity for complete physical exam Can assume ancillary roles (family member, healthcare team member, etc.)	Physical exam findings based on individual actor Cannot support: Invasive procedural training Resuscitative care	Weiner et al. [67]
Task trainer *Technology designed to replicate all or part of a technical skill. Can be simple (foley catheter insertion) or complex (laparoscopic procedure). Can also include cadaver-based models*	Realistic replication of invasive or uncomfortable procedure Can provide learner feedback and performance metrics	High fidelity models are costly Isolates one component of a procedure from care of the entire patient Haptic technology is limited and can hamper physical fidelity	Ma et al. [26]
Mannequin *Full body model, usually containing some ability to replicate physical exam findings and support some procedural training*	Allows care of “whole” patient during critical care events Provides opportunity for all aspects of care (history, physical exam, diagnosis, intervention) on a limited basis	High fidelity models are costly Technical failures can limit assessment utility Limited fidelity of communication and physical exam findings, some of which can be addressed with moulage	Donoghue et al. [68] Kim et al. [69]
SP + Mannequin	Enhances mannequin-based simulation by providing opportunity for more realistic communication Can expand training to include family-centered care Can provide distractors during individual and team assessments	Standardized patient training can be time intensive Increases costs associated with simulation Requires an existing system for standardized patient recruitment and training	Fernandez, et al. [29, 70]
Mannequin + Task Trainer	Can be combined with standardized patients and/or mannequins to provide a more comprehensive assessment opportunity Allows for the combination of more diagnostic and interpersonal skills with procedural/technical skills	Moving from one modality to another can create issues with fidelity Dependence on technology increases likelihood of technical failure	Girzadas et al. [71] Arora [72]

Let’s consider two possible simulation scenarios. In the first scenario, the educator decides that if effective cervical spine immobilization is not provided, the patient will become apneic and arrest. In the second scenario, the educator has a scripted actor (an SP) playing the role of a nurse who reminds the trainee to immobilize the cervical spine during intubation. While the context of the two scenarios is similar, the flow of each scenario is different, and will have significant impact on trainee assessment. The first scenario unfolds such that one early error (failure to perform cervical spine immobilization) changes the course of the simulation; the trainee does not have the opportunity to perform any of the other behaviors expected in the later portions of the scenario. With the second scenario, if the trainee does not meet one early objective (cervical spine immobilization), s/he still has the opportunity to perform every behavior targeted. In other words, in the second scenario each behavior (and therefore measure) is independent and does not reflect prior performance.

The above example illustrates the importance of applying methodologically sound principles to scenario design. Fowlkes, et al. outline a process for creating scenarios that is generalizable and produces context-specific experiences [13]. This event-based methodology is based on the design and placement of discrete event sets within the simulation-based exercise (see also Chap. 2). Each event is tightly linked to the assessment goals of the scenario: event sets are designed and positioned to evoke the behaviors that are of interest to the evaluators. The result is a series of highly specific, observable behaviors that link directly to the assessment objectives and can reliably be evaluated by trained observers. Studies have demonstrated that event-based simulation design yields results with excellent inter-rater reliability without the need for significant time from subject matter experts [10]. Additionally, research has demonstrated good internal consistency and inter-exercise correlations in event-based simulation systems [13].

Principle 4: Scenarios should be designed using a methodologically sound approach.

Principle 5: Event-based simulations that target specific, observable behaviors provide reliable, reproducible assessment platforms.

Well-designed simulation-based assessments create a situation where there is a need for action [14]. Scenario events begin with a "trigger" (e.g., change in vital signs, change in clinical condition, time) that creates the need for the required behavior, such as intubation or CPR. A well-designed scenario event sequence is careful to minimize the interdependence of performance quality [13]. In other words, the way one event is experienced should be independent of how the trainee responded to a previous event. Each event should be able to provide a discrete assessment of performance. To ensure that the scenario progresses, multiple "back-up triggers" may be needed. For example, a trigger for intubation could be persistent, refractory hypoxia. If severe hypoxia does not prompt the expected behavior after a set period of time, the patient becomes somnolent. If the trainee still does not intubate the patient, the nurse SP could provide a verbal prompt such as "Doctor, I think this patient needs to be intubated." The assessors have information regarding failure to manage the airway early yet still are able to assess the performance of the intubation. The progression of the simulation accommodates variation in clinical practice/performance while still unfolding in a systematic way that allows for a standardized assessment.

Principle 6: Scenarios should contain event triggers that allow the clinical situation to unfold in a reliable, systematic manner for each trainee regardless of level of performance.

Principle 7: Back-up triggers should be designed to ensure progression of the event structure throughout the scenario.

The components of event-based simulation design offer realistic training exercises that can be linked to observable performance measures with strong metric properties. In Fig. 7.3 we provide and example of events with different types of triggers. Each component of the scenario must be thoroughly vetted and evidence supporting validity and reliability collected. To maximize reliability, each non-automated part of the scenario, i.e., standardized patients or SPs, should be trained to a predefined level of competency and continuously evaluated throughout the assessment process [12, 15].

Principle 8: "Human" components of the scenario should be trained and evaluated.

Measures

Once the scenario is designed, one should be able to list a set of observable behaviors that should occur during the simulation. The event-based nature of the scenario means that each event is tightly linked to expected actions on the part of the trainee. Depending on the flow of the scenario, one can predict when, and, occasionally, in what order, behaviors will occur. The ability to predict behavior helps focus measurement design and implementation while ensuring that measures are linked directly to the objectives. In this way, the objective-driven nature of the assessment is preserved.

Prior to discussing specific types of quantitative measures, it is important to address the difference between behaviors (process) and outcomes [6, 16]. Outcomes represent the cumulative result of numerous different behaviors. For example, the time it takes to intubate a patient is based on a number of individual behaviors: correct medication ordering, execution of preparatory steps, communication with nursing, rapid recognition of difficult conditions, among others. If you only assess the outcome (time), you cannot provide specific feedback to trainees. More importantly, there may be undesirable behaviors, (e.g., failure to adequately prepare), that would result in a decrease in overall time. Assessing outcome alone does not provide the whole story; capturing behaviors informs educators about what happened and why. In other words, behavioral measures are diagnostic and help to frame meaningful feedback that can change trainee behavior [17]. The education literature uses the terminology performance (process) and product (outcome), but the concept is identical [18].

Principle 9: Assessments should include behavioral measures that are diagnostic and provide learner and programmatic feedback.

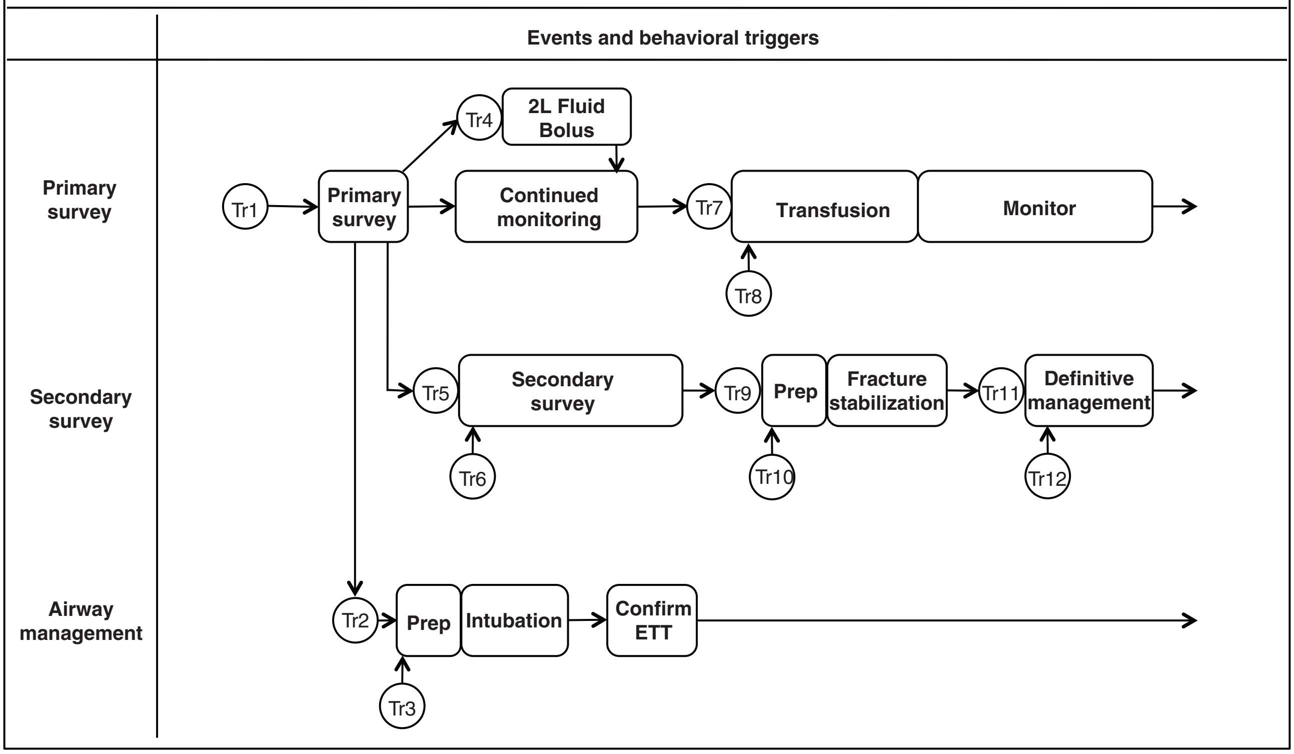
With the understanding that educators should measure discrete behaviors, the question becomes "How do we measure it?" There exist several different types of assessment tools to measure behavior-based performance. Assessment tools range from the holistic (e.g., behaviorally-anchored scales) to the analytic (e.g., binary checklists) [19]. An exhaustive discussion is beyond the scope of this chapter; however, we provide a brief overview of the type of tools available as well as their strengths and limitations. We consider issues of feasibility and impact on learning in addition to more traditional criteria (validity and reliability) [20]. These issues are extremely important, especially when assessments are formative experiences integrated into a curriculum.

Behaviorally-Anchored Rating Scales

Behaviorally-anchored rating scales (BARS) are more holistic, global assessments that use a numerical scale to represent a judgment of the quality of overall performance, or performance on a specific competency or component of the assessment. BARS contain specific behavioral descriptions that characterize different levels of performance. A poor perfor-

Summary: Patient presents after motorcycle accident, tachycardic and normotensive, minimally responsive to painful stimuli. Patient requires intubation. Patient becomes more hypotensive and tachycardic, requiring blood transfusion. Injuries include a femur fracture and an unstable pelvic fracture requiring splinting and binding, respectively. The scenario ends wth the team admitting service.

Resources: Mannequin / Nurse Confederate / Airway management tools / Cardiac Monitor / Radiographs / FAST images



Trigger	Type	Description
T1	Forced clinical action	Participants are brought into patient room
T2	Learner-driven clinical action	
T3 (BB)	Time-based (T=4 min if intubation not initiated)	Instructor cues nurse actor to state "I think he needs to be intubated."
T4	Learner-driven clinical action	Learners recognize tachycardia and initiate fluid resuscitation
T5	Learner-driven clinical action	Learners initiate secondary survey when primary survey completed
T6 (BB)	Time-based (T=2 min after intubation)	Instructor cues nurse actor to state "Should we undress him?"
T7	Learner-driven clinical action	Learners recognize hypotension and initiate transfusion
T8 (BB)	Time-based (T=2 min with SBP<80)	Instructor cues nurse actor to state "I just checked his blood pressure and it is 75/45." If still no response, states "Should we transfuse?"
T9	Learner-driven clinical action	Learners diagnose unstable pelvic fracture femur fracture
T10 (BB)	Time-based (T=10 min from start of scenario)	Instructor cues nurse actor to state "I ordered these films per protocol." If still no response, states "These look like they need stabilization."
T11	Learner-driven clinical action	Learners call appropriate consultation service
T12	Time-based (T=2 min after stabilization of fracture)	Instructor cues nurse actor to state "Should we call someone to get this patient admitted?"

Fig. 7.3 Example of an event-based scenario with clinical triggers and behavior prompts

mance may be designated a "1" and characterized by a behavioral descriptor consistent with substandard performance, whereas a "5" would designate an excellent performance and be described by examples of outstanding behavior. When BARS are used by trained subject matter experts, a high level of reliability can be achieved [21–23]. BARS have the advantage of capturing the "whole picture" without rewarding the unnecessary behavior often seen in junior practitioners [24]. BARS can also be less cumbersome for the rater, as there are typically fewer items to score as compared with task-oriented checklists. Overall, some researchers believe that more holistic BARS ratings represent a more faithful reflection of competency than detailed checklists [22].

BARS assessments have several well-described limitations. Simulation-based studies evaluating complex patient care activities using BARS ratings often require clinical expert raters [25, 26]. More holistic rating systems like BARS are much more dependent on clinical expertise when scoring to ensure reliability. Clinician time is costly, and it is not clear how BARS would fare when implemented with non-clinical raters, although there would likely be some dependence on the specificity of behavioral anchors, extent of training, and simplicity of task being evaluated. Another limitation for BARS assessments is that they may not provide specific feedback to learners [7]. BARS ratings tell trainees how they fared overall in a certain area, but do not provide detailed, diagnostic feedback regarding ineffective or absent behaviors. Likewise, the feedback to educators regarding their curriculum may not be specific enough to accurately pinpoint areas requiring redesign.

Behavioral Observation Scales

Behavioral observation scales (BOS) are similar to BARS in that they use a numeric scale; however, the anchors for BOS are based on absolute measures, such as frequency of observed behaviors, rather than quality of behaviors (e.g., 0 = never observed to 10 = always observed). The behaviors expected of the trainee may occur throughout the simulation during multiple scenario events. While there is the tendency to overestimate infrequent events and underestimate highly frequent events, it is possible to maintain high reliability and accuracy using BOS [17]. However, BOS are rarely used as a sole assessment tool due to their inability to capture the nature of behavior. Nonetheless, BOS remain a valuable way to assess performance over time or across scenarios/events.

Checklists

Binary checklists are frequently used in simulation-based assessments. Checklists produce reliable and accurate results similar to those achieved using BARS [27]. Checklists provide detailed information regarding the execution of specific predetermined behaviors. Qualifiers can be added to checklist items to try and ascertain quality in addition to completeness (e.g., not done, done, done well). By adding qualifiers, checklists can provide specific, directed feedback to trainees on their performance and can alert educators to potential deficits in their curriculum. One must keep in mind that when raters are asked to make judgments about the quality of a behavior, the need for training is increased due to the potential for increased error attributed to rater drift, halo effect, etc. [7, 28]

Checklists have two major limitations. Checklist measures are often criticized for being too reductionist. Checklist measures make the assumption that the sum of the parts equals the whole, implying that the trainee who performs *more* tasks is, by definition, more skilled. In this way, checklists can reward thoroughness rather than competence [22]. Depending on design, checklists may not capture alternate, clinically acceptable approaches to the scenario [6]. To solve this problem, checklist items can be weighted to favor critical and evidence based actions, thus accommodating acceptable variation in performance [29]. Weighting items should be done through a formal subject expert process. In addition to weighting items, outcome measures such as timing can be added to the checklist to provide additional performance information.

The second limitation of checklists involves the potential to create an overwhelming number of items that need to be scored. With more complex scenarios, the number of behavioral items increases exponentially. While the use of event-based scenario design can inform raters when certain behaviors are expected, multiple items may need to be scored simultaneously, especially when multiple competencies (e.g., medical knowledge, communication, teamwork) are evaluated at the same time. Large checklists are very difficult to manage during "live" observations, making video recording an attractive option. Using video recording to assess trainee performance should be balanced with the need to provide immediate, real-time feedback during formative trainings [30].

Communication Analysis

Communication analysis-based measures have been applied for performance assessment, albeit less frequently than checklists and BARS [17]. Communication analysis involves the coding of communication based on predefined categories as seen in work by Hunziker et al. [31, 32]. In these studies, different types of leadership communication, or "utterances" were categorized and counted as a measure of performance. Communication analysis requires a priori definition of categories, with the number of categories ultimately determining the level of complexity [17]. In team settings, each category can be further expanded to clarify important team interactions. For example, one could capture the role of the individual initiating communication and whether the patient or other team member responded. The development of communication analysis software has the potential to automate such assessments, thus decreasing the demand on human raters. Communication analysis addresses very specific skills, and is more suited for research as opposed to education-focused applications.

In presenting the different categories of metrics used in simulation-based assessments, we did not discuss self-assessment questionnaires, as these have significant validity concerns when applied to performance measurement [33]. There is no single "best" measurement design for simulation-based assessments [34]. Simulation experts must carefully consider (a) the need for specific feedback, (b) resource availability (e.g., expert raters, video recording), and (c) the overall goal of the assessment (research vs. formative assessment vs. summative assessment).

Principle 10: When choosing a measurement tool, consider feasibility and impact on educational goals as well as reliability and validity.

Raters

The importance of rater performance to simulation-based assessment validity cannot be overstated [15]. When human raters are part of the measurement system, appropriate attention must be paid to the process of rater recruitment and rater training. Scenario and measurement design approaches can help promote accurate and reliable coder responses; however, even the most carefully constructed measurement tool is prone to error if the coders are not adequately trained. Feldman, et al. provide an excellent review of this topic [35]. Below, we highlight important issues to consider.

Several problems arise when using raters for performance assessments, including: idiosyncratic ratings, rater bias, and rater drift [36, 37]. While rater bias can lead to a substantial amount of error [28], research findings demonstrate improved accuracy and reliability as a result of rater training [36, 38]. This emphasizes the importance of devoting time and resources toward the development and implementation of a sound coder training procedure. Optimally, raters will be monitored throughout the assessment process to minimize rater drift and other threats to reliability [15]. How much monitoring is necessary will depend upon the time period across which assessments are occurring as well as the nature of the assessment (high stakes or research versus formative, training-focused) [35].

Principle 11: Rater training is critical to reliable simulation-based assessments.

Principle 12: The degree of rater training and monitoring should be based upon the purpose of the assessment and the nature of the metrics.

Integration of the Simulation-Based Platform

Once you have designed and tested all of the components of the simulation, it is important to integrate each piece and test the platform [7]. Despite careful design to this point, it is likely that there will be the need for adjustments. Does the simulation allow for clear observation of behaviors present in the measurement tool? Are there measurement items that require refinement? Below is a brief example highlighting why careful integration is so critical.

> You decide to assess airway management skills, specifically correct technique during intubation and total time taken for the procedure. Your scenario has clear prompts to indicate the trainee should intubate the patient, and your measurement tool is designed to capture both time required for the intubation and the correct steps of the procedure. However, when testing the system as a whole, you note several problems. First, if the trainee does not correctly medicate the patient, s/he may have a shorter intubation time, resulting in a "better" score for a suboptimal performance. Second, your assessment form has a series of behaviors representing an appropriate approach to intubation. Upon watching a test simulation, you realize that you are unable to reliably observe some of those behaviors, like testing the light on the laryngoscope. Finally, after testing the simulation across several levels of trainees, you realize that your prompt for intubation might not be strong enough, as more experienced learners are requesting non-invasive ventilation which you cannot simulate.

The above example illustrates how integration of the elements of the simulation reveals issues that would impact the reliability and validity of the system as a whole. Ultimately, the extent to which the system must be tested depends upon the purpose of the assessment. If the simulation is being used for formative assessment, the need for a high degree of precision might not be an issue. Likewise, the scenario might contain points of flexibility, where timing and triggers can be modified as needed to address highly competent or struggling learners.

Principle 13: The components of the simulation-based assessment platform should be integrated and tested as a whole.

A Few Words on Validity

While a thorough discussion of measurement validity and reliability is well beyond the scope of this chapter, some mention of these concepts is warranted. We want to reinforce the notion that validity is not a property of a measure. Rather, validity refers to the degree to which evidence (both empirical and theoretical) supports the interpretation of the assessment "score." Simply put, are you measuring what you think you are measuring?

Evidence of validity can be sorted into 5 categories: content, response process, internal structure, relationship to other variables, and consequences [39]. We do not suggest that each component of the simulation have evidence from each category. In fact, some categories of validity might not be germane to the assessment design or purpose. Table 7.2 provides examples of how to establish evidence of validity for the components of the assessment. Items in Table 7.2 reflect the development and initial assessment implementation phase. Once the platform is integrated, empirical testing can further support the intended application of the simulation-based assessment as a whole and provide additional evidence of validity (e.g., consequences, relationship to other variables). See Cook et al. for a more complete description of validity and simulation-based assessment [40].

Principle 14: Collect evidence of validity for the simulation platform during both design and implementation phases.

Investing in Simulation-Based Assessment Development: Keeping a Practical Approach

While writing this chapter, we struggled with balancing the desire to present a best practices approach with the practical need to frequently use formative simulation assessments in educational programming. One could read all of the above *Principles* and become easily discouraged, as considerable resources are required to implement each step rigorously. The process is not intended to be overwhelming. While we stand by our method, please note that the level of detail and rigor put into each component of the design and implementation process should match the intended assessment application. If one plans on a formative assessment for residents, simulation development might involve (a) creating a scenario with a few basic triggers, (b) building a simple checklist of critical actions based on current clinical recommendations, (c) orienting faculty observers to the checklist and the scenario, and (d) piloting the simulation with learner(s) and querying faculty to assess their impressions on the overall scenario content and checklist items. This is a feasible and reasonable approach to designing a low-stakes, formative assessment.

For higher stakes testing and research, a much more rigorous approach is required to allow meaningful conclusions to be drawn from the assessment scores. Collecting validity evidence from multiple sources is necessary. Additionally, measurement error must be minimized. Simulation-based assessments are subject to an array of potential measurement errors classified as either (a) exam content or (b) scoring errors [15]. Adherence to the principles outlined above will minimize exam content-related errors [13, 41]. Scoring errors are best addressed by quality assurance strategies that include rigorous rater training, rater assessment, and exam security. Boulet et al., provide an excellent review of strategies one can employ to minimize measurement errors in simulation-based assessments [15].

Principle 15: Match the level of rigor in design and implementation to the goals of the assessment.

Special Applications of Simulation-Based Assessment

While the *Principles* outlined above apply to all forms of assessment, there are some applications that deserve special mention. A full discussion of each area is beyond the scope of this chapter, but we provide a high-level overview and offer resources that provide more in depth discussion and examples.

ACGME Milestone Assessment

The new outcome-based ACGME Next Accreditation System (NAS) cites simulation as a potentially powerful modality for practitioner assessment across the spectrum of training. Because simulation provides a standardized patient care experience it can augment direct bedside observation and help ensure that all key performance-based milestones are evaluated and carefully measured. If simulation is to be used in this way, new scenario and measure development will be necessary. This level of commitment requires significant resources from program leadership and simulation centers. Additionally, the use of simulation for ACGME milestone assessment may shift the development and implementation of the simulations from a formative, learning environment to one where assessments are highly structured and reproducible. Such simulations (scenarios and measures) must be supported by significant evidence of validity and reliability, and care must be taken to minimize measurement error. We suggest readers refer to an article by Beeson and Vozenilek that outlines some of the issues associated with simulation-based milestone assessment [2]. This article highlights opportunities to collaborate across specialties where procedural and core competencies can be broadly applied and encourages exploration of new and blended simulation modalities to enable examination of multiple skills (communication, procedural, diagnostic) during a single simulated event. The authors also note several challenges associated with simulation-based milestone assessment, including high cost, limitations in technology, and variability in assessment across institutions.

Table 7.2 Examples of validity evidence to be collected during development of simulation-based assessments

Simulation component	Source of validity evidence	Example of validity evidence	Example of mechanism to collect validity evidence
Objectives	Content Validity	SME review of objectives (deductive)	Ask experts to provide structured feedback regarding the nature of the objectives (e.g., formal questionnaire or focus group) and their appropriateness for the assessment modality
		Conduct a formal needs assessment to determine what objectives should be addresses (inductive)	Ask representatives from key stakeholders (program directors, unit managers, safety officers, etc.) what they perceive as priorities for assessment
		Use of standard assessment competencies (e.g., milestones)	Literature review, expert recommendation, credentialing requirements, etc.
Scenario	Content Validity	SME review of triggers SME review of scenario progression	Ask experts to provide structured feedback regarding the content of the scenario, its progression, and built-in behavioral triggers
	Response Process	Pilot testing of scenarios with post-simulation review to determine: 1. Representativeness of scenario 2. Diagnostic reasoning used during scenario 3. Degree of psychological fidelity 4. Behaviors provoked by scenario 5. Workload to provider ratio required to complete scenario tasks	Structured interview with learners/participants after pilot testing of scenario
	Internal Structure	Reliability of the scenario throughout the assessment process to ensure clinical cues and triggers occurred in a standard manner for all learners/participants- includes technical component as well as SP/actor roles	Evaluate the quality of each simulation using a simple checklist
Measures	Content Validity	Subject matter expert review of measures to ensure they: 1. Reflect standards of care 2. Are appropriate for the scenario and learners 3. Match the stated objectives	Ask experts to provide structured feedback regarding the nature of the assessment items and their appropriateness for the scenario, stated objectives, and learners/participants.
		SME review and ranking of importance or criticality of items	Ask experts to rate how critical a particular action or behavior is to the patient's outcome. This information can be used to develop a "critical action list" or to weight items in a comprehensive checklist.
		Literature review to identify existing measures and associated psychometric properties	
	Response Process	Review of measures by learner/participants to determine how they perceived the relationship between scenario behavioral triggers and assessment items	Structured interview learners/participants after pilot testing of scenario
		Review of measures by raters to analyze: 1. Rater conceptualization of items 2. Areas of rater of disagreement	Structured review process with raters after pilot testing measures
		Train and assess raters prior to initiating assessment	Develop and implement a formal training and assessment process for raters
	Internal Structure	Determine inter-rater reliability	Collect and analyze inter-rater reliability throughout the assessment process

SME subject matter expert

Credentialing and Continuing Medical Education

Simulation has the potential to significantly impact hospital credentialing and continuing medical education. Physician credentialing is the process of gathering information regarding a physician's qualifications for appointment, and the delineation of specific procedures in which a physician is approved to perform. Continuing medical education (CME) is ongoing training for practicing physicians to maintain their competency and/or learn new skills in their field. Credentialing and CME are key for patient safety as together they ensure physician competence and offer the means for physicians to stay current in their practice.

Incorporating a new skill-set is often a challenge for practicing physicians. Dedicated time for training is less readily available, and the resources and mentorship needed to train to a level of competence are considerable. A structured clinical competency experience utilizing simulation can be less resource intensive and facilitate the acquisition of high stakes clinical skills in a safe learning environment. One example of a new skill that was widely adopted is the use of point-of-care ultrasound (POCUS) in emergency medicine. Emergency physicians use POCUS to diagnose life-threatening conditions and assist with time sensitive invasive procedures. Mastery of POCUS requires proficiency in ultrasound image acquisition, image interpretation, and integration into patient care. Ultrasound training in emergency medicine became an ACGME requirement in 2003, and POCUS is currently one of the EM core competencies. Physicians who previously graduated may not be able to demonstrate competency due to lack of formal training, which is a key barrier for emergency physicians seeking hospital credentials in POCUS [42]. Well-designed simulation training supported by hospital administration can help physicians acquire new techniques. When integrated into the hospital privileging process, high fidelity ultrasound simulators and static ultrasound task trainers provide a reliable method for measuring performance and identifying providers in need of further training. In addition, administrators can ensure that physician performance accurately reflects hospital policy and procedures by using simulation during the credentialing process.

Team Assessment

Over the past decade, the importance of teamwork and interdisciplinary cooperation has been highlighted in patient quality and safety reports [43–45]. Emergency medical teams (EMTs) are interdisciplinary action teams that by definition require specialized expertise under uncertain and time-pressured conditions [46]. Simulations can replicate these time sensitive and complex emergency healthcare situations and provide the opportunity to assess team performance. Simulations allow EMTs the opportunity to practice critical processes and can help diagnose key teamwork deficits. Several articles describe approaches to simulation-based team assessment [7, 47, 48].

When simulation-based team assessments are designed, several factors must be considered. First, it is important that you clearly define the team-based competencies that you wish to measure. Using an established teamwork taxonomy, or categories of teamwork behaviors, provides a more evidence-based approach to measurement development. The teamwork behaviors chosen should be reflective of the type of team and the context in which the team performs [16]. For instance, the behaviors one uses to evaluate performance of an emergency department management team conducting a daily management meeting would likely be different than those used by a code team. However, if the management team had to respond to an emergency situation, their behaviors (and measures) should be more in line with those exhibited by the code team. Second, it is critical that teamwork assessments capture teamwork in addition to taskwork and outcomes. That is, one should ensure that measures capture the team-based behaviors (e.g., communication, planning, coordination) that make the team more effective, rather focusing only on clinical or procedural skill performance. Teamwork behaviors should be the focus of feedback and debrief sessions. Finally, one must clearly define the levels at which performance is being measured. Are individuals being assessed in a team setting? Is the team as a whole being assessed? Does the measurement tool accurately reflect these levels? How about the analyses? Level of analysis errors are common in team-based research and careful attention is required to ensure the objectives, measurement items, and analyses clearly specify the levels at which the assessment is to occur [49, 50].

The science of team training and assessment has historically been studied in the non-medical environment; however this body of knowledge is now being applied to healthcare. While this makes sense and is an appropriate place to start, caution must be taken, as it is likely that some characteristics of non-healthcare teams, such as airline crews, are unique and thus do not translate to a healthcare context. Involving team science experts in healthcare team training and assessment is highly recommended [51]. For more information on teamwork and team simulation, see Chap. 6.

Systems Assessment

In situ simulations, those simulations conducted within the actual healthcare setting, provide the opportunity to evaluate how individuals, teams, units, and multiple units function within an organization. *In situ* simulations also allow the evaluation of new equipment, protocols, or work spaces. For example, Geis et al. [52] describe using simulation to evaluate patient flow through a new emergency department and identify latent patient safety threats. Buza et al. describe a simulation designed to assess the emergency response system in a freestanding dental clinic, revealing information pertinent to the individual practitioner, the healthcare team, and the clinic system [53]. Thus, the simulation provided important feedback at multiple levels that could then be (a) integrated into a change plan and (b) re-evaluated. Several manuscripts outline processes for elaborating and assessing systems issues using simulation [54–56]. Kobayashi et al., in particular, outline a conceptual framework for understanding microsystem evaluation and training using simulation [55]. As with team-based evaluations, systems-level assessments are complex and we recommend leveraging the expertise of human factors and organizational psychology scientists when possible [57].

Simulation-Based Training Outcomes: Programmatic Evaluation

Overview

In this section, we turn our focus toward simulation-based training outcomes and ask the question "How can we demonstrate the effectiveness of simulation-based training?" One possibility is to demonstrate improvement in simulation-based performance. However, in light of the resources required to design, implement, and sustain simulation-based training efforts, educators and stakeholders are pushing toward more comprehensive, "higher level" patient outcomes (e.g., length of stay, hospital free survival) and system outcomes (e.g., infection rates, nursing retention). Below we describe issues related to simulation-based training outcomes and provide guiding principles.

Training Evaluation

Training evaluation focuses on determining whether trainees achieve a desired learning outcome. The most popular training evaluation framework is Kirkpatrick's model, which identifies four levels of outcomes: learner reactions, learning, behavior/transfer, and organizational results [58, 59]. Reaction-level outcomes reference how well learners enjoyed a training experience and have evolved to include perceptions of training relevance and self-assessed learning. Unfortunately, physician self-assessment oftentimes does not correlate with observed measures of performance [33, 60]. Reaction-level data is still useful when trying to understand learner motivation and attitudes and may provide insight into how learners view simulation-based experiences within the larger curriculum. Learning-level outcomes are objective measures used to assess improvement in knowledge, skills, or performance as a direct result of training. Written exams and simulation-based assessments are examples of learning-level outcomes. It is important to note that performance on a simulator, regardless of modality, is affected by familiarity with the simulation technology independent of clinical content and test material. Therefore, educators should expect some improvement over time due to test familiarity. Behavioral outcomes refer specifically to assessing the application of learned knowledge or skills in the work (clinical) environment. Medical education is increasingly focused on understanding training design factors that enhance transfer of learned behaviors to the clinical environment. Within emergency medicine, the unpredictable and variable nature of clinical care makes reliable and valid measurement of transfer quite challenging [61]. Finally, level four outcomes provide some assessment of the impact of training on the patient and/or the organization. This could mean patient-level outcomes, healthcare costs, resource utilization, etc. Such outcomes are often of greatest interest but also pose the biggest measurement challenges, as there are multiple factors that influence outcomes at this level.

When determining how to evaluate simulation-based training, it is important to consider the nature of what is being trained. The measurement "system" can then be designed based on theories applicable to the task being assessed [17]. For example, simulation-based team training outcomes should be selected based on conceptual models that predict where (individual versus team) and what (attitudes, behaviors, outcomes) should be measured. The goal of the measures (e.g., formative feedback, research) will also drive the decision of which measures to use. Applying these principles to training evaluation ensures an evidence-based approach and supports further testing of conceptual models of learning and performance.

Principle 16: Simulation-based training evaluation should be guided by conceptual models appropriate for the context and should consider the purpose of the evaluation.

Training Evaluation Versus Training Effectiveness

Traditional views of training assessment focus primarily on training outcomes [62]. While this is of value, we caution that evaluating training solely on the basis of outcome measures may answer the question "did the training meet objectives" but does not explain why objectives were (or were not) met. A more contemporary view of training program assessment focuses on *training effectiveness*, which is distinct from *training evaluation*. Training effectiveness models seek to understand why training is or is not successful by considering the impact of individual, training, and organizational factors on outcomes. Why is this important? Well, we know that the culture of an organization can significantly influence the transfer of behaviors to the workplace [63]. For example, when productivity is rewarded over patient safety, it is unlikely that a practitioner will transfer a newly learned safer (but lengthier) approach to a procedure. Capturing both outcomes and effectiveness would help further understanding of the complex issues that mediate training and outcomes.

Principle 17: Training assessments should aim to evaluate training impact while considering the contextual fac-

tors (individual, environmental, organizational) that may influence outcomes.

A Translational Approach to Simulation-Based Outcomes

Translational science research was originally defined as a "bench to bedside" approach to conducting biomedical research, with an aim toward accelerating the translation of basic science advances into clinical applications [64]. Education researchers have expanded the view of translational science to include rigorous clinical education as a mechanism to improve healthcare delivery [65]. Simulation-based medical education, in particular, has been cited as an example of translational science in education. Translational science research moves the science of simulation and education from the simulation laboratory (T1) to impact patient care (T2) and finally to directly affect patient outcomes (T3) [66]. As noted by McGaghie, et al., well-designed, thematic simulation-based translational science research programs leverage educational processes to produce measurable, sustained clinical impact. Simulation-based translational research, like it's biomedical counterpart, requires a multidisciplinary approach that focuses on rigorous qualitative and quantitative methods supported by conceptual models. This work is worthwhile. Translational research in simulation has the ability to significantly advance the quality and safety of healthcare delivery at patient, system, and population levels.

Summary

There exist evidence-based, best practice guidelines for simulation-based assessment development that result in objective-driven, event-based behavioral measurement systems that are reliable, reproducible, and supported by evidence of validity. The degree of validity evidence collected should reflect the purpose of the assessment and be aligned with how performance results are interpreted and utilized. Special situations such as team and systems-based simulations present additional challenges that can be guided by team and systems science literature.

Evaluation of simulation-based interventions should go beyond proximal outcomes to further understanding of why interventions are or are not effective. Such information will be critical as researchers and educators begin to build a strong foundation of knowledge to support simulation-based translational research programs. We provide a list of guiding principles, summarized in Table 7.3, to assist educators and investigators with future work.

Table 7.3 Summary of guiding principles for simulation-based measurement and program evaluation

Principle 1:	Assessment objectives should be clearly defined and appropriate for simulation-based assessment
Principle 2:	Translate assessment objectives into observable behaviors within a clearly defined clinical context.
Principle 3:	The goals and objectives of the assessment should drive the decision of which simulation modality, if any, to use.
Principle 4:	Scenarios should be designed using a methodologically sound approach.
Principle 5:	Event-based simulations that target specific, observable behaviors provide reliable, reproducible assessment platforms.
Principle 6:	Scenarios should contain event triggers that allow the clinical situation to unfold in a reliable, systematic manner for each trainee regardless of level of performance
Principle 7:	Back-up triggers should be designed to ensure progression of the event structure throughout the scenario.
Principle 8:	"Human" components of the scenario should be trained and evaluated.
Principle 9:	Assessments should include behavioral measures that are diagnostic and provide learner and programmatic feedback
Principle 10:	When choosing a measurement tool, consider feasibility and impact on educational goals as well as reliability and validity.
Principle 11:	Rater training is critical to reliable simulation-based assessments.
Principle 12:	The degree of rater training and monitoring should be based upon the purpose of the assessment and the nature of the metrics.
Principle 13:	The components of the simulation-based assessment platform should be integrated and tested as a whole.
Principle 14:	Collect evidence of validity for the simulation platform during both design and implementation phases.
Principle 15:	Match the level of rigor in design and implementation to the goals of the assessment.
Principle 16:	Simulation-based training evaluation should be guided by conceptual models appropriate for the context and should consider the purpose of the evaluation.
Principle 17:	Training assessments should aim to evaluate training impact while considering the contextual factors (individual, environmental, organizational) that may influence outcomes.

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Patient Safety

8

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Introduction

Nearly 16 years have passed since the *Institute of Medicine's* report: "To Err is Human," called for a safer healthcare environment. It specifically cited communication and teamwork as areas that required improvement and endorsed simulation as a tool to work on these areas. In the past 5 years, a significant body of research has accumulated substantiating the benefits of simulation-based deliberate practice and debriefing. Specifically, simulation has been shown to improve provider knowledge, skill acquisition and retention, and patient safety in the clinical domain [1].

Beginning in 2012 with the initiation of the Next Accreditation System (NAS), the Accreditation Council for Graduate Medical Education (ACGME) instituted milestones-based resident assessment. The Emergency Medicine Milestones project was a collaborative initiative by the ACGME and the American Board of Emergency Medicine (ABEM) [2]. The taskforce defined 23 discrete milestones to provide a framework for the assessment of the development of the resident physician in key dimensions of physician competency. Of these, 20 are amenable to evaluation using simulation (Table 8.1). Moreover, the "Patient Safety" milestone specifically evaluates residents on their acquisition of skills used in performance improvement to optimize patient safety.

To date, the majority of patient safety-focused simulation research has been described in the anesthesia, critical care, obstetric, and pediatric literature, but the principles have application in emergency medicine. Here we review the current literature and suggest optimal methods to apply simulation in the ED to improve patient safety.

Table 8.1 ACGME milestones amenable to simulation-based evaluation

Emergency Stabilization (PC1)
Performance of Focused History and Physical Exam (PC2)
Diagnostic Studies (PC3)
Diagnosis (PC4)
Pharmacotherapy (PC5)
Observation and Reassessment (PC6)
Disposition (PC7)
Multi-tasking (PC8)
General Approach to Procedures (PC9)
Airway Management (PC10)
Anesthesia and Acute Pain Management (PC11)
Other Diagnostic and Therapeutic Procedures: Vascular Access (PC14)
Patient Safety (SBP1)
Systems-based Management (SBP2)
Technology (SBP3)
Practice-based Performance Improvement (PBLI)
Professional values (PROF1)
Accountability (PROF2)
Patient Centered Communication (ICS1)
Team Management (ICS2)

ACGME General Competencies: *PC* Patient Care, *SBP* Systems-based Practice, *PBLI* Practice-based Learning and Improvement, *PROF* Professionalism, *ICS* Interpersonal and Communication Skills

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Procedural Safety

The proper, swift, and safe performance of critical procedures has been a cornerstone of simulation-based education since its inception. Over the last two decades procedural competency and performance measures have become commonplace terms in resident assessments as well as risk management department meetings.

Seminal work by K. Anders Ericcson when applied to the medical profession has clearly shown the direct impact time spent in quality, supervised, deliberate practice of medical procedures has on skill [3]. Simply put: the "see one, do one, teach one" methodology for procedural training is insufficient, potentially dangerous, and no longer ethically acceptable where simulation-based alternatives exist.

In the past, conventional wisdom equated experience with procedural success. However, we now know that experience alone does not lead to improved outcomes with respect to medical knowledge [4] or procedural competency [5, 6]. Mastery learning using deliberate practice has been shown to be more effective in improving procedural safety. A provider, who has engaged in a more substantial, longer training program for a specific procedure, who has passed a series of checkpoints or "milestones" along the way, and who continues to perform the procedure or practice it, will more likely produce better patient outcomes.

> Features of deliberate practice include repetitive skills practice under supervision of an engaged teacher, provision of individualized feedback, and an opportunity to correct errors through additional practice. It is hard to achieve important clinical outcomes without sufficient deliberate practice because procedural tasks require integration of knowledge and psychomotor skills. In order to transfer skills to clinical practice, learners must be familiar with the context in which procedures are performed and have the opportunity to develop problem-solving skills. For these reasons, an effective intervention to boost procedural skills includes both "knowledge and skill" training because both are needed to perform the procedure." [7]

Much of simulation research shows that after deliberate practice learners are able to acquire new knowledge and skills, and are more comfortable with their abilities [8]. McGaghie wrote "the power and utility of simulation-based medical education with deliberate practice toward the goal of skill acquisition is no longer in doubt, especially compared to traditional models of clinical education [9]." The larger question is: "does procedural training with simulation produce better outcomes for patients?" This body of research is not nearly as robust in the specialty of emergency medicine, however there has been some success in making these connections.

A series of landmark studies by Barsuk et al. investigating internal jugular (IJ) central venous catheter (CVC) placement demonstrated that educational interventions made on a low fidelity trainer can translate to better, safer patient outcomes in the clinical setting. These studies utilized a mastery training methodology and followed the training effect beyond the simulation lab. The first study showed that residents' skills with IJ line placement could be significantly improved, allowing for far fewer protocol breaches and fewer passes of the introducer needle in actual patient care as well as an overall reduction in immediate complications of the procedure [10, 11]. The same group went on to show that their learners retained their skills at 6 and 12 months [12]. These studies show translation of critical care skills learned in the simulation lab to the bedside. The group then went further to show that the overall catheter infection rate declined when a simulation-trained resident inserted the IJ [13]. Lastly, the group was able to demonstrate a cost savings to the institution because of the reduction in cost incurred by avoiding the infection [14]. This set of data clearly shows that simulation training can have an important, andpositive effect on patient safety and care.

Another example, from the anesthesia literature, has demonstrated that training improves outcomes both in the short and long term. Kuduvalli et al. presented two simulation scenarios – a "cannot intubate" scenario and a "cannot intubate, cannot ventilate" scenario – to anesthesiologists using a Laerdal SimMan mannequin [15]. After scoring their initial performances, they offered training according to the Difficult Airway Society's (DAS) British national guidelines for management of unanticipated difficult intubation [16]. In the "cannot intubate" scenario more candidates attempted tracheal intubation via LMA after training and this difference was sustained over time (at 6–8 weeks and at 6–8 months post-training). Successful intubation, however,was similar in both groups regardless of training. In the "cannot intubate, cannot ventilate" scenario, there was a significant improvement in the technique and success of cricothyroid cannulation in both the short and long term. This study supports improved procedural performance outcomes when using algorithmic training in high stress, high-risk situations.

Obstetrics simulation data involving shoulder dystocia deliveries have demonstrated great improvement in time to delivery and reduction in neonatal injury. Seminal studies such as Draycott et al. [17], Deering et al. [18], Goffman et al. [19], Crofts et al. [20] demonstrated that simulated dystocia deliveries improved outcomes significantly and laid the groundwork for national guidelines and checklists. Accrediting organizations such as the Joint Commission on Accreditation of Healthcare Organizations and the American College of Obstetricians and Gynecologists now recommend simulation of obstetrical emergencies, including shoulder dystocia for hospital teams.

Concepts demonstrated in anesthesia and obstetric care can easily be translated to the specialty of emergency medicine, with its focus on procedural care and its high intensity, high stakes environment. Further evidence and research in the translation of simulation education to clinical outcomes will be critical for improvement in patient safety [21].

Safety in Clinical Care

The mantra of emergency medicine is to "be prepared." Patient safety is particularly at risk in the ED for a myriad of reasons. Transitions of care, critical procedures, department volume, decision density, interruptions, dynamic clinical conditions, and evolving etiologies are all confronted daily in a busy ED.

Most emergency medicine physicians and staff would agree that there are certain cases that are so frequent and common in the ED that the care can become "routine." These "high frequency" cases must be treated with a consistently high degree of skill in order to maintain a strong quality standard.

Conversely, there are high stakes cases that are rarely experienced in clinical practice which can cause a great amount of stress. Diagnostic difficulty, unfamiliarity with rare procedures, and communication breakdowns are more likely to occur. These cases also pose a particular problem for departmental systems, as it can be difficult to adapt usual workflows to fit these rare instances. Consequently, care can be compromised and the patient can be put at risk for an adverse event. The question then becomes how to teach and practice for these low frequency, high-risk scenarios. Simulation allows physicians and staff to experience these clinical scenarios and apply deliberate practice in the management of these cases. Just as deliberate practice of procedures is important for improved patient outcomes, creating familiarity with rare case presentations can increase patient safety by enhancing vigilance, increasing provider comfort with unusual clinical situations, and allowing for rehearsal of teamwork and communication.

Standardized courses such as ACLS, ATLS and PALS have incorporated simulation into their curriculum for years and are now incorporating "mega-codes" to assess participant learning. The difficulty has been in demonstrating that the "mock" codes translate into better skill mastery and, thus, better patient outcomes. In a study by Wayne et al., internal medicine residents tested at 14 months post-training showed improved skill retention when a simulation-enhanced ACLS course was used [22]. Skill retention is one of the most vital components of increasing physician and staff confidence when dealing with low frequency-high risk scenarios. Two years later the same group was able to show that their educational interventions actually translated to better adherence to AHA guidelines during real patient cardiac arrest events. Unfortunately post-event survival was ultimately not different between the study groups This finding was attributed to the underlying severity of patients' conditions rather than adherence to the protocols. This study serves as anexample of how simulation based educational interventions can impact patient care [23].

In Situ simulation is a method that can be used to identify errors and uncover system vulnerabilities by conducting simulations within the work environment. This allows hospitals to test new hospital procedures or processes. Obvious errors and hidden errors within the environment can be revealed using in situ simulations allowing correction so they do not occur during actual patient care [24]. During *In Situ* simulation, a standardized patient or portable mannequin is placed within the work environment such as in the trauma bay or in a patient room, and the simulation case plays out in the typical care area, rather than the simulation lab. Again the difficulty becomes demonstrating true causation between *in situ* simulation and increased patient safety, but there have been studies that demonstrate a correlation. In one example, Andreatta et al. [25] introduced mock codes within a children's hospital over a three-year period. Random mock codes using a high fidelity mannequin were called at an increasing rate over a 48-month period with immediate debriefing and feedback. Pediatric cardiopulmonary resuscitation survival rates for the hospital over the same period. Survival rates of patients after cardiopulmonary resuscitation increased by 50% over the same time period correlating with the increased frequency of mock code training. These rates were stable for 3 years. The findings of this study demonstrated a high correlation between systematic, sustained simulation training and a significant improvement in patient outcomes .

Similarly Hunt et al. developed a simulation-based teaching approach, termed "Rapid Cycle Deliberate Practice," which focuses on rapid acquisition of procedural and teamwork skills. This method uses direct feedback and allowed multiple opportunities for residents to "do it right." Specifically, during and after each scenario residents received specific feedback and the same scenario was repeated until correct behavior was demonstrated. Residents that received this intervention showed improvement in key measures of quality pediatric life support (interval between onset of pulseless ventricular tachycardia to initiation of compressions and defibrillation) [26].

Hospitals have recognized the usefulness of simulation in training and increasing skill retention. Specific scenarios and interventions have been created to assess measurable clinical outcomes for high-risk scenarios. We will discuss a few of these below. In the authors' health system, several interventions have been implemented. The first program was to prepare ED physicians and staff for precipitous vaginal deliveries. Two of the four hospitals in the system do not have labor and delivery units. Our ED physicians identified a gap in staff skill and comfort when presented with this scenario at these two EDs. The devised intervention consisted of bringing a team from the simulation lab (physician, technicians, nurses) to the ED for an in situ simulation at morning shift change to capture as much staff as possible. A standardized participant playing a mother in labor was in one of the ED bays and staff was told to treat the standardized participant as they would any patient in the ED. The standardized participant, housed with a Prompt Simulator, declared that she was pregnant to the staff and and then proceeded to simulate a precipitous delivery of SimBaby. ED attendings and staff were evaluated in the assessment and management of the mother and newborn, teamwork, communication, and on their efficiency in arranging for transfer of the patients to one of the obstetric-capable hospitals. Immediately after the scenario, a debrief was led by a simulation fellowship-trained emergency physician. Systems issues (i.e. the discovery of a non-working infant warmer), equipment unfamiliarity, and clinical knowledge gaps involving nuchal cord manipulation were identified. A second in situ program that has been instituted at our hospital system was based on clinical cases in which recognition of hypoglycemia in hospitalized patients was delayed. Simulation and diabetes education staff presented to inpatient floors where nurses were to assess a standardized patient with symptoms consistent with hypoglycemia. After the scenario nurses were shown a computer module on how best to address hypoglycemia within our hospitals' best practice guidelines. Post-tests given to nurses showed improvement in recognition of hypoglycemia and the implementation of a "15 g within 15 min" program. Longitudinal tracking demonstrated a 17% improvement in the treatment of hypoglycemia [27].

One of our earliest quality and patient safety-oriented programs was entitled the "First 5 min" Program. Using patient safety data delineating the top five most common chief complaints of floor patients who decompensated in our health system, we created scenarios to train floor nurses on early recognition and resuscitation for these patients. In addition, we trained them to use SBAR-reporting to improve their communication skills. The initial round of training led to a 50% decrease in cardiac arrests on the medical floors where the training was performed. As a result, we have continued this as a regularly scheduled program.

We have successfully applied simulation-assisted training for patient care initiatives in various clinical settings: using simulation for state-mandated obstetric hemorrhage and shoulder dystocia training, having every emergency physician practice on new equipment (i.e. new video laryngoscopes) before they are deployed in the ED, and operating room teamwork training using an "OR fire" scenario.

In 2013, we piloted an interdisciplinary simulation-based teachback training program initiated by our pharmacy department to address patient understanding of discharge instructions and medications for heart failure (CHF) patients. Simulations were created using standardized patients to train the nurses and pharmacists on the CHF floor at one of our hospitals. The training required the learners to be use flexible communication to discuss discharge instructions/medications, and assess for understanding using the teachback method. Patients were contacted to assess medication adherence and readmission rate was tracked. We found that patients who were treated on the floor where training was provided had a decreased CHF readmission rate relative to other CHF floors in our health system. This effect lasted about 1 year.

Another program, initiated in 2015 by our NICU staff, was to train parents of special needs infants on the care of equipment (tracheostomies, feeding tubes, or any other lines) and management of typical problems (i.e. respiratory distress) in the simulation lab before they parents took their child home. Parents and staff have reported that those who have participated in this program have increased comfort and skills with the outpatient care of these infants.

Safe Teamwork

Good teamwork is essential to the safe practice of medicine [28]. Teamwork and communication skill improvement have been a major focus of hospitals seeking to improve patient safety since the release of *To Err is Human* in 2000 [29]. A team is defined as two or more individuals who work together to achieve a common goal using specialized skills and knowledge [30]. Certain knowledge, skills and attitudes (KSAs) are often attributed to teamwork and recognized behaviors such as the "huddle" are often used as a measure of good teamwork [31, 32]. Although individuals on teams may have expertise in their respective fields (nursing, medicine), a team of experts often does not produce expert teamwork [33]. This is true in situations where team members do not work together frequently or in high risk environments such as critical care or emergency medicine (ad hoc teams). Seventy to eighty percent of healthcare errors can be due to poor teamwork and understanding [34]. Simulation has been used extensively to help teach and assess teamwork skills in these situations.

In situ simulation has also been used to assess and identify teamwork capabilities. Patterson et al. implemented in situ simulations in the ED to identify latent or hidden safety errors [35]. They created scenarios in which a multidisciplinary healthcare team responded to critical simulated patients in an urban ED during all shifts. Recorded scenarios and debriefing were used to identify safety errors. Although there was no significant change in non-technical skills, the authors felt the simulations were effective at identifying errors and reinforcing teamwork skills. When striving for high reliability, teamwork is a vital element. All members of the team, whether they are nurses or physicians, must be coordinated to achieve safe patient care goals [36].

Communication is *the* critical entity for safe patient care. Teamwork should not be narrowly defined as the behaviors and actions performed by individuals who comes together during a crisis such as a cardiac arrest. It can be as subtle as the dynamics of an interaction between a physician and nurse discussing the care of a patient or when a physician transitions care to another physician. This happens frequently and all too often haphazardly in the ED. Handoffs between emergency medicine physicians and hospitalists often have gaps in communication due to specialty-based practice and cultural differences based on what is felt to be important in a clinical story [37]. Nurse and physician communication lapses are often based on delay in sharing important clinical changes. Creating specific prompts and reinforcing specific behaviors can lead to the decrease in communication delay and gaps in both these settings.

The Emergency Medicine Leadership Council in 2010 endorsed simulation as an important tool to teach and practice teamwork and communication techniques. Many studies show improvement in communication as part of a larger measurement of teamwork. For example, in Morey et al., there was a statistically significant improvement in quality of team behaviors between the experimental and control groups following training [38].

The teaching of teamwork knowledge, skills, attitudes, and behaviors with deliberate practice in various simulations has been shown to improve teamwork. In Wallin et al.'s study, medical students were assessed on team skills before and after simulated trauma team training. They were then allowed to practice team skills in 5 different full-scale simulation scenarios with feedback. Ninety percent of the behaviors measured improved after intervention [6]. Using in situ simulation to assess and practice teamwork in pediatric trauma resuscitations, Hunt et al. showed more teamwork tasks being implemented as well as significant improvement in some of those tasks [39]. Both of these studies show that using simulation to teach and practice teamwork can help improve team performance. Shapiro et al. showed a trend to improved teamwork skills observed in the clinical setting after deliberate practice of a teamwork intervention in a simulated environment was added the existing curriculum. Although findings were not statistically significant, the trend encouraged the use of simulation in teamwork teaching [40].

Teamwork training courses such as the Emergency Team Coordination Course (ETCC ©) and TeamSTEPPS ® use simulation to practice and reinforce concepts. Both courses emphasize the importance of specific KSAs in the interdisciplinary team. Since medical and nursing education is frequently separate, there is often a struggle when these two groups of medical professionals are placed on a team without any practice. These courses were made to be interdisciplinary to help to create a shared mental model and for medical professionals to recognize the common goal they have in patient care. TeamSTEPPS ® is a validated course to help teach teamwork [41]. The Agency for Healthcare Research and Quality (AHRQ) developed TeamSTEPPS ® to improve leadership, situation monitoring, mutual support, and communication vital aspects of teamwork [42]. Lisbon et al. showed that the knowledge and attitudes of ED staff significantly improved after TeamSTEPPS ® training at both 45 and 90 days after implementation [43]. The adoption of the huddle behavior was also noted in the study. In Capella et al. trauma teamwork in the clinical setting was shown to improve after TeamSTEPPS ® training. It also had a positive impact on patient care with decreased in times to the CT scanner, intubation, and transfer to the OR [44]. Perceptions of teamwork are also hard to measure. The TeamSTEPPS Teamwork Perceptions Questionnaire (T-TPQ) instrument for measuring perceptions of teamwork was found to be a highly reliable instrument with construct validity [45]. Overall TeamSTEPPS has been shown to be a successful way to improve patient safety through the use of simulation.

As stated by Eppich et al., "successful teamwork, including good communication, lays essential foundations for well tolerated, effective care in the dynamic, high-stakes and often ill-defined environments of emergency and critical care pediatrics" [46]. By improving teamwork, one can decrease errors in communication and other skills that will in turn improve patient safety. The best method to help teach these skills and help to retain them is through the use of simulation.

Conclusion

Medical simulation has been advocated for a myriad of applications in emergency medicine to improve procedural skill, communication, teamwork, and clinical care While there is a growing body of evidence demonstrating that simulation improves patient safety practices, significant ED-specific clinical outcomes remain difficult to measure. Building on the demonstrated positive clinical outcomes described in the studies in this chapter, investigators should continue to devise research studies to evaluate where simulation training will yield the best return on investment and greatest patient safety results. Because the emergency department is a dynamic, chaotic, and high-risk environment, research demonstrating the effectiveness of simulation in improving patient safety outcomes will likely have tremendous impact on advancing the overall quality of the healthcare delivered to our patients.

Take Home Points

- Procedural training can improve competency. Studies have shown improved outcomes using specific procedures such as central line placement, dystocia deliveries, and difficult airway management.
- Conducting simulations within the work environment or "in situ simulation" is a method that can be used to identify errors and uncover system vulnerabilities.
- Teamwork training via in situ simulation has been shown to improve communication and teamwork measures.
- Specific programs, like Team STEPPS, are publically available, established and can be used in a variety of settings
- Further evidence and research in the translation of simulation education to larger outcomes such as reduction in errors and improved quality is needed

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Part II

Simulation Modalities and Technologies

Standardized Participants

9

Jeffrey N. Siegelman, Sidhant Nagrani, Connie H. Coralli, and Douglas S. Ander

Standardized participants (SPs) have become an increasingly important component of simulation-based healthcare education. SPs is a broad term that defines a lay person who has been trained to portray, to "simulate" a variety of medical situations [1]. They can also be trained to assess performance and provide feedback. When a SP is used in an assessment environment they typically do so in a highly consistent "standardized" manner.

The roles that the SPs can play are broad and can include a patient, family, health care provider and more. Typically when in the patient role the SP is often termed the confederate. They are scripted in this role to provide realism and additional challenges within the case or provide additional information and cues when needed.

SPs can be used in a variety of educational situations. They can be trained to simulate a wide range of medical and communication scenarios and also provide feedback to the student as part of the formative process [2–6]. In addition, they can be used to educate learners in more difficult encounters such as breast, pelvic and rectal examinations [7]. They can also be trained within the context of an objective structured clinical examination to assess the student using a checklist [8]. SP encounters may be one-on-one or part of a simulated encounter that includes high fidelity simulators. SPs can provide a standardized experience, allow learners to practice in a safe environment, improve efficiency by not using actual faculty for teaching and assessment, and provide the convenience of having a program available for a wide range of educational needs.

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Utilization of Standardized Participants: Formative Roles

There is a push toward training medical personnel in patient care prior to actual interactions with patients. There are several motivations for this change: an ethical/moral imperative [9]; a mandate toward competency-based assessment of trainees [10]; and achieving better healthcare outcomes [11]. Simulation is becoming increasingly accepted as a modality of training to achieve these goals. There are multiple opportunities within Emergency Medicine (EM) education for the use of SPs as part of a simulated experience.

Teaching Communication Skills

General

Almost all medical personnel are required to take a medical history from their patients, but giving learners the opportunity to practice this skill can be a challenge. This training is typically done with the aid of real patients, but sometimes finding patients with histories suitable to illustrate a teaching point who are also willing to participate in a teaching exercise is difficult. It is also unreasonable to expect a sick patient to provide the same history for multiple learners in a scripted fashion. Further, controlling these patient encounters can be extremely challenging, and in some cases, impossible. With standardized participants, a suitable history can be constructed, and the SP can change their behavior as needed to help train the learner in a relatively safe environment with low clinical stakes. The SPs can provide feedback to the students following the simulated encounter, and thereby serve as teachers. In addition to the relatively simple skills of obtaining a history and communicating with the patient an SP provides a perfect opportunity to practice more difficult skills such as delivering bad news, disclosing errors, and dealing with difficult patients. Some specific instances in which SPs are particularly useful in emergency medicine

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training and beyond are described below. A particular disadvantage to the use of SPs is the cost of using them for a large number of trainees. The costs described later may not be significant for each individual SPs time but the dedicated staff that is required to administer an effective program will significantly increase overall costs. Fidelity and reliability can be a concern. Although mitigated by training, enforcing consistency over multiple encounters can be challenging and relies on the skill and experience of the SP involved [12].

Bad News Delivery

Teaching the delivery of bad news of various types can be accomplished using SPs [13]. Imagine a scenario where a learner has to inform a patient they have been diagnosed with cancer. The learner may be expected to simply give the SP a "warning shot" and then deliver the bad news. However, the learner may not behave predictably or apply the techniques as being taught, necessitating the SP to react realistically and appropriately to the situation, while subtly providing the learner with opportunities to steer the encounter in the desired direction and at the same time being careful not to lead the learner. Training of the SPs becomes an important, yet time consuming, component of a SP program to minimize lack of standardization.

A type of bad news delivery is death disclosure. Death disclosure is perhaps the single most difficult part of a physician's job. The SP as a family member allows the learner opportunity to gain comfort with a skill set to effectively inform the family of the patient's death and then guide them through the challenging process of hospital paperwork, identifying the corpse, summoning a spiritual leader to aid them as desired, as well as helping in funeral home selection while simultaneouslygiving them space to grieve [14].

Disclosure of Adverse Events/Medical Errors

Adverse events and medical errors occur due to a variety of reasons. Not all are preventable or ameliorable, and many do not impact the patient negatively. However, it is considered best practice to inform the patient of all medical errors and adverse events. This maintains the patient-provider trust while fulfilling the provider's ethical duty to the patient. SPs can be effectively used to simulate patient encounters where medical personnel are trained to effectively report medical errors and adverse events to the patient [15].

For example, a patient presents suffering from burning on urination, and is diagnosed with a UTI. The physician orders a cephalosporin, overlooking the patient's penicillin allergy. Even if no adverse event occurs, to maintain trust, it would be advisable for the physician to disclose the medical error. SPs can be effectively used to play the patient in this scenario, allowing the physician to gain comfort in admitting an error, while reassuring the patient that more attention would be paid in the future.

Difficult Patients

Dealing with difficult patients is by far one of the most challenging parts of a healthcare provider's practice. It demands that the provider adequately address the patient's concern, be it having to wait an extended amount of time to be assessed, or a failure to meet the patient's expectations in care. This can be complicated by various emotions the patient is experiencing at what is often a very challenging time in their lives. The health care provider must manage the patient while keeping a check on their own emotions. An SP experience can provide a valuable and underused resource to help the physician develop this valuable skill. For instance managing a patient with an alcohol abuse complaint who is defensive about their condition can be simulated by a SP and used to provide direct feedback [16].

Sexual History and Addressing Intimate Partner Violence

Sexual history taking is a sensitive yet critical part of the patient-provider interaction. Both the patient and provider may harbor feelings of anxiety, prejudices, and hesitation in discussing sexual issues and practices that can put the patient at risk. This is especially true when interacting with lesbian, gay, bisexual, and transgender patients. SPs offer providers the opportunity to rehearse sexual history taking and develop use of inclusive language in a safe, welcoming atmosphere [17, 18]. Similarly SPs can be used as part of a program to teach about Intimate Partner Violence [19, 20].

Team Leadership and Team Building Skills

Implicit in all exercises where SPs form a part of a medical team--be it medical, surgical, or resuscitative, or even when performing the role of confederates providing impetus to a clinical scenario--is that SPs are helping the learners develop both team leadership, as well as teamwork skills. Any team exercise allows the leader to assign roles and coordinate the team's effort, thereby building leadership skills. The exercise also allows team members to train in their specific roles, while practicing closed loop communication and developing strong teamwork. All the while, the SPs in the role of an embedded participant can subtly prompt the scenario toward its intended purpose. For example, although a well-trained nurse may habitually practice closed loop communication and repeat all orders back to a doctor who is leading an ACLS resuscitation, an SP playing a nurse may choose to remain silent, or even not carry out an order at all, forcing the team leader to seek confirmation of the order having been carried out [21].

Physical Examination

Sexual Assault Exam

This forensic examination is not typically addressed in medical school education but a necessary skill in EM. It is also the type of skill that is best suited to be taught in a simulated environment with the use of SPs due to the nature of the examination, its legal implications, and the emotional state of the patient. The SP can be used to teach both the necessary communication skills and the correct collection techniques for this examination [22].

Critical Care

Family Witnessed Resuscitation

Here, SPs can serve multiple roles. In a set of EM resident physician training exercises conducted by one of the authors, medical personnel played the roles of nurses and parents during the family witnessed resuscitation of an infant in cardiac arrest. The SPs who played the part of nurses and the family brought more realism to the scenario by making it cross disciplinary, and aided in moving the learner toward the goal of conducting family witnessed resuscitation of a high-fidelity infant mannequin. They could also prompt the physician learner to pay attention to the family as needed to help fulfill the goal of the exercise. As frightened parents, the SPs allowed the learner to balance comforting and informing the parent with the medical responsibility of reviving the patient. The exercise built strong team leadership skills by assigning tasks to various team members (including SPs), while simultaneously running the resuscitation. Although there is no evidence that use of confederates during family witnessed resuscitation is valuable there is some literature that denotes increased stress with these types of distractors and the need for research on the effects of training [23, 24].

Utilization of Standardized Participants: Summative Roles

As undergraduate and graduate medical education moves towards competency-based medical education, the use of simulation for high stakes summative assessment will increase. As part of the Accreditation Council for Graduate Medical Education's Next Accreditation System, each specialty has broken the six core competencies down into sub-competencies specifically focused on the training needs of its residents [10]. Within each sub-competency are specific milestones which residents must meet to achieve the next level of proficiency. EM has twenty-three sub-competencies, 19 of which list simulation as a suggested evaluation method (See Table 9.1). Undergraduate medical education is moving towards Core Entrustable Professional Activities for Entering Residency identified by the Association of American Medical Colleges as a set of "graduation competencies" - activities that are necessary prior to starting residency [25]. For many of these, SPs would be an appropriate adjunct to teach these professional activities and assess for competency. SPs have been a routine component of the United States Medical Licensing Exam Step 2 Clinical Skills Exam assessing both communication, physical examination, and interpersonal skills [26–28].

Table 9.1 EM sub-competencies suitable for assessment using standardized participants

Patient care	Interpersonal and communication skills
PC1: Emergency Stabilization	ICS1: Patient Centered Communication
PC2: Performance of Focused History and Physical Exam	ICS2: Team Management
PC3: Diagnostic Studies	
PC4: Diagnosis	**Professionalism**
PC5: Pharmacotherapy	PROF1: Professional Values
PC6: Observation and Reassessment	
PC7: Disposition	**Systems-Based Practice**
PC8: Multi-tasking	SBP1: Patient Safety
PC9: General Approach to Procedures	SBP2: Systems-based Management

In the Emory University EM Residency program, semi-annual high stakes assessments are conducted individually with each resident using either high-fidelity simulation or standardized participants depending on the content and milestones being assessed. These sessions are in addition to the more frequent formative sessions so that all residents are comfortable with the simulation or SP environment at the time of high stakes assessment. Faculty raters, in a separate space, observe the clinical encounter and rate the performance on a critical actions checklist with each observable behavior mapped to a specific milestone. Time is reserved for feedback and brief teaching points.

Medical student emergency medicine clerkships and residencies use SPs as part of end of rotation Objective Structured Clinical Examinations (OSCE)s [29, 30]. They typically play the part of the patient but can also fill the role of the nurse. In addition to playing the various roles, the SPs can be trained as evaluators [31].

Use of Embedded Participants

Nurse

Utilizing SPs as nurses, especially those who have worked clinically in that role, can add to student immersion and the overall feeling of realism in the case. They serve in the role of an embedded participant confederate using their clinical knowledge to improve the fidelity. Additionally, the nurse can be directed to steer the flow of the case away from unintended pathways allowing the focus of the case to reflect the objectives. The nurse can be used to insert a medication error to assess situational awareness and use of a variety of communication tools. The nurse can also provide a running account of actions performed or orders requested which the rater may have missed or even complete the entire checklist if properly trained.

Depending on the clinical experience of the nurse and the quality of the SP training program, standardization from case to case can require varying levels of resources. Training must focus on both teaching relevant medical concepts so that the SP can respond appropriately to orders, as well as on the level of involvement the SP should offer. In most cases, they should serve as a passive adjunct for the learner, carrying out orders but not offering specific data or suggestions. As we will discuss more below, properly training SPs ahead of their roles is extremely important.

Family

The SP can serve two main purposes when serving as a family member or witness. Primarily, the SP can set up the opportunity to assess competencies related to communication and professionalism. This can also include ethical issues, such as discussing a Do Not Resuscitate order or managing a family-witnessed resuscitation. In addition, the SP can serve as a distractor whom the learner must appropriately manage during the case. Keep in mind that distractions embedded in the case may make it difficult for a junior learner to complete critical medical actions of the case. Therefore, when creating the case determine the level of the learner and the goals in mind, such as assessing multi-tasking or flexible communication strategies. Levels of distraction must be tailored to the learner to create a realistic environment without distracting from the learning objectives of the case. Distractors should only be added with the goal of helping the learners reach the learning objectives.

Emergency Medical Services (EMS)

In cases dealing with patient handoffs, the rater may choose to assess the learner's ability to receive the EMS report. In most instances, however, this report can be easily delivered by the simulation operator or on a visual stimulus, obviating the need for this costly resource.

Consultant

Some scenarios benefit from having an SP play a medical consultant in the room, as opposed to having the simulation operator provide a voice only. This can help focus the learner on the skills or behaviors being assessed without distraction. For example, when testing procedural sedation competency, it might be helpful for an orthopedic consultant to perform the reduction or fracture manipulation so the learner can focus on the sedation. It might be difficult however to train an SP actor who does not have medical experience to act and respond like a sophisticated medical consultant. Thus, they may detract from the sense of reality more than they contribute to it.

Patients

The SP can also serve as the patient directly during a high stakes assessment. This allows for more direct assessment of provider-patient communication and professionalism, both by the SP and a third-party rater. One can also use the SP to assess case scenarios which are not easily simulated by a high-fidelity mannequin, such as neurologic or psychiatric complaints. Extensive training is key to successfully executing these cases in a standardized way which accurately reflects the disease pathology intended in the case scenario. Also, anticipating and scripting responses to deviations from the intended case flow is important to be able to assess the intended behaviors.

Hybrid

SPs can be used in conjunction with high fidelity simulators. For instance a labor and delivery scenario could use an SP as the mother communicating discomfort while using a split table and sheet and an obstetric simulator can be used to allow the learner to deliver the baby. The same can occur with task trainers such as having the trainee place a central line or a chest tube while caring for a SP who requires and emergent intervention. This allows for assessment of both communication skills and the necessary psychomotor skills.

Use of SP for Feedback

Standardized participants have a unique opportunity as participants to provide feedback to learners, as they simultaneously participate in, and witness the simulated patient encounter. This allows them to pick up on subtleties of a patient encounter that even multiple video angles or observers cannot capture. This feedback can be provided either verbally or in a written format.

Verbal Feedback

Often used in formative assessment, verbal feedback from an SP can quickly inform a learner of how they could improve on their performance. This information could be as objective as reminding the learner to order a specific lab test, or as subtle as providing feedback on how the learner's attitude and performance made the SP feel as a participant in the encounter. For example, if the SP is playing the role of a family member in a family witnessed resuscitation, they can give feedback to the learner as to whether the learner showed enough consideration toward family members, and included the family in the resuscitation. If dealing with a difficult situation such as delivering bad news the SP can provide feedback related to empathy, physical distance, and eye contact. It can be difficult for an external rater to fully appreciate these nuances, and is often better judged by someone actively participating in the simulated encounter.

Checklists

Checklists are often used during summative assessment to judge the level of the learner's competence [32–34]. In the authors' program, biannual summative assessments allow evaluation of EM resident physician performance, and faculty raters observing the encounter fill out checklists to assess the learner's competence. Given the distance from the learner, and limitations of audio/video recording equipment, faculty often verify their observations with an SP playing nurse during the encounter, who independently records observations. In other instances, the SPs serve as the primary raters themselves, and fill out a checklist.

SP Program Administration

SP Skill Requirements

Portraying a case and being able to consistently and in a standardized manner deliver the history and physical simulations of the case is important. This tends to be the easiest part of being an SP. Another essential skill is the ability of the SP to remember what each learner does or does not do correctly until the case concludes and the SP completes his/her checklist from memory. This tends to become progressively more difficult to do accurately as the day progresses and learners begin to run together in the SPs mind. For this reason it is important to limit the number of learners an SP will encounter in a session as well as the number of checklist items the SP will complete for each learner. The longer the checklist and the more learners an SP encounters in a session, the less accurate the checklist completion will be. The other important skill necessary for an SP to be successful is the ability to give professional feedback which includes recognizing and prioritizing what parts of the learner's performance are most important for feedback as well as delivering it in a professional manner. It should be noted that the literature surrounding SP abilities is not robust and many of our statements are based on experience, expert opinion, and guidelines from the Association of Standardized Patient Educators (ASPE).

Developing a Group of Trained SPs

Ideally, an institution would have an identified and trained group of SPs readily available. If your institution already has an SP program, this would be the place to start. If not, the program will need to be developed from scratch. The program director may either choose to recruit individuals who will fill a particular need or start building a group that includes individuals who could fill diverse age, gender, racial and body type needs.

Identifying an initial cohort of potential SPs may seem challenging. Successful SPs can come from a variety of backgrounds. The question of whether to use actors or non-actors is a frequent topic of concern in SP programs although there is no literature investigating this question. Actors come trained to portray a wide range of characters and are used to their performances being tweaked until the performance is deemed satisfactory. Non-actors (for example teachers) on the other hand may require more training and direction to portray the character realistically, but their attention to detail, memory, and experience giving feedback in other settings may outweigh those issues. Whatever the background of SPs, the same skill set is required for success. Many programs use a mixture of actors and non-actors and are able to incorporate both successfully into an SP program.

Contacting actors (acting schools, community theaters, etc.) is a simple place to start. Other groups who have been successful sources of SPs are retired educators and school alumni. Many programs recruit from the general population at large with help wanted ads such as "adult learners needed to educate medical students." Once a group of SPs are in place, word of mouth is an ideal way to locate additional candidates.

Most SPs are hired using a combination of application, interview, audition & orientation. An application form collects basic demographics information and should be accompanied by a head shot (if the applicant is an actor) or a photo otherwise. It is important to obtain information about abnormal physical findings the applicant has as these can influence casting decisions. Although not a common practice, a physical exam could be performed as part of the application process to assess physical findings and determine their relevance to cases they might portray.

At an in-person interview and/or audition information can be gathered about the applicant's:

- Ability to follow directions
- Reliability and punctuality
- Understanding of the role

As part of the audition process it is helpful to show the applicants a video of an SP encounter so they clearly understand what they will be doing. Many applicants, for example, are surprised that they will be examined while in a hospital gown. Also, an explanation of the extent of the physical will be important so they understand the boundaries unless they are being hired specifically for more personal elements of the physical exam such as the pelvic or male GU exams.

It is also useful to train applicants for a simple case that includes a physical simulation, have them portray it with a "learner," and have them complete a simple checklist. This exercise allows one to evaluate portrayal, memory and checklist completion skills.

The interview and/or audition can also be used to explore that applicant's motivation for being a SP. Asking the applicants why they want to be an SP and to describe previous interactions with physicians can identify potential SPs whose motivation is to right a wrong they have experienced with physicians. This motivation rarely results in a successful SP. Look for SPs whose motivation is to contribute to the education of health professionals or whose goal is to practice their craft in a new setting. SPs who come at this work from a coaching or teaching perspective will likely be more successful.

Casting an SP for a Specific Case

Once applicants are selected for the program, it is helpful to provide initial orientation and practice in portrayal, checklist completion and feedback. Once an SP has demonstrated his/her skills in the basics they can be cast in any case for which they meet the basic demographic characteristics and do not have any abnormal physical exam exclusions. When casting SPs for a particular role, it is important to the fidelity of the case to choose an SP who is consistent with the age and gender of the patient they will be playing. To do so otherwise is confusing to the learner and makes it more difficult for the learner to suspend the disbelief necessary to fully engage in the simulation experience. For instance, to portray a pregnant woman, an SP would need to be a female of child-bearing age. Body habitus and scars may need to be considered as part of the casting process. For instance an abdominal pain case may require exclusion of a SP with exploratory laparotomy scar unless you want to steer the case towards a small bowel obstruction.

SP Training

In order for the SPs to perform well they must understand the expectations of them. Case specific training is necessary for all simulations no matter how simple they seem to the clinician. The amount of training needed varies depending on the complexity of the case, the skills being required of the SP, whether the experience is formative or summative, and if summative, how high the stakes are for this exam. Most cases for formative experiences or low stakes exams can be trained in several hours.

The SP should be sent written case materials before the training date so that they can learn those materials and memorize the details of the case and come to the training prepared. The Association of Standardized Patient Educators' website (www.aspeducators.org) has a number of case templates in their Virtual Learning Center accessible to members which will help to organize the case material. An SP trainer, if available, can assist with getting these materials in a format that will be easy for the SPs to understand and incorporate. Jargon should be eliminated or explained and the materials should be organized in a logical manner for the SP.

In person training, at a minimum, will consist of:

- A review of the logistics of the event (date, time, number & level of learners, whether checklist completion & feedback is required, etc.)
- An overview of the objectives of this event
- Answering questions the SPs have about the case
- Conducting a "table read" or run through in which the trainer or faculty serves as the learner and takes the history of/performs a physical exam of the SP. If there are multiple SPs portraying the same case, this will be the opportunity for standardization of the portrayal.
- Practice of all physical simulations as a group to ensure standardization.
- Review of the checklist and discussion of the grading criteria
- Discussion and/or practice of feedback/debrief methods

Other training techniques that may be used include:

- Reviewing films of previous events using the case
- Practice scoring checklists of previous videos
- Practicing feedback of learners on prior films

Some scripting of "unscripted questions" is necessary when training the SP since it is never known what the learner will ask or how it will be asked. As a rule, SPs are taught to answer negatively to any question to which they have not been given a specific affirmative answer. Along these same lines, it is unnecessary and undesirable to include any negatives, even pertinent ones, in the training case materials going to the SPs. Since they are only learning affirmative answers it unclutters the training materials to omit all the "negatives" and the SPs don't have the knowledge to differentiate pertinent from non-pertinent negatives.

Training SPs to complete checklist accurately starts with having a checklist written in precise and lay language so that it is easy for the SP to understand and so no judgments are required on their part. The yes/no format of the history checklist are usually easy for an SP to complete. If the SP is to complete a physical exam checklist the SP must be trained in all acceptable methods to perform each component of the physical exam on the checklist. The physical exam checklist will ask the SP to determine whether a maneuver is done correctly, attempted but done incorrectly, or not done at all.

Repeated practice on scoring the checklist and comparison to the "ideal scored checklist" will increase accuracy and reliability. This ideally scored checklist can be developed by the faculty to represent the "gold standard" for this case. Having the SPs practice the history and physical on each other, then score each other, and then be checked off by the SP trainer or faculty is a useful training technique.

If the SP is to be responsible for feedback or debriefing, these skills must be taught and practiced. Each institution will develop its own feedback/debrief method and SPs will need repeated practice to develop expertise in this skill. As part of the SP training, feedback skills can be practiced after watching tapes of past or similar encounters or after practicing the case with a trainer or faculty.

SP Safety

"First do no harm" is as applicable to SPs as to authentic patients. When developing roles for SPs care must be taken to avoid injury or emotional harm to the SP. Consider the impact of physical simulations that might be harmful to the SPs over a long period of time and develop the case in a way to minimize these. For example, if the case calls for abnormal respirations that would be difficult for the SPs to sustain throughout the encounter, the SP may be able to perform these initially and when the learner first starts the lung exam then minimize these when the learner's focus is elsewhere. Also consider the effect of repeated examinations such as patella manipulations or testing pain sensation over a slate of ten learners. Limit the number of examinations such as forceful deep abdominal palpation or liver exams that may leave bruises or cause pain.

Certain exams that place SPs at risk of physical injury are avoided altogether in standardized patient work such as checking corneal reflexes. Learners are warned in advance not to do these exams.

While there are a special group of SPs who allow learners to use their bodies to learn breast, pelvic, rectal and male GU exams, these exams are not typically included in general SP work and students should be warned in advance not to do these exams. However the SPs who allow learners to perform pelvic exams on them can be very useful when teaching sexual assault exams, for instance.

The emotional impact of the case should also be taken into account. It's important to inform SPs when you will be asking them to engage in emotionally charged roles such as palliative care, rape, suicide, abuse, etc. SPs who are or have dealt with such issues recently many not be the best candidates for such roles. At times SPs who feel comfortable accepting these roles will unexpectedly be affected by then. Be sensitive to this and be prepared to stop the simulation and care for the SP in extreme situations. After all emotionally charged roles, a debrief or check-in with the SPs needs to be held to make sure they have come out of character and are emotionally stable to leave the area.

Quality Assurance of SP Work

Particularly for testing purposes assessing the quality of the SPs work should be an integral part of the process. Typically this is accomplished by having a second trained observer, another SP, staff or faculty member observe the SP and complete a checklist of the SPs performance. This QA observer would also rate the learners using the same checklist as the SP so that inter-rater reliability can be calculated and evaluated. The observer can also assess portrayal by the SP.

Develop of SP Case Materials & Evaluation Materials

The development of teaching and evaluation materials works best when it is a collaborative, multi-step process incorporating clinical expertise and utilizing best practices. Beginning with clear objectives will allow easy alignment of the case scenario and evaluation methods. While the initial draft of a scenario may be developed quickly, sufficient time needs to be allowed for refinement and piloting of the scenario and evaluation instruments.

Each case will need to include: SP demographics (age, gender, etc), SP characteristics (affect, demeanor, etc.) exclusion factors (scars, physical abnormalities, etc.), a complete description of the case, physical simulations required, props and/or other simulation devices along with any case specific reports (lab, x-ray, etc.).

Evaluation materials may include checklist and rating instruments for SPs and faculty as well as written post-encounter assignments for learners.

Case specific feedback guidelines can also be included in the case training materials for the SP.

Administering an SP Program

A trained, experienced SP educator or staff of SP educators will enhance the ability to use SPs efficiently and successfully. There is a well-established SP methodology-based on more than 30 years of research and practice that is well documented in the literature. The Association of Standardized Patient Educators (ASPE) is the profession's authority on all things SP and has developed SP Standards of Practice and identified and defined commonly used terminology. They are an excellent resource when questions arise about working with SPs (aspeducators.org).

SPs can either be hired as "part time prn employees" or they may qualify to be hired as "independent contractors." There are highly specific rules defining the criteria for who may qualify as an independent contractor and the HR or legal department of an institution typically will determine which category is acceptable.

Policies and procedures are critical to a successful SP program and an easy way to convey expectations to the SPs and faculty. Confidentiality and professionalism issues must be discussed. SP consent forms & SP agreements of employment will likely be required. Some institutions require background checks. Criteria for hiring and casting SPs should be clearly spelled out and followed to ensure fair dealings with the SPs.

Rules regarding lateness and/or not showing up should be established from the beginning and be clearly conveyed to each SP. Given the complexity and people involved in a simulation event, not having the appropriate number of trained SPs ready to go at the start of an event is a disaster and to be avoided. For higher stakes OSCE's having a back up should be considered.

SPs are normally paid for both training and performance hours with a minimum number of hours guaranteed for each visit to campus. The minimum is usually defined as between 2 & 4 hours.

A pay scale will need to be established. Some programs will pay the same hourly rate for all SPs. Others will pay one rate for training and a higher rate for performances. Still others may establish different rates so that more experienced SPs will be paid more. Most SP work is paid hourly with the exception of cases involving breast, pelvic, rectal or male GU exams – these are more commonly paid on a "per learner" basis. Pay rates vary widely with some regional differences.

SPs will need feedback on their skills in order to hone their skills and do their best work for you. The best feedback will provide specific examples of observable, modifiable behaviors and suggestions on how to improve or maintain those behaviors. In this way your SPs will continue to prefect their performance and simulation skills and improve on their checklist and feedback skills (See also "Appendix 1, Chapter 9 Supplemental Case Scenario").

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10 Virtual Environments for Education in Healthcare

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Background and Introduction

VR refers to a computer-simulated model of reality, including the conditions and circumstances of a hypothetical scenario, in which the participant engages and interacts with others and the virtual environment itself. VR shares elements with computer games, such as a narrative and story depicted through high-quality graphics, animations, sounds, and a system of challenges linked to feedback [1–6]. The term *serious gaming* is often used to distinguish factual simulations from fantasy games. VR healthcare simulations are further distinguished by clinical instructional elements, clear learning goals, clinical problem solving challenges, and opportunities for collaborative exploration. A screen shot from one recent example is shown in Fig. 10.1. A recent review by Graafland et al. [7] highlights many of the commercially available platforms and notes that many are only partially validated, if at all. The same is true for augmented reality, where VR is layered on top of real world images or engages substantial haptic interfaces [8]. This topic is particularly challenging to define, because virtual environments can be graphically simple yet contain a broad array of actions, or can be very detailed graphically but with few action choices depending on the stage of development. While Graafland's review is the most germane to our topic, a recent systematic review by Cook et al. [7] looked at "virtual patients," which have their own taxonomic subsets [9]. The articles reviewed by Cook et al., ranging from 1966 to 2008, were chosen because the educational method was tested against a comparison group. Although the results showed only a small effect of VR based training, study heterogeneity limited the conclusions [7]. We reference here a few notable recent efforts in areas such as the practice of history-taking [10–15] and clinical decision-making [10, 14, 16–20]. The authors believe this field represents one of the most exciting areas in healthcare education in part because of the need for educational scholarship. Our hope is to guide the collaborative efforts of clinical educators to fruitful collaborations with developers, the products of whom can be tested through educational research.

Problem-solving in VR consists of role-playing in contextualized scenarios, in which participants can safely explore medical errors, difficult procedures, hand-off communications, and other high-risk, problem-prone situations and processes. These situations should be recreated in VR with sufficient challenge to keep the players engaged without frustrating them to the point of exhaustion. Nineteenth-century psychologist Lev Vygotsky called this optimal range within which learning transpires as the *zone of proximal development* (ZPD). This zone can be thought of as the gap that exists between the participant's independent capability to solve a problem and that which he or she can do with the guidance of someone more experienced [21]. Adequate challenge in VR is provided both in the narrative of the case scenario as well as in the individuals' freedom to choose in the form of navigation and exploration. The accumulation of choices leads to various responses in the form of changes in the VR environment, often including changes to the patient avatar appearance and/or physiology. This variability reflects the unpredictable nature of patient care, the complexity of human behavior, the participants' ability to explore new situations, and improve overall situational awareness [22]. Much like playing a game, VR allows for successive attempts until reaching a pre-programmed criterion standard, or the observing instructors standard, before moving to a harder case; the VR becomes a context in which the ZPD for learning occurs.

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Fig. 10.1 Respiratory distress VR simulation created by the authors on the Avaya Engage platform

Automated formative feedback in this ZPD can include: comparison of learner answers to expert consensus answers, critical actions met, timed goals, movement errors for haptic procedures and most efficient movement combinations, permission to move to harder cases, and integrated adaptive learning with increased difficulty. The degree of feedback in VR can be more granular due to automated collection, for example details on laboratory orders beyond the faculty of consensus the case required, and given the richness the feedback must be presented in graphical methods that make it intelligible to the learner. Some of these feedback methods are in fledgling stages in healthcare and the development of automated feedback has been encouraged by U.S. granting bodies. VR can suffer from the same high acuity and/or rare case presentation bias of patients seen in mannequin simulation. However, the opportunity exists to generate more and varied cases relatively easily as platforms, standards, and case authoring tools mature. Even though VR scenarios can be designed for single participants, collaboration allows for social understanding in a particular context where students have agency; they play an active part, contribute to, and are changed as a result of their participation [23]. In the massively multiplayer online role-playing games (MMORPGs) like World of Warcraft™ (Blizzard Entertainment, Irvine, CA), a virtual fantasy gaming environment, it is through the social dynamics of collaboration and competition that new players build knowledge. The VR becomes more than a game scenario and begins to function as a learning community.

Participants interact in the VR through a digital representation of themselves called an *avatar*. This virtual character is used to interact with and manipulate the virtual environment and also becomes the representation of one's self-presence in the VR. Avatars can be highly personalized, reflecting the participating individual's physical characteristics by altering the digital character's shape, skin, and hair colors along with animations simulating body gestures. However, detailed customizations are not necessary for participants to find meaningful engagement in the virtual environment. Giving learners relevant roles and avatar appearances to choose from can help speed the orientation process and team formation. Individual avatar appearance in some platforms can be so flexible as to allow for characters that may appear funny or distracting. Still, there may be times when a highly customized avatar is desirable, for example in a military application showing particular body armor relevant to wound patterns, or the combat medic's exact kit. In the VR identity is represented by the graphical avatar. Customization of the avatar can facilitate exploring professional identity, especially for medical and clinical students that are in early formation. Manipulating the avatar or assuming an avatar of other appearances allows participants to explore and gain insights into the roles of other clinicians, for example from that of doctor or nurse, or to that of the patient or family member, thus giving the learner multiple perspectives within the same scenario and a greater appreciation of the patient experience. Altering avatars also allows for cultural awareness exploration through traits and characteristics presented by other race and ethnicities. Likewise, roles could be exchanged within clinical teams, supporting inter-professionalism and broadening team members' perspectives and experiences. Along with multiple participants' avatars in a virtual world, there can also be non-player characters (NPC) controlled either by limited programming in the VR or through a secondary artificial intelligence (AI) program. AI-controlled NPCs can behave like standardized patient actors; however, this is an emerging technology that requires powerful computing hardware. AI-controlled NPCs will not be discussed in this chapter so as to keep the focus on understanding how to use a basic VR environment for medical simulation.

VR simulations can be constructed for individual, small group, and interprofessional teams. Unlike games, VR emphasizes social interaction through collaborative exploration and leveraging each other's expertise to solve clinical problems. The highly visual aspects of both the VR environment and the participants' avatars facilitate collaboration through various communication styles similar to those used in person-to-person interaction. Besides verbal, non-verbal, and visual cues, most VR platforms support text-chat functions. As a team participates in a VR scenario, they can collectively observe the effects of their individual and cumulative actions (or actions feedback can be delivered to the individual, forcing him or her to communicate findings to a team). In this way, the VR co-locates participants who may be physically remote and moves them from abstract discussion into shared actions through their avatar manipulating virtual objects in the virtual learning environment.

Distinguishing Elements of Virtual Reality

What may seem like exceptional technology to faculty and staff today is a routine part of the emerging generation of medical and clinical students' formative experiences entering the workforce. Accessing digital resources in new ways is becoming a natural part of our day-to-day world; students expect the presence of technology. Traditional classroom approaches need to be rethought; not just because new technology is available but because new technologies like VR provide ways to engage students and leverage limited resources such as mannequin labs, cadavers, clinical rotations, novel situations, time, and money. VR offers unparalleled flexibility and several advantages over traditional bedside and mannequin-based labs (see Table 10.1).

Early work suggests that VR provides a comparable setting for learning that is comparable to other forms of clinical training [24–29]. The authors view it as another tool in the medical educators' repertoire to be considered when initially designing instructional solutions. Like any instructional strategy, VR presents certain advantages and disadvantages depending on the situation and curriculum plan [30, 31].

Table 10.1 Distinguishing elements with advantages and disadvantages of VR

Element	*Advantages*
Persistent space	Participants interact with/ change the environment. Changes reset or persist.
Co-location	Synchronous or asynchronous. Overcomes temporal and geographic boundaries.
Presence	Setting and objects are real enough for qualitative immersion.
Social collaboration	Social context where participants can leverage their collective knowledge, skills and abilities.
Psychological safety	Increased anonymity. More willingness to fail. Consequences to wrong actions can be quickly corrected.
Element	*Disadvantages*
Initial costs	Customization of VR environment and complex patient avatar animations (usually offset by reuse and scalability)
Avatars	Limited gestures or no facial expressions; subtle physical changes to the avatar with physiology changes may be difficult to visually represent and expensive to customize
User interface and cognitive overload	Overly complex interfaces with dense information channels can quickly overwhelm the player/participant(s)
Psychological freedom	As with participating with any social media participants, particularly if avatars are anonymous, may lower their social filters and inappropriately express opinions or act out
Adoption	Faculty biased by limited knowledge and perception of popular entertainment based gaming
Human contact and emotional connection	People skills and compassion that can be absent when working with non-living models

Virtual Reality as a Learning Environment

Learning in VR is supported through the visual representations and spatial relationships of objects and the behavior of interactive objects that creates a parallel reality. Learning is a situated activity in which a person's thoughts and behaviors are linked to the environment in which an experience, and all elements contributing to that moment, becomes the means for understanding and dealing with future situations [32]. The virtual elements become abbreviations, or shortcuts, representing more complex knowledge. For example, the authors created several VR cases (cardiac and allergic reaction) to introduce providers and clinicians on the use of a new emergency cart recently rolled out in the outpatient setting. The cart was designed with sufficient visual detail to represent the cart itself and the components found on the cart including medications box and airway management supplies. The VR cases required the participant to interact with the cart and its contents in several different emergent scenarios. This situated the emergency cart use in context of office-based medical emergencies. When used correctly, virtual representations can become metaphors that closely align with what is already known by learners and are focused on the learning outcomes. Learning is not in isolation; rather, it is in the broader context of relationships in which all the elements involved have meaning [23]. VR has the potential to reinvent medical education with its ability to not only provide virtual patients demonstrating pathophysiology, but also patients in the greater context of a busy emergency department, natural disaster, battlefield, or exam room. Thus, learning is situated [32] in the context created by the VR and can facilitate movement through the learning curve and time to performance for choices of critical actions, treatment algorithms, communications markers, or case completion [33].

Advantages of Virtual Reality

In addition to the advantages noted in Table 10.1, two other advantages of value to note are the reliability of the VR environment and the ability to shape identity within an interprofessional team using VR. Even with the use of programmable task trainers, mannequins, and trained standardized patients, VR can provide a higher degree of *reliability,* reducing inconsistencies when repeating the same scenario. This consistency between simulation sessions will facilitate more reliable assessment and feedback. Reliability should not be confused with restricting participants' ability to freely choose a course of action—even when that action is wrong, it simply means the simulated scenario will be presented to the learners in the same way creating a more consistent learning experience.

Further consideration of cost-effectiveness can be seen in the scalability of VR when compared to the cost of constructing a simulation center and equipping it, as well as the capacity limits inherent to physical space. Development costs for VR are spread across the hundreds or thousands of schools or learners using the environment; moreover, development costs for scenarios constitute small increments once an appropriate learning environment is created. VR is effectively and infinitely reusable within the limits of content shelf life. As one example, if we consider one learner to one avatar case-based learning compared to actor-based education. Given today's technology, the actors may still be better at portraying complex communications challenges. But for basic cases in which learners ask the avatar a series of questions, choose diagnostic tests, and create a differential, the VR case can be distributed effectively via school library subscriptions, eLearning interfaces, or can even be open access. No need to train actors and all learners get the same stimuli of images or videos, the same lung sounds, same feedback on performance, etc.

Participation within a group of practitioners allows the members to explore and build their *identities* [32] in an interprofessional framework, a concept increasingly recognized as important [34]. In one of our early prototypes, clinicians were assigned specific team roles in a simple rapid response team case. The VR simulation was then run several times, with participants switching roles each time to allow participation from multiple perspectives without changing avatars. Consistently brought up in debriefing was the power of having experienced other roles as opposed to simply having had hypothetical discussions about them. This role change can occur very quickly through avatar swapping, an approach that the authors used in an office-based emergency setting with an administrative partner, a medical assistant, a nurse, and a provider. During debriefing, team members again commented on the deeper understanding and respect for each other's roles that arose from the experience. Qualitatively, personal experience in a role contextualized in the medical team, along with the exchanges between roles, knowledge, and skill levels, is a powerful learning experience [35].

Technology and Information Literacy

Different learner groups may be able to handle different interfaces to the VR environment. Those with prior gaming experience quickly mastered the VR interface. The authors observed that, while younger generations had more social media experience, age was not a predictor of performance. Even after the project moved from Second Life® (Linden Lab, San Francisco, CA) to a simpler web-based interface found in AvayaLive™ Engage (Avaya Inc., Santa Clara, CA), basic computer literacy including familiarity with installing browser plug-ins and the ability to navigate with a mouse were necessary. The authors have noted participants' limitations in the ability to understand keyboard shortcuts, the need to click on a web-rendering surface to access a library resource, as well as in the ability to use these library resources once reached. Also, as with real care, the average person's working memory limits the number of active patients managed simultaneously, as well as the number of open management plans, etc.

Faculty may face many of the same, and perhaps more, issues than learners do with regard to technology and information literacy. While many, if not all, will have seen video games or virtual environments, they may be intimidated about the prospect of using this technology for education. Faculty concerns may include the competing demand on their teaching time, the learning curve inherent when adopting a new instructional technology, misunderstanding the educational objective, and biases for or against new media technologies. Faculty members may also have the unfounded worry that they need programming skills. Good instructional front-end analysis by medical educators will help faculty understand when, and for how long, their expertise will be needed for curricular development. Case or scenario development templates can be extremely helpful in defining learning objectives, observable critical actions, markers of success for capture, and plans for faculty observation in their roles as debriefing facilitators. Faculty should guide the determination of which artifacts need the most realism, and can provide feedback at several stages of development, but would not be expected to program either the game graphics or logic. A faculty learning curve exists with any form of simulation; hence, they will need time to place this education within a broader blended-learning context (readings-didactic-virtual-task-mannequin-bedside-teamwork). Faculty may also perceive the use of VR as a lower-value learning tool, because of its typical use for gaming rather than education and, indeed, recent reviews indicate that significant validation work is needed for educational applications of VR [20]. However, validation will always lag behind technology adoption in any field, and we expect that many applications will prove to be valid educational tools.

Practical Approach to VR Design and Development

The authors used and recommend a rapid-cycle, design-based approach to developing VR scenarios. Rapid-cycle design-based experiments engaged the participants as co-producers using their feedback to improve subsequent versions. This creates a dynamic and incremental development process that rapidly moves from design to development to implementation. Design-based research pragmatically tests various iterative design changes with the affordances that a particular technology, methodology, or pedagogy offers in a given context. These experiments focus on the individual learner, the other participants, and the learning environment as a system; hence, the iterative process of reflective inquiry refines the design [36]. The design team fully explores participant satisfaction, compatibility with their existing values and needs, and the relative ease of implementation and utilization patterns without overinvesting financially or emotionally in the technology.

Developing high-quality virtual simulation is every bit as labor intense as is mannequin-based simulation. Grants or other protected financial and human resources can make development feasible. A team-based approach is suggested, with a clinician giving insight as to the degree of clinical accuracy needed, and the degree to which any one clinical finding is needed to meet the learning objectives. The clinician can be brought in intermittently as the virtual world is created to help direct each phase of development toward clinical learning objectives. Also, clinicians can simply immerse themselves in case-building for already existing virtual platforms.

The authors highly recommend that clinical educators try their hand at VR development. With a start-up cost of less than $10,000 and the help of a part-time undergraduate intern, the authors created proof-of-concept VR simulations using the Second Life® platform. With the experience gained after having now constructed multiple VR simulations using three different platforms, the authors suggest consideration of the following design elements:

- *Fidelity* includes the audio and visual components reproduced in the VR environment as representations of artifacts and settings in reality. Fidelity is experienced in the VR part of the overall context-dependent relationship between artifacts and the context in which they are situated, which includes visual details, lighting, color and audio values, and audio tone qualities. In one context, a wound might be very basic as part of a major trauma virtual resuscitation (apply dressing to stop bleeding); in another, it might be very detailed as part of a wound care management course (decide on dead tissue to remove, choose method to remove, remove dead tissue, choose dressing, etc.). Exaggerated visuals, animations, and audio can also be used to draw attention without distraction. For example, if teaching some aspect of a medical procedural kit is desired, then include a zoom to kit option with interactive pieces.
- *Authenticity* is reflected in the narrative that is the basis of the VR simulation and needs to be credible and of clinical value to the participants. Like face-validity, the first few moments in the VR simulation are key to engaging the participants in the narrative and keeping them engaged as it unfolds into the unified clinical story. As in any good story, there must be a plot, revealed through the sequence of events, and congruence of the story and the virtual artifacts. Gathering the background information may be part of the VR exercise, or it may be given in a format appropriate for the care environment (a triage note, a pre-op history, etc.) It takes an educator's perspective to decide whether the process of gathering the data has educational value or if use of the data is more congruent with the learning objectives, or both.
- An advantage of VR is that it allows intentional manipulation of the *temporal flow* of events, deliberately speeding up irrelevant—or slowing down integral—processes, tasks, or actions that you cannot otherwise alter in reality. For example, a type of seizure might allow slow motion replay. Players may be able to go back and find the paramedic, who has the key piece of information that should have been gathered earlier in the scenario. VR designers can deliberately break down the steps of a procedure to

demonstrate caveats, pearls, or likely failure points. A procedure may slow down one or multiple players as it would in real life. For example, the setting up of an IV pump may take time for a nurse making him/her unavailable as a team resource, and an animation could run at a predetermined speed to represent this, or the involved nurse might have to direct the process at specific points. If the task is not the educational focus, and it's too slow, people may lose interest. Choosing instantaneous, near real time, or slowed action timing may further the learning objectives and educators should carefully consider timing as a variable. Time must also be put in the context of available or expected educational time.

- Through the *interface,* the participants manipulate and control their avatars and the virtual environments—probably the biggest challenge for new VR users. The intuitiveness of the interface is a more significant a predictor of future use than is age or prior gaming experience. This has to do with every aspect making up the interface: the mapping of the keyboard and mouse controls to the in-world actions as well as the construction of the VR environment artifacts, action triggers, pop-up menus, etc. Three-dimensional objects, either with too much detail, too small to see, or requiring complex manipulation, will present a barrier. If zooming in is required, participants need awareness and instruction on how to zoom. Controls or action triggers scripted (programmed) into the VR need to reflect the behavior of their real counterparts.
- The learner group must be considered in *interface design decisions*. Those in the gaming generation know the term first-person shooter perspective and will understand the difference between this and other gaming views; thus will likely be able to toggle in and out of map views easily. Many non-gamers or non-digital natives will struggle with the rapidity of vantage point shifts and will need to engage the interface for different perspectives. As with any game, a busy heads-up display provides a lot of information, but takes time and repeated use to understand. When any learning application, in particular VR, is infrequently used, the interface will remain a concern. Special-needs learner populations can be uniquely served by VR applications, requiring specialized interfaces that are not discussed here.
- Participants expect *feedback mechanisms and interactivity* in a virtual world. All the participants using our first prototype expected the computer to guide them if they ran astray of correct procedures. Thus, the use of scaffolds, prompts, cues, and responses can help guide rather than control the learner; a balance should be established between the participants' freedom to take action and being forced to take action. Feedback provides a means of confirming that action has been taken and the participant can proceed, or a result ensues from the accumulation of actions. This contributes to the virtual representation of cause and effect. Feedback can be manipulated—increased or decreased—associated with the participants' preparedness to enter a simulation as well as with the stated learning objectives.

Having a clear and simple development framework will help keep the design team moving toward a finished product, especially when experimenting in VR for the first time. A practical framework emerged from our experiences and is shared in Fig. 10.2. As noted in the figure, the virtual design template in Appendix 2a is very helpful in guiding the scenario development process.

The degree of real-world process integration needs will vary with the learner audience. For example, early medical student learning of basic clinical cases or anatomy/physiology does not require tailoring to local work flows. However, the closer the learner is to real clinical engagement, the more the virtual artifacts should resemble the real environment. Administrators, educators, and clinicians might all be engaged to ensure that agreed upon learning targets can be met relative to organizational need.

Each customization will come with a cost. For example, choosing to customize the overall virtual reality gaming engine might incur significant monetary costs as well as development time and long term cost of ownership. However, simply creating some environmental artifacts (realistic EKG machines, colors and textures of your hospital or clinic's floors, walls, and furnishings) will be less costly. All such costs should be framed in the context of their value to education. If we are not specifically teaching the "knobology" of a particular device, like the EKG machine previously mentioned, then a less detailed virtual representation recognizable as an EKG machine may be sufficient. When an object is needed as part of the VR simulation context but not germane to the specific learning outcome, purchasing an existing digital representation may be less costly than creating it.

Clearly, as educators, we want to invest in customizing items that are relevant to the learning objectives. For example, if you want the participant to be able to click on the patient and see a rash that indicates life-threatening disease, that piece of integration is worthwhile. Likewise, artifacts that are linked to key task accomplishments, such as tying a virtual knot or giving a particular medication, must be accurate and framed so that it is clear when they are, or are not, accomplished.

One key area of integration is the electronic medical record (EMR) or electronic health record (EHR). Use of the EMR is now built in to nearly all workflows in the inpatient setting and is very rapidly being built into nearly all outpa-

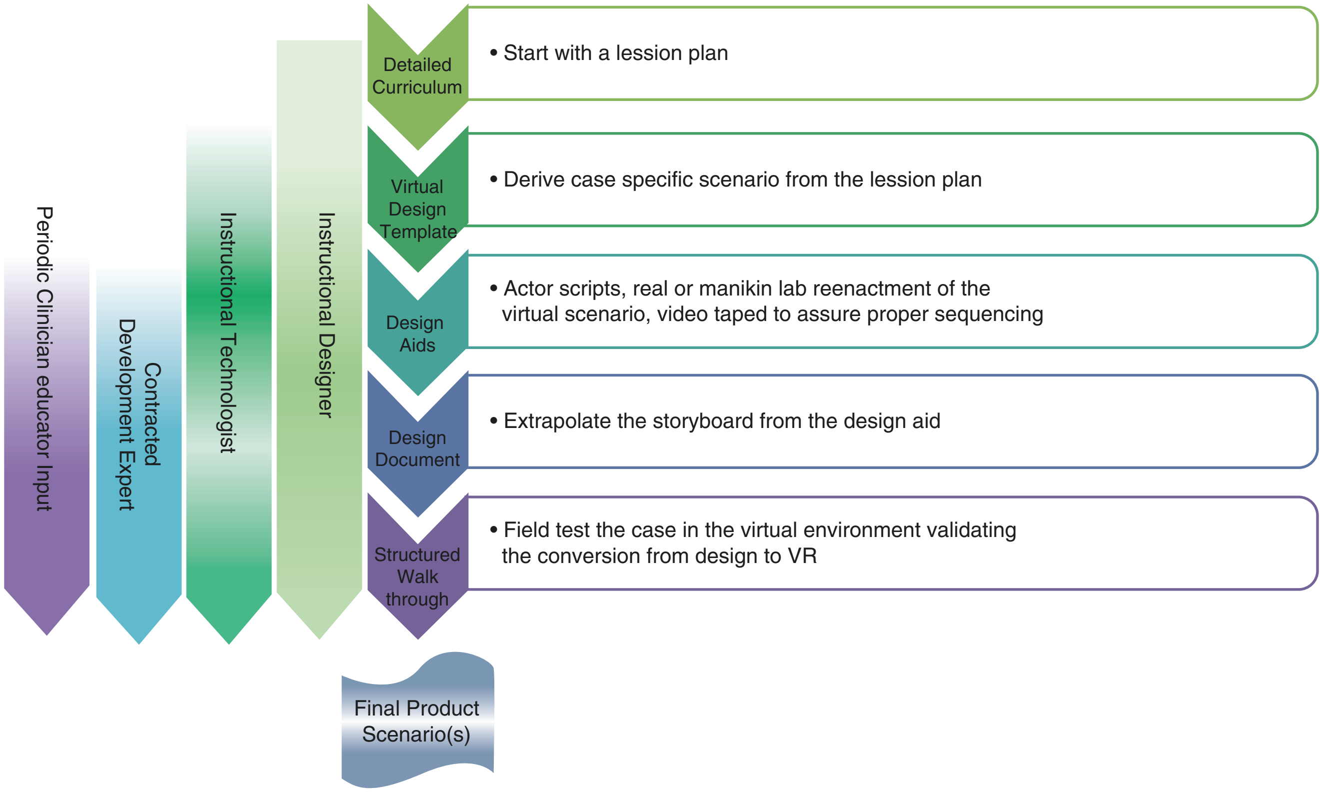

Fig. 10.2 Diagram model of VR design framework

tient settings. Thus, creating some artifact that represents the EMR is logical. Again, the learning objectives should drive the degree of integration. For medical students, a generic EMR with the correct categories may be appropriate, while nurses embedded in a work environment may benefit from access to a sandbox EMR within the virtual environment. Linking to such a record may be accomplished via web-rendering surfaces that act as an in-world portal from the VR to the actual EMR platform. If all players are interfacing with the same sandbox EMR, then issues of time asynchrony within the EMR should be minimal.

The design team should minimally include a lead instructional designer, clinical content expert (physician, nurse, etc.), and an instructional technologist. Other development considerations should include budget, available time, the target audience, instructional purpose, and the level of technical support to be provided for the participants and faculty.

Several VR products are available that provide flexible, economical, and powerful training platforms. For those interested in the development process, the authors suggest starting with a low-cost, easily accessible, and well-supported environment. In addition, if you have not already done so, you will gain some first-hand insights into the dynamics created in a multiplayer setting and have some fun by exploring popular MMORPGs through play.

Application of VR in Emergency Medical Education

VR has already demonstrated early applications in emergency preparedness [25]; triage under pressure and trauma teams [24, 25, 29]; overcoming psychological barriers (everything from working under stress to presence of blood) [37]; objective structured clinical examinations (OSCE) [38, 39]; surgical procedures [40, 41]; anatomical models [42]; medical errors, patient hand-off, interdisciplinary training [43]; and replacing live patient encounters [44, 45]. As noted earlier, each environment requires scholarly work to determine reliability and validity if it is to be used for summative rather than formative assessment. The authors see the potential for VR assessments in OSCEs, procedural training, interprofessionalism, and team coordination, among others [46].

Beyond a checklist or test, VR is a means of looking at behavior in a new way by examining the data accumulated on the computer server on which the VR simulation runs. Some VR platforms will record all participants' interactions, both with other users and with objects. Educators can determine where the learner's concentration of focus is, which might demonstrate performance issues, clarify a possible point at which error occurs, or indicate a scenario design flaw. The server running the VR captures all kinds of data:

length of time a player's mouse hovers over a virtual object, number of clicks, shortest path through a complex action, reaction time, eye focus, audio logs, audio transmission, interaction of the player with everything and everyone. Educational researchers will require time and collaboration with specialists, such as human factors engineers and cognitive psychologists, to make sense of this new data stream.

Case Study in VR Development

The authors started our exploration of virtual reality in Second Life® (SL). While other VR programs are available, SL remains one of the most popular with a diverse population using it for recreation, education, market research, communications, and modeling. SL is an excellent entry point for those new to VR, being supported by a large international community, several wikis, accessible developers, and robust marketplace. Currently, a good portion of research into VR has been based in SL, which is freely accessible using Linden Lab's client program or any one of several third-party viewers. Part of the SL client interface includes all the 3D modeling tools needed to build virtual objects as well as a scripting language used to program interactivity to these objects. Using the SL Marketplace proved to be a very economical means of acquiring initial 3D objects (e.g., chairs, beds, buildings, and other general objects) with basic action scripts. The authors also used the SL Marketplace to contact third-party developers to customize or build specialized objects to suit our needs. Fig. 10.3 depicts a scene from a STEMI VR simulation created by the authors on the SL platform.

The first VR simulation the authors created in SL was a detailed re-creation of our inpatient interdisciplinary simulation center. The VR simulation was a structured learning activity to orient the new participant to the laboratory facility, policies, protocols, and set expectations prior to his or her first activity. Participants played in the VR in teams of four with a non-clinical in-world guide available to provide basic support. Upon completion, a clinician led the debriefing, which included questions about the VR design. Feedback from these early participant groups was fed-forward into the

Fig. 10.3 STEMI VR simulation created by the authors on the Second Life platform

next iteration and used to establish the iterative design-based qualitative methodology the authors continue to follow. The second VR simulation we created in SL was based on an ST-elevated myocardial infarction (STEMI) used for rapid response team training. The first VR simulation was repurposed to and used as the orientation activity to the VR environment. The distinguishing feature of this second VR simulation included the design of specific clinical roles and the requirement of group collaboration to successfully resolve the scenario. The STEMI simulation necessitated collaboration and more deeply engaged the participants.

The second platform we used was the AvayaLive™ Engage product. Our move to this platform provided a simpler web browser–based interface that required only a downloadable plug-in. As with SL, we found significant convenience by using a hosted version of AvayaLive™. This platform proved stable with excellent quality of voice-over internet protocol IP (VOIP). The browser-based user interface was significantly simpler and, after a quick orientation activity, users were capable of participating in their first VR simulation. Unlike SL, the AvayaLive™ environment supports 3D objects, built using industry standard tools, which makes them highly portable to a new compatible environment. However, a trade-off is the requirement to either contract 3D development, or to build expertise with the more sophisticated 3D modeling and animation tools than those found in SL. If capability is restricted to developing only the environment, a vendor may be contacted to handle some aspects of the 3D integration. The authors created four VR simulation cases in AvayaLive™, presenting high-risk and problem-prone office based medical emergencies. At this point, a critical decision point was reached: to continue both the technical work of building VR environments and author scenarios or to focus only on the clinical content. Even though the technical development was highly successful, we determined to move onto a third platform to expand our range of cases while further reducing the cost of ownership.

The third platform the authors implemented was a custom version of the CliniSpace™ (Innovation in Learning, Los Altos Hills, CA) platform. This platform is highly customized as a hosted solution for learning in healthcare and allowed us to focus on clinical scenario development and minor environmental changes, rather than on complete environment development. The developer completed all initial customizations to the basic environment and a robust set of clinical objects were already available part of the platform. The environment is multi-user and browser accessible, comes with a case authoring tool, and has integrated state-driven physiology modeling. Fig. 10.4 depicts a scene in the inpatient room from the standard ClinicSpace™ VR learning environment.

Fig. 10.4 Inpatient exam simulation created by the author on the Lehigh Valley Health Network customized version of the CliniSpace™ platform

Technical Issues

In most gaming and VR applications, there are varying degrees of computing work to be done on the local PC and the central servers. If your healthcare network uses a model in which very little computing power resides in the local PCs, the application should be chosen accordingly. Likewise, health networks generally have preferred browsers, often not of the latest version, which may impact functionality. You should also discuss any VR platform with your data security personnel to assure that the product will meet your institution's security requirements. Computers—and their graphics cards, specifically—may be a limiting factor; however, neither of these will matter without adequate bandwidth. Likewise, plans to play video clips through the interface should consider the bandwidth required for good playback. VOIP is often used within the context of a gaming engine and may suffer from bandwidth performance issues that affect audio clarity, to the point of impeding learning, not only of conversation but also of environment and specific body sounds. If objects or NPC avatars are to complete certain tasks, the tasks must be tested to ensure they perform reliably as desired. As discussed above, the level of realism of the simulation depends on the impact relative to the learning objectives.

Faculty, Institutions, and Context

Our work in the virtual world suggests that, after an initial positive experience, age is not a barrier for faculty. Most are willing to embrace the technology, particularly those already engaged in other forms of simulation. Those faculty who have embraced their roles as debriefing facilitators, rather than founts of knowledge, tend to see this as another method to empower learners to discover new knowledge and challenge their abilities.

Faculty may have difficulty finding release time for development of virtual environments and/or use of VR in education. Incentive structures for participation in mannequin-based curricular development and execution have taken decades to evolve (and continue to evolve); the argument must be made for the educational value that this technology provides. The authors were successful in garnering significant support from senior leaders (executives, department chairs, information technology (IT) leaders) by walking them through the virtual world. Encouraging them to participate in scaled-down simulations allowed them to observe, first-hand, that VR is more than just play.

The design-based, rapid-cycle development approach discussed has worked well in combination with a developmental evaluation strategy to initiate and evaluate the effectiveness of change initiatives in a complex and uncertain environment. Developmental evaluation, particularly suited for innovation and program redesign efforts, will help to frame concepts and test concepts in action through an iterative process, quickly returning feedback for adjustments, refinements, and even, if necessary, early-on termination of failed efforts.

As with any project, scope-creep can be a concern if multiple stakeholders are brought in later in the project. Before development, key stakeholders should be engaged; in addition, stakeholders for each new phase can be apprized at the right time. The authors recommend consultation with institutional IT well in advance as well as throughout the project as requirements crystallize and change. Having a designated IT contact can help provide continuity in the rapidly evolving technical landscape.

In conclusion, VR applications in healthcare education represent an exciting frontier that is ripe for development and scholarship. The authors encourage fledgling creators of VR education programs to experiment and play with virtual reality to gain first-hand experience. By taking a design-based rapid-cycle approach, VR educational design teams can build experience and put VR environments or scenarios into practice with a reasonable time and money investment. A few key points to consider:

- Well-developed VR-based simulation can automate feedback to individuals and teams and is in keeping with established learning theory.
- Instructor presence can be accommodated through visible or invisible avatars or viewing platforms.
- VR-based simulation development takes significant effort and has unique advantages and challenges.
- Using a structured development approach and design framework will help assure the translation of a simulation case into the virtual environment.
- Key design features of fidelity, authenticity, temporal flow, interface design, and feedback mechanisms all contribute to the overall learners' experience.
- If developing multiple facets, including the environment, avatars, and the scenarios, development effort can be substantial.
- If choosing an established platform and building cases, simulation based educators can move quickly to creating meaningful learning experiences.
- Technical and security requirements, initial development costs, and platform subscription costs should be considered.

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Task Trainers in Emergency Care Simulation

11

Jared Kutzin, Antoinette Golden, and Michael Cassara

Introduction

Technical skills are critical to the practice of emergency medicine. Task training is therefore essential for the initial and continuous professional education of all emergency care practitioners. Task trainers, which are also known as part-task trainers or partial task trainers, are designed to allow learners to focus their practice on specific, key elements of patient care, instead of focusing on the big picture clinical conditions that high-fidelity mannequins allow for. Part-task trainers are focused on specific procedures that clinicians need to be competent in understanding or performing. At the most rigorous level, simulation instructors who engage in task training, undertake a highly complex instructional endeavor with one primary goal: to prepare competent, independent emergency care providers who, at a moment's notice, stand ready to expeditiously and safely perform high-consequence procedures in acutely ill or injured patients without rehearsal. And, in many cases the time between training and performance of some critical life-saving procedures may span decades. Therefore, task training is an important component of any comprehensive emergency care simulation program for basic skill competency and ongoing professional readiness.

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Task Training

In the cognitive psychology literature, a technical skill is more generally defined as a *task*. Wood describes a task as "a pattern of behaviors with some identifiable purpose or direction" influenced by information cues and resulting in a measurable result (product) [1]. *Task training*[1] is defined as the "use of a simulation modality to assist in the process of learning to complete a technical skill(s), or a procedure, which is a series of steps taken to accomplish an end" [2]. Task training "incorporates cognitive knowledge and technical skill into a precise sequence of actions that are safe and efficient, targeting any level of learner" [3]. This form of task training is known as *whole task training*.[2] Whole task training implies instruction in the entire task, including every subtask of the technical skill in conjunction with other technical and nontechnical skills (e.g., corneal foreign body removal conducted simultaneously with slit lamp operation and patient communication).

Task training in its most common form in emergency medicine education should be more precisely distinguished as *partial task training*.[3] Partial task training is instruction in the "key elements of the procedure or skill being learned" using synthetic, biologic, or other (e.g. virtual or computer-based) substrates as models [4, 5]. Partial and whole task training may be integrated with other simulation modalities as part of hybrid simulations or mixed modality simulation experiences. As learners become more advanced in their practice, whole task training may supplant partial task training to allow for more fidelity of the task being performed.

[1] Other terms used interchangeably include *procedural simulation, procedural task training,* and *procedural training.*

[2] Other terms used interchangeably include *integrated task training, integrated procedural training, integrated procedural training with a psychomotor focus, whole procedure training* and *whole task training.*

[3] Other terms used interchangeably include *part-task training* or *procedural task training*.

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Task trainers may take many forms. Traditional task trainers use synthetic or biologic substrates. Historically, cadaveric and biological trainers were frequently used before the advent of simulated tissue. Biologic task trainers include whole and sectioned human and animal cadavers (e.g., unpreserved fresh-frozen and embalmed human cadavers) and other nonliving biologic substrates (e.g. hard-boiled eggs and fruit). Biological task trainers using living animals and newly deceased patients, previously described in the literature as part of civilian and military health professions educational activities, are less frequently being used in contemporary civilian simulation-based technical skills instruction because of ethical, moral, and cost considerations associated with their use [6, 7]. Computer screen-based and virtual platforms have been also been described and used successfully for simulation-based education focused on technical skill acquisition and assessment. Among emergency medicine simulationists, complex and low-fidelity synthetic partial task trainers are two modalities most commonly used for task training. Complex partial task trainers include virtual reality (VR) and haptic training models that interact with the learner and provide immediate physiologic feedback (e.g., breath sounds, cyanosis, change in response of material to suturing with real-time feedback). Low-fidelity synthetic task trainers include plastic, rubber, or silicone models for skills such as endotracheal intubation or thoracotomy. Low-fidelity synthetic task trainers may not provide timely prompts and cues to the trainee, lowering perceptual fidelity. However, emerging technologies have allowed for low-fidelity synthetic task trainers to provide specific feedback for certain tasks, such as compression depth and rate during CPR. Other task training modalities (e.g., computer screen-based simulators, standardized patients, and technology-enhanced mannequin simulators) are more frequently being described and, in contrast, may provide opportunities for whole task training [8]. The emergency care simulationist should select the task training modality based on the available resources, facilitators, learners, and session-specific educational objectives.

Task trainers serve to facilitate learning, training, and evaluation of performance [9, 10]. There are many trainers available including trainers for practicing IV access, CPR, basic and advanced airway techniques, central venous catheter placement, chest tube placement, pericardiocentesis, and torso ultrasound. The advantages of simple, low-tech mannequins are their portability, easy storage, accommodation for repetitive practice, and relative in-expense compared to high fidelity mannequins. Part-task trainers can also be used to teach physical examination techniques and findings for sensitive exams such as the breast, rectal, testicular, or vaginal exams or invasive procedures such as suturing, peripheral and central line placements, or lumbar punctures.

Cadavers

Cadaver labs offer a controlled environment for medical training, observation, and task repetition [11]. Cadaver labs provide opportunities for hands-on practice with models and ultrasound. Cadaver labs, though costly, provide the physical reality of a human patient with the most fidelity and accurate anatomy, which are likely superior to plastic mannequins, computer simulators, or animal modules to teach invasive procedures. Cadavers simulate the feel of tissue and landmarks that are challenging to replicate with synthetic models though traditional formaldehyde prepared cadavers are still limited in realism, compared with the actual human patient. A recent advance in cadaveric preparations, Thiel soft-fix embalming method retains the human patient's natural look and feel, and may improve training fidelity [12]. Invasive procedures that could be performed on cadavers include central venous access (subclavian, jugular, and femoral), cricothyrotomy, intraosseous needle insertion and infusion, thoracostomy, and venous cutdown. In addition, the application of universal precautions by the particiapnt could be observed. Although the use of a cadaver requires the use of gowns and gloves, demosntration of their application does not require the use of a cadaver to assess the participants performance. However, teaching with cadavers can be controversial and cost prohibitive. Coupled with the increasing scarcity of cadaveric tissue, some medical schools have been forced to find alternative educational practices, such as virtual reality and 3D software applications to teach anatomy, physiology, and invasive skills [13].

Screen-Based and Virtual Reality

Virtual-reality (VR) simulators illustrate anatomy and physiology and their relationship to clinical skills. VR simulators may offer the opportunity for independent, asynchronous learning by providing didactic videos for learners to review prior to attending a simulation lab training session. Once engaged with the VR simulator, the learner can initially be guided to perform segments of a procedure and then progress to independent practice/performance and finally to the assessment of the learner completing the procedure [14].

Translation of tasks from virtual reality trainers to the operating room have demonstrated that participants had less mean errors, faster gallbladder dissection, were less likely to falter, and were less likely to injure the gallbladder or non-target tissue than trainees undergoing standard training [15, 16]. Surgical specialties have demonstrated the potential benefits of virtual reality trainings, specifically for screen-based training [17, 18]. Potential emergency medicine procedures that may benefit from virtual-reality training include fiber-optic laryngoscopy, fiber-optic assisted intubation, and point-of care ultrasound [19].

Screen-based learning can take many forms including single-player and multi-player games. One of the most common forms of task training that utilizes screen-based learning for emergency care providers is the American Heart Association (AHA) HeartCode® Online program which teaches cognitive and critical thinking components of Basic Life Support (BLS), Advanced Cardiac Life Support (ACLS), and Pediatric Advanced Life Support (PALS). These programs allow the user to select actions based upon information provided to them on the screen. The learner must choose each task at the correct time to successfully complete each scenario. The learners use the online program prior to demonstrating their skills in person during a skills validation session. The online program is a version of task training as it allows learners to demonstrate each piece of the various skills before demonstrating in total at their validation session.

Plastic, Rubber, Silicone

Plastic, commercially available, task trainers are available from every major (and minor) simulation company. Many companies offer extensive catalogs detailing their task trainer offerings. Task trainers may include, central venous catheter trainers, airway trainers, Foley catheter trainers, intraosseous (IO) and intravenous (IV) needle insertion trainers, umbilical artery/vein trainers, and many more. The value of these trainer is that their lack of body fluids, ease of transport, and uniformity allows learners to practice individual components of a skill prior to being fully immersed in either a patient care environment or high-fidelity simulation which requires both cognitive and technical skills to be put together. If using commercially available task trainers, simulationists should take some basic steps to help preserve the life of the tissue. These steps include utilizing lubrication spray when indicated, draining all vessels in between use, storing in a cool dry area, and avoiding large bore instruments (i.e. a cordis or dilator used in central line training or an ET tube larger than recommended). Simulation center administrators should anticipate replacement parts on a regularly scheduled basis and can work with vendors to identify warranty plans or tissue replacement plans to help minimize the expense of buying replacement tissues at the last minute or in a small quantity.

Low-Cost and Low-Fidelity Alternatives

There are many low-cost options for task training. There are multiple published articles related to simulationists developing their own trainers for pericardiocentesis, cricothyrotomy, lumbar puncture, suturing, perimortem c-section, thoracostomy, and thoracotomy procedures [20–22]. These include pork ribs and garbage bins representing a thoracotomy, various electrical hardware to simulate lumbar puncture models, and gelatin and balloons for pericardiocentesis. While often fun to make, the perceived realism of these do-it-yourself simulators is often lacking and the time necessary to make and re-make the simulators for repeated use may be more costly than commercially available simulators. Low-cost, "do-it-yourself" (DIY) task trainers are most helpful for educational programs that are infrequently implemented (i.e. once or twice per year), used by learners over a short period of time, or as an adjunct to other trainers for programs in which a large amount of learners will be present. An example may be a conference in which commercially available products are not practical to purchase but could be built for use by the attendees, for example a gelatin, pericardiocentesis trainer which will deteriorate within weeks but provides realism and ability to ultrasound for a short-period of time. Simulationists can find tips for constructing DIY task trainers by reviewing local or national workshops and poster presentations which often provide easy to follow construction techniques. Simulationists should work in partnership with clinical experts to ensure their homemade models are clinically accurate and a "practice session" should be held to identify any shortcomings and troubleshoot any limitations. One example of a DIY simulator is a priapism management trainer constructed for about $100. Dai et al., constructed a homemade simulator using hotdogs and red vine candy and found that it was an effective, inexpensive, and reproducible method of teaching emergency medicine residents to manage priapism [23].

Emergency Care Simulation Curriculum

Many emergency procedures are ideal to be practiced using task trainers. Some of the more common skills included in task training programs for emergency care providers are listed in Table 11.1 below.

Two less common skills are knee arthrocentesis and joint injections. A novel simulation curriculum for Emergency Medicine Residents was developed to teach these skills using simulation task trainers. While emergency providers are often focused on life saving skills such as airway management and intravenous/intraosseous access, just as important are skills to help manage and rule out debilitating conditions, such as a septic arthritis. At the Mount Sinai Morningside – West Emergency Medicine Residency, residents are exposed to a knee arthrocentesis simulator as part of their annual procedure day. A faculty member board certified in Emergency Medicine with added qualifications in Sports Medicine facilitates the curriculum to ensure that Emergency Medicine residents are prepared to identify and treat this relatively rare condition.

Table 11.1 Common technical skills necessary in emergency care

Basic Airway Direct Visual Laryngoscopy Oral Pharyngeal Airway Nasal Pharyngeal Airway Bag-Valve-Mask	Pericardiocentesis	Lumbar Puncture	Central Venous Catheter Insertion
Advanced airway Video laryngoscopy Elastic gum bougie	Thoracotomy	Cardiopulmonary resuscitation (CPR)	Transcutaneous pacing
Surgical Airway Cricothyroidotomy (surgical and Seldinger)	Intravenous and intraosseous insertion	Physical exam skills	Transvenous pacing
Needle decompression	Foley Catheter insertion	Heart sound identification	Paracentesis
Chest tube insertion	Ultrasound skills	Lung sound identification	Thoracentesis
Incision and drainage	Precipitous delivery	Suturing	Ventilator management
Perimortem C-section	Lateral Canthotomy		

When developing a simulation task trainer curriculum the overall goal should be specified as to whether it is an introduction to the skill, a formative evaluation, or a summative evaluation. If the curriculum is designed to be an introduction to the procedure, such as a lumbar puncture, for a medical student or intern, it would likely include a review of the indications and contraindications to the procedure, potential risks of the procedure, and a description of the procedural preparation and process. Curriculum development should include ample time for questions, inspection of and orientation to the task trainer, preparation of the equipment, and manipulation of the task trainer.

Formative evaluation curriculum includes "just-in time" training or deliberate practice curriculums which may be developed to refresh or enhance a learner's skills. An example of just-in-time training may include an intubation task training program immediately prior to a critical care rotation or practicing a LP procedure immediately before performing one in the clinical setting. Kessler et al., developed a curriculum for just-in-time and just-in-place training for pediatric lumbar puncture [24]. While they found no difference in success rate, they did find improvement in process measures and behaviors [24].

Deliberate practice curriculums focus on fine tuning and enhancing learner skills. A deliberate practice curriculum will provide immediate, descriptive feedback to the learner. The curriculum may provide a checklist of items that learners need to complete and facilitators should teach to. Anchors should be descriptive and objective (i.e. makes multiple, inefficient movements to make an incision) to cue the evaluator to make suggested modifications to the procedural technique. Hunt et al., pioneered the use of rapid cycle deliberate practice (RCDP), focused on the first five minutes of resuscitation skills [25]. Their research found that using this teaching method to teach skills improved clinical outcomes, such as basic life support (BLS) skills and time to defibrillation [25].

Finally, summative evaluations often used for high stakes procedures such as intubation or central line training, utilize global rating scales or checklists with standardized preparations of task trainers. There should be limited or no "teaching" or "feedback" of procedural skills during the evaluation. It is imperative to properly train raters to obtains consistency throughout the evaluation process.

A second novel simulation curriculum, developed for emergency nurses (and later expanded to residents and physician assistants), incorporated the use of ultrasound and "phantoms" that allowed learners to learn the technique and practice inserting peripheral IVs with ultrasound guidance [26]. This formative training program utilized a hands-on active learning environment and deliberate practice approach to meet the needs of the learner. While the use of ultrasound guided IVs by emergency nurses has been in place for the past 15 years, the adoption has been extremely limited across the country [27, 28]. Incorporating task trainers into the curriculum allows for nurses to gain competence in a new skill that improves patient care, reduces throughput time, and enhances the nurse's stature. The training on part-task trainers has demonstrated improved confidence in the technique and increased usage of the ultrasound to place peripheral IV's reducing the reliance on invasive central lines or other temporary mechanisms, such as intraosseous (IO) access. To ensure that the needs of the patient were met, a summative evaluation component was added to ensure patients benefited from the program and technique (Table 11.2).

Cost Considerations

While a full review of task trainers is beyond the scope of this chapter, each simulationist should do their due diligence before purchasing a part-task trainer. Due diligence should include requesting a demonstration of the task trainer with the opportunity to practice the intended procedure, a thorough

Table 11.2 Comparison of part-task trainers

Trainer type	Approximate cost	Pros	Cons
Un-embalmed cadaver	$800–$3000	Reduced rigidity and realistic properties	Short utilization period Infectious disease risks Tissue compliance Regulatory requirements Specialized facilities and staff
Embalmed cadavers	$800–$3000	Can be used for a longer time than unembalmed cadavers	Rigidity Loss of tissue texture, consistency, and surgical planes. Unpleasant odor Regulatory requirements Specialized facilities and staff
Soft embalmed (Thiel cadaver)	10%–20% higher than traditional embalming costs	Longer lasting tissue preservation. Cadavers can be kept in plastic bags without refrigeration. Color, suppleness of skin, joint flexibility, and fascial integrity of the cadavers is retained	Regulatory requirements Specialized facilities and staff
Animal models	Varies on animal and parts	Best means to simulate patients in terms of preparing for anxiety and demands of patient care	IRB approval required Regulatory requirements Specialized facilities and staff (including anesthesia) Ethical concerns. Extensive cost to obtain and house the animals
Ex-vivo	Varies on part	Limited to no ethical concerns With external pumps can mimic active bleeding Less expensive than live animal models	Regulatory requirements Specialized facilities and staff
Virtual reality	Varies on simulator	Useful for specific skills (i.e. surgery)	Limited tactile component, thereby limiting functionality and use (i.e. IV starts) Limited competition
Synthetic tissue	$40,000+	Reusable Highly realistic No ethical concerns	No chemicals
Plastic, rubber, silicone	Highly variable depending on task and manufacturer	Durable Reusable Many trainers available to simulate many procedures Many vendors and competition Looks like the body part it is meant to represent	Limited realism Anatomical correctness may be limited One simulator is capable of allowing 1–3 tasks. (i.e. chest tube trainer may not allow for intubation)
DIY models	Varies (typically low cost)	Low cost Can create many to facilitate learning of large groups	Takes time to create and ensure realism Requires learners to significantly "suspend disbelief"

accounting of costs, including initial purchase price, consumable/replacement part(s) cost, and intended life-span, along with end-user evaluation of realism. Commercially available pictures, which intentionally make the product look enticing, often are not representative of the anatomy and feel of the product. While all the simulators listed below are synthetic, the quality of the materials, anatomical correctness, and procedural accuracy are highly variable.

Multiple instances of simulators not being clinically accurate can be found. Inaccuracies include a simulated lumbar puncture trainer being designed to not allow the needle to pass completely through the subarachnoid space resulting in 100% success in getting simulated cerebral spinal fluid or airway mannequins that are too stiff and challenging to intubate, thereby not providing a realistic experience for novice learners. Additional concerns include the needle decompression site on a part-task simulator being at the third intercostal space instead of the second intercostal space and fluid filled phantoms not producing flashback when an IV catheter is inserted. Significant lapses in simulator fidelity threaten the learner and instructor engagement ("buy-in") and the overall educational efficacy of the task training experience.

While price does not always indicate a better product, there are distinct differences between simulators at varying price points. It is in the best interest of simulationists using part-task trainers to thoroughly evaluate each option before making a purchase. Some simulation vendors will bring task trainers to your facility for testing and evaluation. This is an essential step

Table 11.3 Examples of commercially available task trainers

Trainer	Manufacturer	Capabilities	Cost[a]	Audience
Airway management	Laerdal	Basic and advanced airway	$$$	Pre-hospital providers, nurses, medical students, residents, attending faculty
	Gaumard	Basic, advanced, and surgical airway	$$–$$$	
	TruCorps	Basic, advanced, and surgical airway	$$$–$$$$	
	Simulab	Basic, advanced, and surgical airway	$$$	
	Simulaids	Basic and advanced airway	$$	
Catheterization training	Limbs and things	Interchangeable male/female anatomy	$$$	Nurses and residents
	Gaumard	Interchangeable male/female anatomy	$	
	Laerdal	Interchangeable male/female anatomy	$$	
	Simulaids	Male and female trainer	$$	
	Kyoto Kogaku	Interchangeable male/female anatomy	$$$	

[a]Cost is determined by looking at MSRP from retail websites
Key:
$ = less than $500
$$ = $501–$999
$$$ = $1K–$2.5K
$$$$ = more than $2.5K

when evaluating potential products as it allows potential learners to be exposed to the task trainer, experts to provide feedback, and simulation staff to test the quality, realism, ease of use, and expected lifespan of the product (Table 11.3).

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Mannequin Simulators

12

David A. Meguerdichian

Mannequin-Based Patient Simulation

Mannequin-based simulation relies on the use of manufactured mannequin simulators to recreate a patient encounter for a learner, typically in a simulated environment. Mannequin simulators exist along a full spectrum of capabilities ranging from basic task trainers to full body, computer-reliant patient mannequins. In general, these devices are classified based on their function and fidelity, meaning how closely the device replicates reality.

For decades, emergency medicine (EM) educators have used basic simulator mannequins, such as intubation heads and cardiopulmonary resuscitation models, to teach core EM skills [1]. More recently, several manufacturers have developed models that more closely simulate the features and physiology of an actual patient. These life-like human mannequins are comprised of integrated computers and generators driven by complex mathematical models and operated remotely by an instructor. Unlike the other end of the mannequin spectrum, these devices produce visual and auditory physiologic signs that can be appreciated by the learner and provide output measures such as blood pressure, pulse, and oxygen saturation that are displayed on integrated monitors.

Simulator mannequins have gained increasing favor over the last two decades namely due to the fact that they serve as viable alternatives to the practice of using animals and clinical patients as models on which to learn and practice medicine (Fig. 12.1). Simulator mannequins have also stepped in as a teaching tool to fill the training voids created by resident duty-hour restrictions and reduced physician teaching time. With an increasing focus on patient safety since the release of the Institute of Medicine's "To Err is Human: Building a Safer Health System", simulator mannequins provide a platform for repetitive and safe practice in the error prone profession of medicine [2].

History of Mannequin Simulation

Medical simulation and the mannequins at its core were modeled after the use of simulators in other high risk, teamwork based professions. The aviation, military, and nuclear power sectors have created simulators aimed at placing trainees in realistic situations in which they can receive immediate feedback regarding their decisions. With flight simulators showing evidence-based improvement in pilot skills, the development of medical simulators and their use in medical education seemed like an appropriate application of technology to another high-risk, skill driven profession [3]. Several early medical simulators aimed to address this need and laid the foundation for many of today's modern devices (See Table 12.1).

In the early 1960s, the first modern example of a medical based mannequin, Resusci Annie, was produced by the plastic toy manufacturer Laerdal. This basic mannequin, one that would be classified as a task trainer by today's standards, was created for the practice of mouth-to-mouth resuscitation [4]. The device later evolved to become a mannequin used to teach cardiopulmonary resuscitation following the introduction of a spring to allow for chest compressions and recoil.

Close to a decade later, the first life-like, full-scale human patient simulator was created at the University of Southern California by Dr. Stephen Abrahamson and Dr. Judson Denson. This mannequin, called Sim One, was developed to help train anesthesia residents. This early device had several high-fidelity characteristics including features such as blinking eyes, reactive pupils, a mobile jaw, and a chest that simulated cardiopulmonary processes [4, 5]. This served as the first computer-based simulator to be used in medicine.

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Fig. 12.1 Medical team training and intubation practice being performed on SimMan 3G® mannequin. (Photo courtesy of Laerdal Medical. All rights reserved)

Table 12.1 Early Simulators: A listing of early simulators that helped lead to the development of modern day devices

Mannequin	Era created	Designer	Description
Resusci Annie	1960s	Asmund Laerdal	Cardiopulmonary resuscitation training device with internal spring to allow for simulation of chest compression and airway that can be manipulated to allow for ventilation
Sim One	1960s	Stephen Abrahamson Judson Denson	Lifelike, computer controlled device with high-fidelity features such as breathing, eye blinking and papillary changes
Harvey	1968	Michael Gordon	Fullsize mannequin able to display physical exam findings consistent with 27 cardiac conditions
CASE (comprehensive anesthesia simulation environment)	1987	David Gaba	Mannequin with incorporated waveform generator and computer that could be use to manipulate vital signs to create critical events in a simulated operating room environment
GAS (Gainesville Anesthesia simulator)	1980s	Michael Good JS Gravenstein	Mannequin with refined lung design that could simulate anesthesia distribution and used to teach management of critical events in anesthesia

Unfortunately, due to the high expense of its software and reliance on apprenticeship-style training, this device did not see widespread use or mass production.

Driven by patient safety, two separate teams created patient simulators aimed at improving team training and patient care. At Stanford Medical School, Dr. David Gaba created the CASE (Comprehensive Anesthesia Simulation Environment) that combined waveform generators and virtual instruments attached to a Macintosh computer to form a mannequin whose vital signs could be manipulated to simulate critical events [4]. Gaba used their mannequin to focus in on team performance during critical events [5]. During the same time, a team at the University of Florida, Gainesville, championed by Dr. Michael Good, created the Gainesville Anesthesia Simulator (GAS). This group aimed to create a simulator that could help learners identify and appreciate critical events in anesthesia [4, 5]. Aside from differing goals, the two devices also differed in their means of operation with the former being instructor driven and the latter running off software enabled sequences that responded to actions of both the instructor and learner [4]. Both prototypes were commercialized in the 1990s but their widespread adoption was limited due to the costs of these devices.

At the turn of the century, financial constraints became less of an issue as many commercial manufacturers began to offer mid-fidelity simulators, devices with focused or customizable features, at lower costs than the full-scale models [5]. This included the first SimMan mannequin by Laerdal and the first Emergency Care Simulation mannequin by Medical Education Technology Inc. Other companies, such as Gaumard Scientific, which created one of the first full fidelity obstetrics simulators, and Kyoto Kagaku are creating a more diverse and growing market of mannequins Today, these diverse, moderate priced simulators can be found in most medical education training facilities throughout the country and around the globe..

Principles of Mannequin Programming

Many factors come into play when designing a simulation scenario using a high-fidelity mannequin. The timing of events and complexity of the programming are critical factors to be decided prior to the start of any scenario.

With time, one must take into account the learner that will be participating, as their fund of knowledge and ability to manage the simulated case will command this factor more than anything. Timing is also dictated by the need for debriefing which often takes a half to two-thirds of the allotted time for the educational session. As a result of these driving forces, events incorporated into the simulation scenario may need to be accelerated in order to achieve the desired outcome and teaching objective within the allotted period. Examples of this include fluid boluses or medication administrations that could take over an hour in the real clinical setting but are instead delivered in a matter of seconds to minutes to the mannequin in the simulated environment. A fine balance must be met here so that the realism of the scenario, attention of the learner, and objective of the session are not lost due to events occurring either too fast or too slow.

Simulation encounters using high-fidelity mannequins can be either pre-programmed by the operator or "run on-the-fly" by the instructor without any pre-course programming (Fig. 12.2). Programmed mannequins require input and work by the operator prior to the simulated event. In this situation, the operator must have a working knowledge of the medical and simulation aspects of the case or readily have an assistant to help with one or the other. During the planning stages, the operator can program physiologic changes, vital sign abnormalities, noises, and physical exam findings into the mannequin software. The timing and speed of decompensations as well as the response to expected interventions can also be programmed. Care must be taken to avoid unrealistic responses to interventions during this stage so as to preserve the realism of the case. Although it can be time-consuming during the initial programming and setup, programmed cases have the benefit of allowing educators to standardize cases as well as teach and evaluate learners while not worrying about adjusting the mannequin in real time.

One aspect of programming that can be helpful is trending of events. Utilizing trending features of the mannequin software allows the operator to program in changes in clinical presentation and vital signs over a specified number of seconds to minutes (Fig. 12.3). This feature is key as it prevents the rapid change in vital signs that would otherwise occur and would render the physiologic changes unbelievable. Several trends can be programmed into a simulation scenario prior to running the case (See Table 12.2). With

Fig. 12.2 Simulated patient encounter being "run on-the-fly" by the instructor using Laerdal's SimMan 3G® user interface and SimView®. (Photo courtesy of Laerdal Medical. All rights reserved)

Fig. 12.3 CAE Healthcare's Muse® user interface that allows logging and trending of events. (Photo courtesy of © 2016 CAE Healthcare. All rights reserved)

Table 12.2 Trending: Examples of the effective use of trends and their ability to produce realistic vital sign changes with clinical interventions

Description of trend	Outcome
Shock	Gradual increase in heart rate of 10–15 beats/min over 3–5 minutes Gradual decrease in blood pressure of 10-15 mmHg/min over 3–5 minutes Gradual increase in respiratory rate of 5 breaths/min over 3–5 minutes Gradual decrease in end tidal CO2 of 3-5mmHG/min over 3–5 minutes
Intravenous fluid administration	Gradual decrease in heart rate of 5–10 beats/min over 1–3 minutes Gradual increase in blood pressure of 5-10 mmHg/min over 1–3 minutes
Oxygen administration	Gradual increase of oxygen saturation of 5%/min over 30–60 seconds Gradual decrease in respiratory rate of 2–5 breaths/min over 1–3 minutes
Vasopressor administration (eg: Dopamine)	Gradual increase in blood pressure by 5–10 mmHg/min over 1–3 minutes Gradual increase in heart rate by 5–10 beats/min over 1–3 minutes

proper programming and use of the mannequin software, common trends can be copied and reused in other scenarios, saving time in future programming. Common examples of this include the improvement of tachycardia with intravenous fluid administration or the improvement in hypoxia with the application of supplemental oxygen to the mannequin.

Another form of programmed mannequins are autonomous simulators. These machines can provide intervention feedback without an operator and rely on mathematical modeling algorithms to prompt changes to the mannequin's physiology based on a specific intervention (Fig. 12.4). These devices arose from computer-based simulators and use complex mathematical models to direct physiologic and pharmacologic changes. In the autonomous simulators, the mathematical terms help define the response to both operator devised events and the interventions carried out by the learner. With these devices, the simulator can create real-life physiologic responses automatically and take much of the in-situ workload off the operator. This

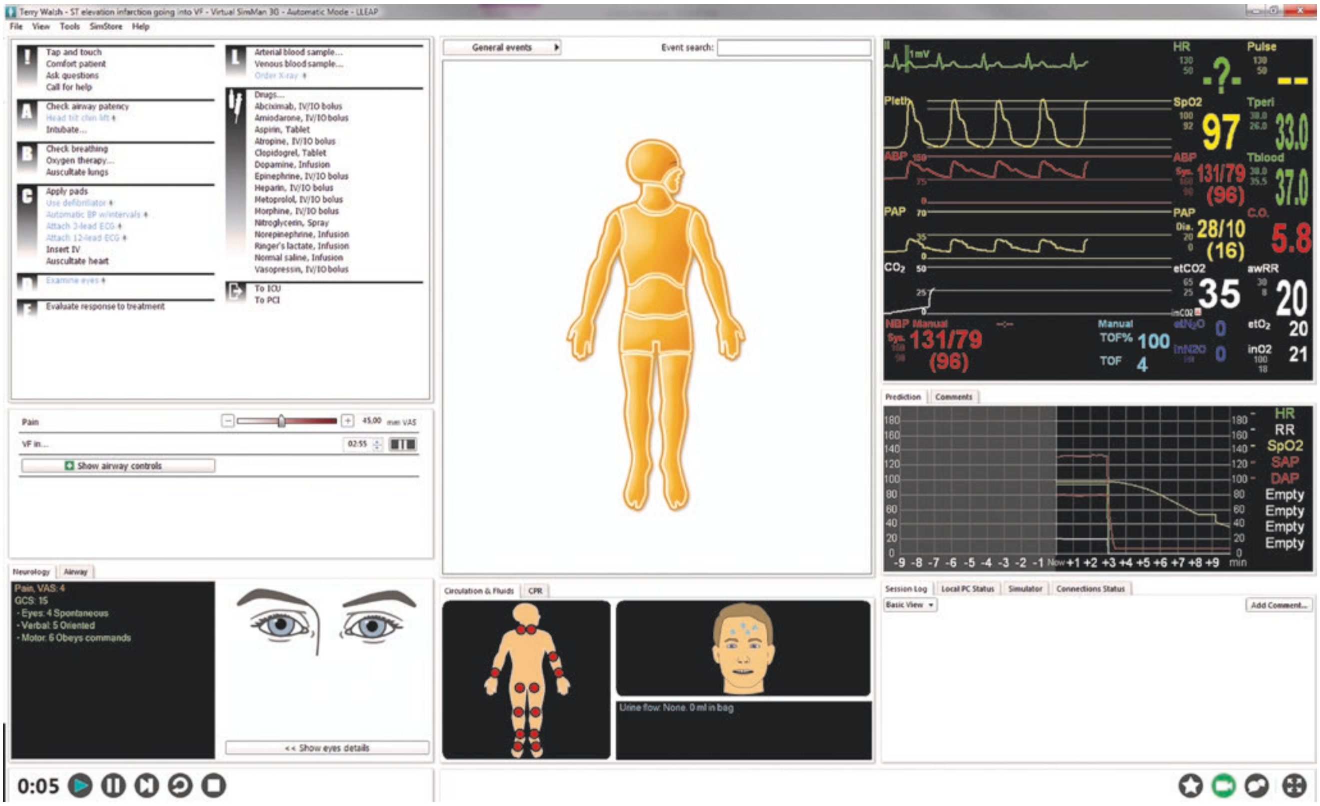

Fig. 12.4 Laerdal's SimMan 3G® user interface operating in autonomous mode. (Photo courtesy of Laerdal Medical. All rights reserved)

attention can then be directed to observation and evaluation of the learner. As an example, if the instructor wanted to simulate a case featuring a patient undergoing alcohol withdrawal, they could program the mannequin to become increasingly hypertensive and tachycardic over a desired period of time. Instead of relying on the instructor to change the vital signs on the go, the autonomous simulator could correct these parameters automatically in response to the intravenous infusion of fluid and administration of benzodiazepine-based medications all aimed at countering the sympathetic overdrive of alcohol withdrawal. Devices like Human Patient Simulator (HPS) and METIman distributed by CAE Healthcare have a pharmacology system integrated into their mannequins and software that register intravenous and inhaled medications causing an automatic, dose dependent response when administered by participants (Fig. 12.5). Similarly, these devices can substitute the need for complex trending in cases where there are multiple interventions and major changes to physiologic parameters. Wide spread use of autonomous simulators has been tempered by the cost of these devices and often the desire for more operator control.

As an alternative to the programmed approach, simulators can be operated "on-the-fly". This approach works well in simple cases where very few changes to the simulator or its physiology are expected. For example, a scenario involving a patient with atrial fibrillation with rapid ventricular response would only require the operator to manage the rate and rhythm of the heart. A pharmacologic intervention or call for defibrillation by the learner would merely require realistic adjustment of the vital signs by the operator. Furthermore, operating "on-the-fly" allows the educator to also manipulate time and allow novice

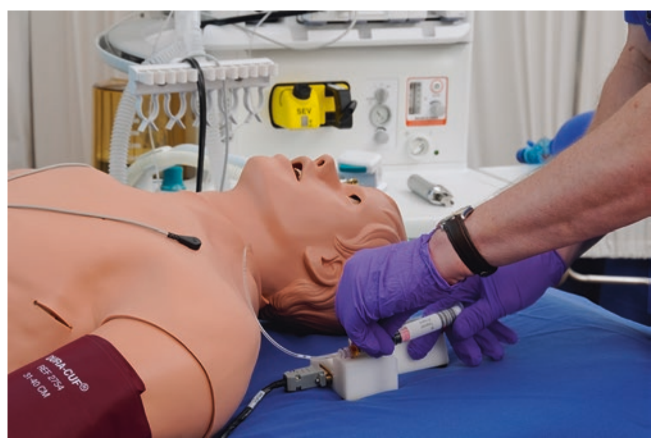

Fig. 12.5 CAE HPS® Human Patient Simulator uses bar code technology for its drug recognition system that allows the system to identify the concentration and dose of the drug administered. (Photo courtesy of © 2016 CAE Healthcare. All rights reserved)

learners more opportunity to identify and respond to the medical condition presented. For instance, in a scenario where pronounced hypoxia is present, the operator can provide more time for a new medical student to identify and react to the situation rather than allowing the simulator to deteriorate and code in a fashion more consistent with a real, time-based physiologic response. As a result of these and other simple cases, the operator running the mannequin "on-the-fly" can easily balance managing the logistics of the simulator with the observational duties expected of the instructor.

As an intermediate between programmed cases with trending and cases run "on-the-fly", one can utilize embedded programs in some simulators to automatically improve or worsen the clinical picture with the click of a single button. Many platforms allow scenarios to be programmed where by clicking a single "improvement" button in the software results in the pre-desired changes to automatically occur over a pre-specified time period. Quick buttons like these in the software allow for controlled changes to the mannequins physiology over a predetermined time without any significant effort on the operator's part within the case.

High-Fidelity Mannequin Characteristics

At the core of high-fidelity mannequin simulators is the fact that these devices have intrinsic properties and higher functions that help to recreate certain aspects of human physiology and anatomy. The high-fidelity characteristics of these mannequins attempt to humanize the plastic mannequin and provide the type of visual, tactile and auditory feedback one would expect with a live patient (See Table 12.3).

Table 12.3 Common High-Fidelity Simulator Features: A list of integrated features found in many of the modern full size adult high-fidelity patient simulators

Common features of high-Fidelity adult simulators
Tetherless
Integrated monitors
Palpable pulses (carotid, femoral, radial, brachial)
ECG transmission
Laryngospasm
Airway occlusion
CO2 detection
Reactive pupils
Eye blinking
Intravenous placement
Intraosseous placement
Chest thoracostomy
Needle thoracostomy

Cardiovascular Considerations

Within most high-fidelity mannequins, pulse rate and strength can be appreciated at several anatomical positions such as the carotid, femoral and radial areas. This characteristic is critical for learners trying to properly identify pulses especially in code situations. With the use of the mannequin's software, these parameters can be manipulated as the clinical picture changes. Along with pulses, the mannequin's heart sounds can be appreciated in the typical anterior chest positions. In general, each high-fidelity simulator comes with an extensive library of various heart sounds, ECG tracings, and corresponding pulse rates that can range up over 200 beats/min. Mannequins use ECG studs or directly connect to real ECG machines to simulate ECG acquisition (Fig. 12.6). Similarly, anatomically appropriate studs are in place on the anterior chest wall to allow for defibrillation (Fig. 12.7). Most high-fidelity models will register the energy level and number of shocks administered and can be set to automatic conversion once a certain pre-set threshold has been reached for the case. These features are useful for teaching synchronized and asynchronized cardioversion pearls as wells as aspects of cardiac pacing to emergency medicine learners. High-fidelity mannequins are great for cardiopulmonary resuscitation practice and evaluation (Fig. 12.8). Compression depth, release and frequency can be detected by the device, generate palpable pulses and send quality data to the operator's computer for feedback.

There are several mannequins on the market created solely for a more focused approach to cardiovascular simulation education. One example is *Harvey The Cardiopulmonary Patient Simulator*, a product now marketed by Laerdal, which was first created in 1968 by Dr. Michael Gordon, with the goal of providing a mannequin simulator capable of thoroughly teaching bedside cardiac assessment skills [4]. The device realistically simulates auscultatory events in four classic areas, reproduces heart murmurs, and simulates precordial impulses. Such a device highlights the blurring of lines between partial task trainer and high-fidelity mannequin simulators.

Respiratory Considerations

High-fidelity mannequins have imbedded mechanical technology that help to simulate several key features of respiratory physiology. Most devices are able to simulate bilateral and unilateral chest wall rise and fall. Similarly, these mannequins can vary with their level of compliance and resistance which make them useful in teaching cases of asthma or COPD exacerbation where such factors are critical for portraying encounters with these patients. Auscultation can occur both anteriorly and posteriorly with most devices

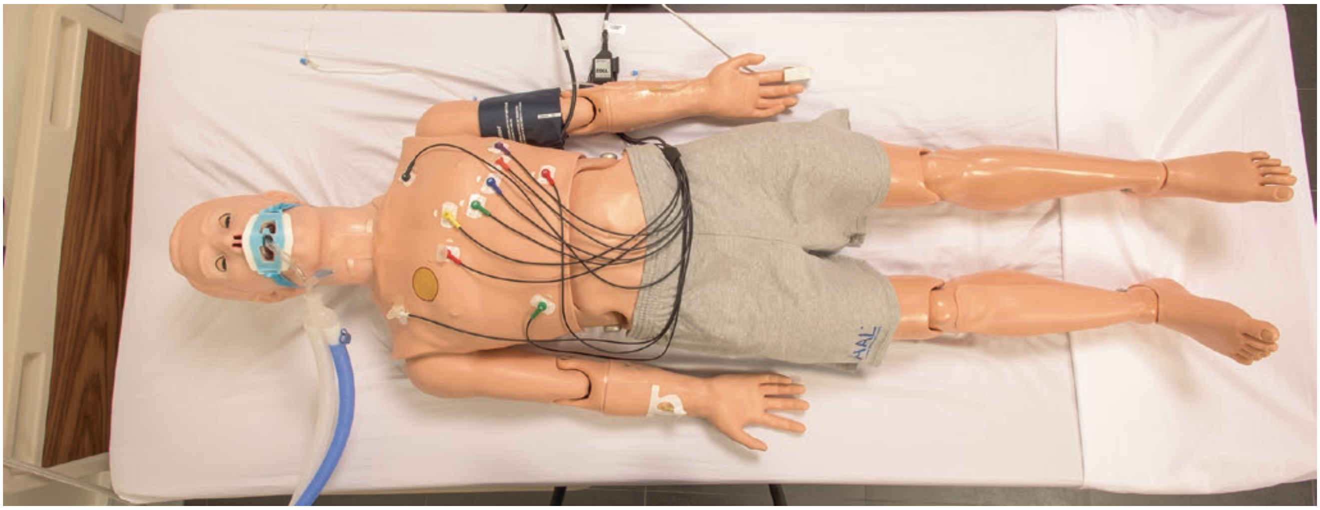

Fig. 12.6 Hal® S3201demonstrating the ability to perform real ECG acquisition. (Photo courtesy of © 2016 Gaumard Scientific. All rights reserved)

Fig. 12.7 Hal® S3201demonstrating defibrillation pads attached to the anterior chest wall studs for defibrillation training. (Photo courtesy of © 2016 Gaumard Scientific. All rights reserved)

Fig. 12.8 Cardiopulmonary resuscitation practice being performed on SimMan 3G® mannequin. (Photo courtesy of Laerdal Medical. All rights reserved)

capable of producing normal and abnormal breath sounds. Parameters such as tidal volume, oxygen saturation, and respiratory rate can be adjusted by the operator through the mannequin software and interface.

Some mannequins have advanced respiratory system features that allow them to function closer to real patients. For instance, HPS can expire carbon dioxide automatically based on the clinical scenario. The amount of end-tidal carbon dioxide produced can then be detected and fed back to the learner in real time (Fig. 12.9). Some mannequins, such as the HPS, can have this measured through waveform generated capnograms while others simply provide a qualitative output as one would find with a colorimetric carbon dioxide detector. Aside from measured means of respiratory distress, some mannequins can display signs of pronounced cyanosis as indicated by blue lights illuminating on the lips. More advanced respiratory features include the ability to respond to ventilator support modes such as continuous positive airway pressure and pressure support ventilation. Some simulators can even be configured to fight the ventilator settings entered to allow the learner to troubleshoot this frequent, real life scenario.

Fig. 12.9 The respiratory status of the simulated patient can be assessed with auscultation of breath sounds by the learner or through end-tidal carbon dioxide monitoring with HPS® Human Patient Simulator. (Photo courtesy of © 2016 CAE Healthcare. All rights reserved)

Fig. 12.10 HPS® Human Patient Simulator being managed post intubation. (Photo courtesy of © 2016 CAE Healthcare. All rights reserved)

Airway Considerations

Given that educators in Anesthesiology and later Emergency Medicine were the driving forces behind the creation of high-fidelity patient simulators, it is not surprising that most mannequins allow for realistic airway management. In general, mannequins allow for proper positioning for airway management including head tilt, chin lift, jaw thrust and cricoid manipulation. Along with this, these simulators can be bag-mask ventilated and intubated via the oral and nasal routes (Fig. 12.10). Operators can challenge their learners by manipulating the airway with tongue swelling, trismus, pharyngeal obstruction, laryngospasm or bronchospasm. Further realism can be achieved by replacing the soft upper dentures with a hard set of teeth or by applying decreased cervical range of motion to the mannequin.

Several features exist in these mannequins to help the instructor teach the learner about trouble shooting difficult or failed airways. If the endotracheal tube is placed in the esophagus, gastric distention can be simulated. The simulators will often automatically provide feedback to the learner if there is improper tube placement. For instance, an esophageal intubation will result in lack of breath sounds in the chest upon auscultation while a right mainstem intubation will result in unilateral chest wall rise. If oral or nasal intubation is unobtainable and the patient falls into the can't intubate can't ventilate category, most high-fidelity mannequins allow for surgical or needle cricothyrotomy through replaceable neck skin (Figs. 12.11 and 12.12). Through the integrated software, critical actions of airway management and intubation can be logged and time stamped for review during debriefing sessions.

Fig. 12.11 CAE Caesar® trauma patient simulator undergoing cricothyrotomy procedure for failed airway. (Photo courtesy of © 2016 CAE Healthcare. All rights reserved)

Fig. 12.12 Hal® S3201with a surgical airway placed through replaceable neck skin. (Photo courtesy of © 2016 Gaumard Scientific. All rights reserved)

Other High-Fidelity Considerations

Aside from the standard airway, breathing, and circulation components, high-fidelity mannequins have an array of other features and interfacing equipment designed to enhance the simulation experience.

Sounds

Most high-fidelity simulators have embedded speakers connected to a wireless microphone that allows the operator or an assistant to speak as the patient and provide vital history for the case. This feature transforms the mannequin into a standardized patient and enhances the interaction with the learner. This is only possible though if the learner is counseled on and able to suspend disbelief as the voice will be coming from a mannequin with no facial gestures or lip movements normally appreciated in typical history taking. Some models come with pre-recorded sounds such as coughs and voices. Other sounds can be generated by the simulator include various body sounds such as those from the heart, lungs and bowels. All of these pre-recorded or programmed sounds can be triggered by the simulation scenario or activated by the operator.

Eye Settings

Many mannequins have eyes with advanced capabilities that can be used by the learner to assess the state of disability and level of consciousness. Some models have eyelids that blink, open and close spontaneously. Some even have pupils that constrict and dilate on exposure to light and also allow for pupillary accommodation (Fig. 12.13). Programming can alter the speed of pupillary response as well (Fig. 12.14). These features, although advanced, can seem mechanical at times and thus requires the learner to again suspend disbelief as they interact with the mannequin.

Fig. 12.13 Hal® S3201demonstrating the ability to constrict and dilate its pupils in response to light. (Photo courtesy of © 2016 Gaumard Scientific. All rights reserved)

Fig. 12.14 Demonstration of SimMan 3G's® programmable pupillary response. (Photo courtesy of Laerdal Medical. All rights reserved)

Limbs/Joints

Full-size mannequins have 4 extremities and some degree of joint mobility. Single-axis rotation is seen typically in the lumbar spine, knees and ankles. Three-axis mobility is usually found in the neck, shoulders, hips and wrists. Limbs also provide locations for palpating pulses. For example, Laerdal's SimMan 3G can have pulses palpated in the left brachial region, bilateral radial region, bilateral femoral region, bilateral popliteal region, and over the dorsum of both feet. Aside from this, several models offer add-on limbs that can simulate traumatic injuries such as an amputated arm or leg with associated bleeding.

Vascular Access

Intravenous access can be obtained in designated areas within most high-fidelity models. Intravenous cannulation, often times with realistic confirmation via blood flashback, is usually supported in one extremity. Common access points include the brachial, cephalic, basilic and antecubital veins. Some adult models and most pediatric mannequins are capable of simulating intraosseous line placement with the most common site being the tibia. This feature is key especially when using these mannequins for mock-code scenarios as the learner can appreciate the ease and effectiveness of intraosseous lines under such emergent conditions.

Procedural Skills and Interventions

High-fidelity mannequins possess the ability to train learners on invasive procedures critical to the field of emergency medicine. Core procedural skills such as needle decompression, chest thoracostomy, pericardiocentesis, surgical cricothyroidotomy and urinary catheter placement can be carried out on these mannequins (Fig. 12.15). In general, procedural training is often times better served on partial task trainers as these models are specifically

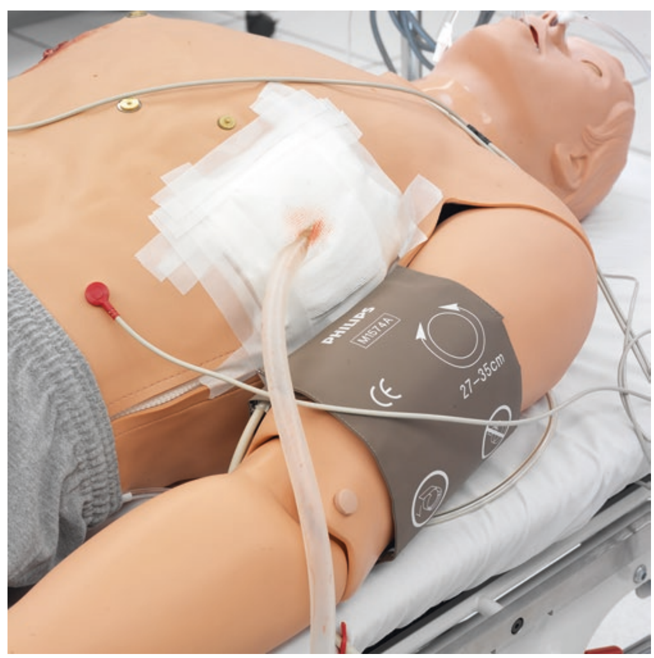

Fig. 12.15 Chest thoracostomy training on the HPS® Human Patient Simulator. (Photo courtesy of © 2016 CAE Healthcare. All rights reserved)

designed for the skill being taught and usually are easier to turnover for the next learner. Also, some of the realism of these procedures can be lost due to limitations of the mannequin. For example, needle decompression can be performed on SimMan 3G in the correct anatomical positions but the manufacturer recommends using a much smaller gauge needle (22gauge or smaller) than what is used in clinical practice so as to extend the longevity of the chest skin and pneumothorax bladders. Nonetheless, the ability to perform procedures on high-fidelity mannequins allows the instructor to incorporate these critical aspects of care into a simulation scenario and further enhance the realism of the case.

Patient Monitor

Similar to the clinical arena, a bedside monitor accompanies most simulator mannequins. These devices can display the mannequin's blood pressure, oxygen saturation, respiratory rate, pulse, and end-tidal carbon dioxide reading. Several programs even use this device to allow the operator to display critical images associated with the scenario upon request such as radiographs and electrocardiograms. Alarms associated with the monitor add to the realism of the scenario. The vitals displayed on this device are input and adjusted from the control computer and can either be programmed or changed "on-the-fly" by the operator.

Pharmacologic Administration and Drug Recognition Systems

A select group of mannequin simulators have an incorporated drug recognition system. Within these simulators, complex models exist to allow for an automatic realistic, dose related response to an administered drug. One example makes use of barcode technology that automatically identifies a drug, its concentration and dose from a set of labeled standard syringes. The incorporated software includes an extensive drug library and allows the mannequin to respond to the administered agent. Another mannequin model allows the drug used and its concentration to be registered manually by the operator or automatically through the use of radio frequency identification tags. These advanced models allow the learner to experience the cause and effect relationship of the medications they administer to their simulated patient.

Factors Guiding the Use of High-Fidelity Mannequins

Mannequin simulators, with their advanced and realistic features outlined above, clearly add to the fidelity of the simulation scenario. Despite this, one must consider several factors to help guide the selection of a mannequin to use for an educational program or when creating a new simulation center.

Cost

One of the main factors that come into discussion when considering the use of high-fidelity simulators is the cost associated with purchasing the device and its set up. Initial purchasing costs for a simulator mannequin can range from $30,000 to over $200,000. Generally, the costs of the mannequin increases as more advanced features are found in the unit. Additional expenses can include the cost of physical space, mannequin consumables to enhance the scenarios, hospital consumables to replicate the working environment, recording equipment, and staff salaries. The latter is key as properly trained simulation staff can help troubleshoot and address technical problems in real time. Finally, similar to any machine, mannequins can also incur maintenance and repair expenses.

In order to consider the cost-effectiveness of this technology, Iglesias-Vazques et al. compared the outcomes of an Advanced Life Support course using high-fidelity simulators compared with standard training models. This study showed a slight increase in passed candidates for the high-fidelity group but at a significant overall cost that was 3.77 times more expensive than the cost associated with the traditional model [6]. Lapkin et al. performed a similar analysis for nursing education. Based on a cost-utility analysis, the authors here concluded that medium-fidelity mannequins were more effective and cost one-fifth less than their high-fidelity counterparts with regards to nursing clinical reasoning, knowledge acquisition, and learner satisfaction [7].

Given increasingly tighter budgets and fiscal restraints by hospitals and universities, cost considerations often must come to the forefront when considering the use or purchase of a high-fidelity simulation model. Educators and administrators must identify the best fit for their department and create a long-range plan that takes into account future educational needs, upgrades, and maintenance costs. To offset the cost of the mannequins, many institutions have made use of grants, special allocations, outside donors and renting of the simulator to various agencies [8].

Fig. 12.16 In-situ training due to tetherless, portable devices like the CAE Caesar® mannequin adds to the simulation and experience for the learner. (Photo courtesy of © 2016 CAE Healthcare. All rights reserved)

Portability

In general, most mannequins will be stationed in a fixed location typically within the confines of a simulation center or educational suite. However, with advancement in technology, several of these devices are now tetherless and thus more portable. Adding to this, several devices now have rechargeable, internal batteries and smaller compressors making portability easier. Despite being mobile, these devices do weigh in the range of 75 to 85 pounds and require transport in their storage containers or on a hospital stretcher. Educators looking to perform in-situ training or mock codes should consider acquiring the portable devices (Fig. 12.16). By transporting the mannequin to the actual clinical site, one is able to use this educational device in the genuine working environment, enhancing the fidelity of the experience for the learner. This in situ simulation also limits the cost needed to recreate and acquire supplies necessary to simulate the working clinical environment. Finally, portability can be an added benefit from a cost-sharing perspective. Several centers or institutions can share the device and thus partner in the costs and maintenance of the simulator.

Educational Value and Skills Training

Prior to performing an educational intervention, a needs assessment should be carried out to determine which simulation modality should be implemented based on the teaching task at hand. The educator should aim to match the level of fidelity to the learner's expertise knowing that the optimal level of fidelity can vary based on the learner's prior real-life and educational experiences. High-fidelity mannequins provide the instructor with a device capable of simulating wide variations in physiological parameters and models that can be subjected to repeated clinical and procedural interventions [1, 9]. These features allow the learner to partake in deliberate practice followed by focused educator-run debriefing that helps solidify core teaching concepts through active learning. Partial task trainers, often times a cheaper and more focused device, can be used when the sole purpose of the session is confidence and competence of psychomotor skills for a particular procedure. High-fidelity mannequins, alternatively can be used for procedural education in the setting of case-based scenarios where the learner is encouraged to decide when to perform a critical procedure and how to integrate it into the overall care of the patient in the case [1]. If the educational session is more directed at teaching or evaluating history taking, physical exam, communication or professional skills, standardized patients are a much better option than mannequin simulators (Chap. 9) [10–13]. The humanistic interaction and emotional responses encountered when delivering for example, a death notification or bad news, are hard to replicate with a plastic mannequin even with the most advanced technology. Thus, based on the learning objective and target population, instructors can decide if the use of a high-fidelity mannequin is the best tool for teaching or if alternative modalities might be better

Fig. 12.17 Crisis resource management and team training for a group of medical providers using Laerdal's SimMan 3G®. (Photo courtesy of Laerdal Medical. All rights reserved)

employed. Understanding the amount of fidelity needed for the different types of learners and objectives is an area ripe for educational research initiatives going forward.

High-fidelity mannequin simulators find their educational strength in their ability to adapt and meet the needs of a wide array of educational objectives [14]. Simulator mannequins can be used to present hallmark cases and clinical findings with consistency and repetition [9]. They can also have graduated levels of difficulty allowing the educator who is driving the device to meet the learner at their educational level and attempt to push them beyond this boundary. Furthermore, mannequin based simulation cases provide the learner with an opportunity to appreciate and deal with system-based issues that extend beyond the nuts and bolts of medical care [14]. For example, learners can trouble shoot equipment failure or the inability to connect with a crucial consult while managing the critically ill mannequin.

Building off of this concept, mannequin based simulation has been especially useful for crisis resource management. This model was adapted from similar training systems employed by the airline and military sectors and focuses on effective communication skills, positive group dynamics, and proper resource utilization [15]. Mannequin simulators situated in either a simulated environment or placed within an actual clinical area can be used to run scenarios that provide the trainee team with challenges aimed at promoting complex, goal-directed group behaviors (Fig. 12.17). Through the use of carefully crafted cases with appropriate mannequin adaptation and the incorporation of robust feedback, these sessions provide a fantastic means for group education, error reduction and patient safety [16, 17]. Here again, the adaptability of the mannequin and its simulated environment help reproduce the chaos used to build strong resource management skills.

Limitations and Negative Transfer

Understanding the limitations of the high-fidelity mannequin is key to a successful educational initiative. Suspension of disbelief is critical of learners in any simulations scenarios as the models, despite the highest fidelity, can never replicate reality. The plastic feel of the mannequin's skin and mechanical qualities of its heart and breath sounds limit its realism. Furthermore, in the clinical environment, we treat patients on how they look. Many of the nonverbal cues that are so heavily relied upon such as skin color, mental status, work of breathing or anxiety are incompletely reproduced even with the best moulage. Recent advances in technology have tried to bridge this gap with mannequins able to demonstrate cyanosis through the incorporation of blue lights and others able to perspire to mimic diaphoresis. Even so, the ability to hone the skill of pattern recognition, one necessary for the prompt management of critically ill patients, is a challenge due to the imperfections of these highly technical models. Educators and learners alike must be aware of the possibility of negative transfer, which occurs when the mannequin or simulation scenario's imperfections, such as sped up timing and lack of mannequin color change, result in improper knowledge acquisition [9, 15]. Acknowledgement of the limitations and proper debriefing are key to overcoming these limitations and successfully teaching with a high-fidelity mannequin simulator.

The Evidence for Using Mannequin Simulators

As high-fidelity mannequin simulation has grown and become more utilized in the field of medical education, the literature surrounding this topic has focused on the impact of these devices on learners and their skill acquisition. Since its infancy, studies have shown learner preference for the use of high-fidelity simulation mannequins over other educational interventions and a greater satisfaction with more realistic mannequins [18–27]. Beyond satisfaction, educators like Bond et al. argued that high-fidelity mannequins could be used to assess patient care skills, communication, systems based practice, critical illness evaluation, procedural skills and interpersonal skills of learners [28]. High-fidelity simulation mannequins thus have been used to teach and evaluate principles including shoulder dystocia [29], PALS [30], ACLS [31], patient care in an intensive care setting [32], and goal directed therapy for sepsis [24]. These mannequins have also been shown to improve procedural skills including paracentesis [33], central venous catheter placement [34], fiber optic intubation [35], and general airway management [36–38]. The question still remains on whether higher fidelity correlates with better outcomes as several studies have shown no difference in skill acquisition between high and low fidelity models [18, 19, 39, 40]. Until this can be fully delineated, the appropriate mannequin choice should be dictated by the type of learner, the learning objectives of the session, and the resources available.

The ultimate utility of these models is demonstrated when simulation based training shows improved performance during patient care in the clinical arena. For instance, high-fidelity mannequin training has shown a greater adherence to ACLS protocols as compared with standard training [41]. In another study, air medical crews had higher endotracheal intubation success rates and fewer hypoxic arrests following the construct of a difficult airway simulation curriculum [42]. Similarly, improved airway management skills were seen both in the laboratory and clinical settings following simulation-based training [43]. High-fidelity simulation has also shown improved care for patients in the medical intensive care unit following mannequin training [32]. The pediatric literature has also shown improved patient care and pain management following formal simulation based teaching [44, 45]. Further publication of studies showing mannequin training improves clinical outcomes will be key for the continued growth and funding of this resource intense educational model.

Types of Mannequin Simulators

At the present time, the companies producing high-fidelity simulators include CAE Healthcare, Laerdal Medical, and Gaumard. Each company has a variety of portable simulators across a spectrum of ages that can be modified with interchangeable genitalia to represent either a male or female. A few examples of the available mannequins are described below shown in comparison view in Table 12.4.

SimMan 3G

SimMan was one of the first full-size, computer-operated, wireless, mobile high-fidelity patient simulators that was marketed by the Laerdal company. The newest version, SimMan 3G, has several advanced capabilities aimed at increasing the fidelity (Fig. 12.18). This device can simulate bleeding from its internal blood reservoir, convulse, discharge secretions from its eyes, and automatically respond to medications administered via the Drug Recognition System that registers the amount, type and speed of a drug. Furthermore, SimMan 3G can provided CPR feedback and allow learners to perform procedures such as intraosseous line placement and needle decompression. Laerdal also offers several other high-fidelity mannequins aside from SimMan 3G and purchasable simulation content and curricula from their online marketplace, SimStore.

Human Patient Simulator (HPS)

The Human Patient Simulator (HPS) is an adult, full-size mannequin first released to the market in 1996 (Fig. 12.19). It supports the use of anesthesia and medical gases and performs real gas exchange of oxygen and carbon dioxide. The HPS was the first device to provide patient monitoring with real physiological monitors. It also allows for mechanical ventilation and comes packaged with over 50 simulated clinical experiences. Additionally, the device comes equipped

Table 12.4 Comparison of features for high fidelity mannequins

	Features	HAL 3201 (Gaumard)	Trauma HAL S3040.100 (Gaumard)	SUSIE S2000 (Gaumard)	HPS (CAE)	METIman (CAE)	CAESAR (CAE)	APOLLO (CAE)	SimMan 3G (Laerdal)	SimMan 3G Trauma (Laerdal)	SimMan Essential (Laerdal)
Anatomy / General	Full Body	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Wireless and tetherless	Y	Y	Y	N	Y	Y	Y	Y	Y	Y
	Real Monitors	Y	Y	Y	Y	Y	N	Y	Y	Y	Y
	Autonomous	Y	O	O	Y	N	N	N	N	N	N
	Drug Recognition System	Y	N	O	Y	Y	Y	Y	Y	N	N
	Preloaded Scenarios	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Neurology	Blinking Eyes	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Reactive Pupils	Y	Y	Y	Y	Y	N	Y	Y	Y	N
	Seizures/ Convulsions	Y	Y	N	Y	Y	N	Y	Y	N	N
Airway	Bag Mask Ventilation	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Head-tilt, Chin-lift	Y	Y	N	Y	Y	Y	Y	Y	Y	Y
	Oral / Nasal intubation	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Intubation depth detected	Y	N	Y	Y	N	N	N	N	N	N
	Laryngospasm	Y	Y	Y	Y	Y	N	Y	Y	Y	Y
	Pharyngeal Swelling	Y	Y	Y	Y	Y	N	Y	Y	Y	Y
	Tongue Edema	Y	Y	Y	Y	Y	N	Y	Y	Y	Y
	Breakaway teeth	N	N	N	Y	Y	N	Y	N	N	N
Respiratoy	Spontaneous breathing	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Unilateral Chest rise	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Chest tube insertion	Y	Y	N	Y	Y	Y	Y	Y	Y	Y
	Needle decompression	Y	Y	N	Y	O	Y	Y	Y	Y	Y
	Variable Lung and Chest Compliance	Y	N	N	Y	Y	N	N	Y	Y	N
Circulatory	IV cannulation	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Blood pressure measurment	Y	Y	Y	Y	Y	N	Y	Y	Y	Y
	Carotid pulse	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Brachial pulse	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Radial pulse	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Femoral pulse	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Popliteal pulse	Y	Y	Y	Y	Y	Y	Y	N	N	N
	Dorsalis pedis pulse	Y	Y	Y	Y	Y	Y	Y	N	N	N
	Intramuscular injection site	Y	Y	Y	Y	Y	N	Y	Y	Y	Y
	Intraosseous injection site	Y	Y	N	N	N	Y	Y	Y	Y	Y

(continued)

Table 12.4 (continued)

	Features	HAL 3201 (Gaumard)	Trauma HAL S3040.100 (Gaumard)	SUSIE S2000 (Gaumard)	HPS (CAE)	METIman (CAE)	CAESAR (CAE)	APOLLO (CAE)	SimMan 3G (Laerdal)	SimMan 3G Trauma (Laerdal)	SimMan Essential (Laerdal)
Cardiac	CPR with real-time feedback	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Defibrillation capabilities	Y	Y	Y	Y	Y	N	Y	Y	Y	Y
	Pacing capabilities	Y	Y	Y	Y	Y	N	Y	Y	Y	Y
	ECG display	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Heart Sounds	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Digestive/ Urologic	Gastric distention from excessive BVM	Y	Y	Y	Y	Y	N	Y	Y	Y	N
	Urinary catheterization	Y	Y	Y	Y	Y	N	Y	Y	Y	Y
	Interchangeable genitalia	Y	N	N	Y	Y	N	Y	Y	N	Y
	Auscultation of bowel sounds	Y	Y	Y	Y	Y	N	Y	Y	Y	Y
Trauma	Bleeding and Hemorrhage Control	N	Y	N	N	Y	Y	Y	Y	Y	N
	Traumatic extremities	N	Y	N	N	Y	Y	N	N	Y	N

Fig. 12.18 SimMan 3G®. (Photo courtesy of Laerdal Medical. All rights reserved)

Fig. 12.19 HPS® Human Patient Simulator. (Photo courtesy of © 2016 CAE Healthcare. All rights reserved)

Fig. 12.20 CAE Caesar® trauma patient simulator. (Photo courtesy of © 2016 CAE Healthcare. All rights reserved)

with reactive pupils, blinking eyes, palpable pulses, urine output capabilities, and automatic responses to administered drugs with the enhanced drug recognition system. The HPS is known for its advanced physiologic programming as well.

Caesar

Caesar was developed by CAE Healthcare to help simulate trauma, disaster care, and the treatment of soldiers injured in combat (Fig. 12.20). This mannequin is designed for training military and first responders. It's self-contained 1.4 L blood tank capacity and six bleeding ports allows it to simulate significant hemorrhage. Furthermore, Caesar comes equipped with tourniquet sensors that allow for learners to place these devices with resultant hemorrhage control. Caesar is a tetherless based unit, has full articulation at all joints including the back, and can have multiple trauma-related interventions performed on the model such as needle thoracostomy. The mannequin itself is designed to resist harsh environments and even supports water-based decontamination thus making it ideal for in-the-field training.

Noelle

The Noelle S2200 Victoria is Gaumard's newest maternal and neonatal birthing simulator (Fig. 12.21). This mannequin allows the learner to experience childbirth from the onset of labor through the delivery and aftercare of the newborn. Victoria is completely tetherless and can simulate low and high-risk deliveries through its library of preprogrammed scenarios. Learners can experience normal delivery, shoulder dystocia, breech delivery, and C-sections. The device also comes with a full-term, tetherless newborn that can simulate signs of distress such as cyanosis, bradycardia, and tachypnea (Fig. 12.22). This feature increases the experience by allowing the learner to also care for and perform neonatal resuscitation. Gaumard also produces several standard, tetherless high-fidelity mannequins, a female mannequin, and a midrange birthing Noelle model that lacks some of the high-fidelity features of the Victoria model.

Pediatric Simulation Mannequins

There are several pediatric mannequin models available from the same manufacturers who distribute adult devices. Most mannequins work on the same operating platform as the adult versions. There are several features that vary between devices including age appropriate voices, palpable fontanelles, an umbilicus that can be cannulated, and the ability to demonstrate cyanosis through incorporated blue lights. SimBaby (Laerdal) (Fig. 12.23), Pediatric HAL (Gaumard) (Fig. 12.24), and PediaSIM (CAE Healthcare) (Fig. 12.25) are examples available in the marketplace.

Fig. 12.21 NOELLLE® S2200 Victoria Maternal and Neonatal Simulation System. (Photo courtesy of © 2016 Gaumard Scientific. All rights reserved)

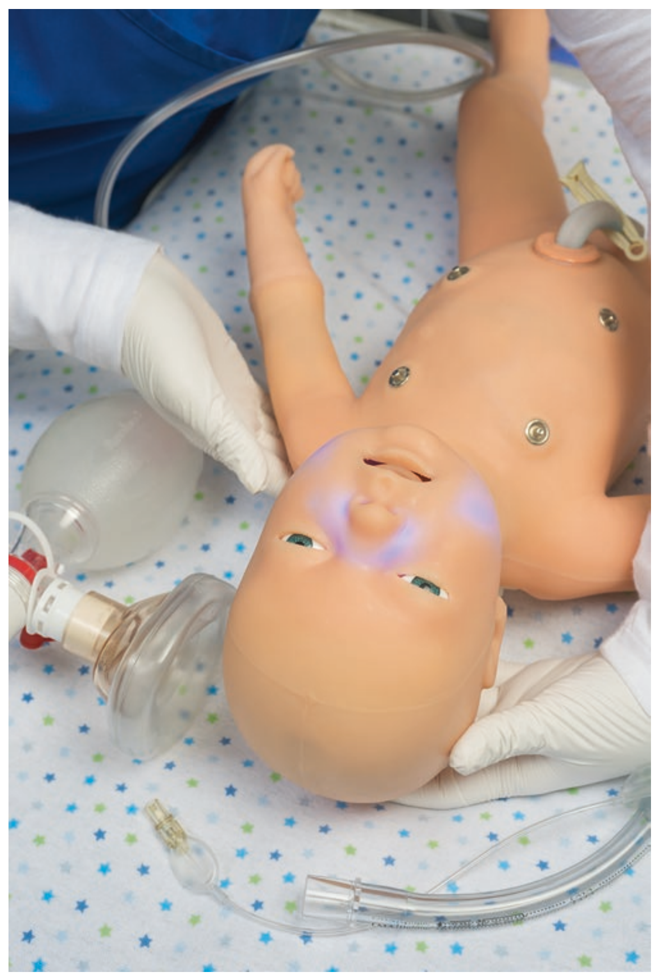

Fig. 12.22 Newborn Tory® 2210 simulator demonstrating cyanosis. (Photo courtesy of © 2016 Gaumard Scientific. All rights reserved)

Fig. 12.23 SimBaby® patient simulator. (Photo courtesy of Laerdal Medical. All rights reserved)

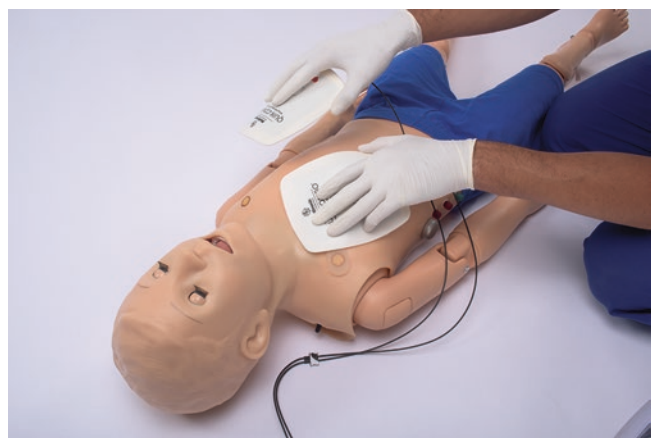

Fig. 12.24 Pediatric HAL® patient simulator. (Photo courtesy of © 2016 Gaumard Scientific. All rights reserved)

Fig. 12.25 PediaSIM pediatric patient simulator. (Photo courtesy of © 2016 **CAE Healthcare. All rights reserved)**

Conclusion

Although not a replacement for actual patient encounters, high-fidelity patient simulators provide a safe and near life-like model for practicing patient care. The use of these devices has exponentially increased in the field of emergency medicine over the last two decades. These devices provide real time physiologic feedback through cardiopulmonary and neurologic physical findings. Attached monitors and embedded sensors increase the fidelity and even permit some level of automation for most models. Through their fidelity and the use of deliberate practice with appropriate debriefing, these simulators are an ideal device for teaching clinical, procedural, and team training skills in a variety of clinical and non-traditional settings. Cost, space, and the appropriate amount of fidelity for the learner and objectives are important considerations. As technology advances, the goal is for the development of more dynamic features in an attempt to better assimilate reality and decrease the obvious limitations of these mannequins Continued scholarly investigation of mannequin simulators is necessary to justify their employment, assess their most effective use, and ensure that the educational efforts carried out on these devices result in improved patient care and safety in the clinical arena.

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Emergency Medicine Simulation Moulage

13

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Introduction

Moulage is the technique of creating wounds, rashes, and other physical findings on both mannequins and standardized patients in order to enhance the fidelity of a simulation case. Horror films and other theatrical productions employ similar techniques to demonstrate ghastly wounds, including everything from impalements to abdominal evisceration. This chapter will provide a guide for simulation educators on how to create a variety of physical findings for common simulation scenarios in Emergency Medicine.

Moulage originated in the late nineteenth century when wax models were used to document and teach dermatologic manifestations of syphilis, leprosy and tuberculosis [1, 2]. Moulage is used today in medical simulation to provide learners with a realistic learning environment where exam findings follow a "what you see is what you get" philosophy to add to both the physical, cognitive, and emotional realism of a scenario. Use of moulage to portray physical exam findings may allow learners to more fully immerse themselves in the scenario and behave more like they normally would in a clinical setting.

Educators have used and published on the use of moulage in a variety of settings. Dermatologists used moulage to both assess [3] and improve [4] medical student recognition of melanoma lesions on physical exam with standardized patients. Emergency physicians used blood moulage to assess how both physicians [5] and patients [6] estimate the quantity of blood loss in a variety of settings. Intensivists created a moulage technique to mimic a full thickness chest wall burn on a model that also allowed learners to practice performing an escharotomy [7]. Nursing educators used a low-cost burn moulage technique to demonstrate smoke inhalation injuries and superficial, partial thickness, and full thickness burns for undergraduate students [8]. Another undergraduate nursing curriculum included moulage to practice staging contusions and review underlying physiologic mechanisms [9].

Use of moulage should be targeted towards the learning objectives for a particular scenario. For example, in a mass casualty incident where learners are expected to triage a large group of patients based on a focused physical exam, physical findings can be aligned with triage goals. In a case where learners must manage gastrointestinal hemorrhage, moulage can be used to show learners the extent of bleeding in order to guide their management decisions. In a trauma scenario focused on primary and secondary survey, moulage findings can focus on common abnormal physical findings, such as chest wall crepitus and gunshot wounds. In an undifferentiated toxicology scenario, moulage can mimic physical findings like diaphoresis that may direct the learner to a specific toxidrome.

The practice of moulage is founded on theories about realism in simulation, including the fiction contract. A fiction contract between learners and instructors establishes that learners will agree to treat the scenario like they would a real patient and to suspend judgment of the degree of realism of a scenario, while the instructors will make the scenario as realistic as possible and necessary for the desired learning objectives [10].

There are several elements that determine realism in simulation. Dieckmann [10] applies a framework from social psychology to describe three types of realism in simulation: the physical, conceptual and emotional [11]. In a scenario involving a mannequin, the way the mannequin and the environment look, smell, feel, and sound represent the physical reality. The conceptual reality includes how the case evolves,

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as the patient's vital signs and condition respond in a rational way to various interventions and events. For example, if the patient has significant blood loss, the blood pressure will decrease. The emotional reality encompasses the learner's holistic response to the scenario, including how activated or engaged they may feel.

How much realism is necessary to achieve sufficient learner engagement? Depending on the learning goals, some scenarios may benefit from addition of moulage, while others may not. For example, for scenarios focused on team training, physical realism may be less important for achieving desired learning objectives, while physical realism may be essential to improve procedural skills [11, 12]. Dieckmann argues that more physical realism alone does not necessarily improve learning outcomes, but rather, that it is more important to match the level of each type of realism to the specific goals of the situation [10].

Moulage is only useful to the degree that it improves learner engagement. The goal of moulage is not to mimic every clinical situation exactly as it would appear in real life, but to provide sufficient physical clues for learners to be actively engaged with the scenario to achieve the desired learning outcomes.

Simulation education already requires a significant time commitment from instructors. Moulage can be done simply, without requiring extensive investment of time. A variety of supplies are available at different price points to allow access for budget conscious practitioners. This extra investment may add a great deal to a scenario and be a fun process for both instructors and learners.

The Basic Moulage Kit

The following equipment and recipes will show you how to create simple, low cost, realistic moulage for a variety of common Emergency Medicine scenarios. A number of pre-made moulage kits are commercially available at a variety of price points and can be a resource to provide these materials. Alternatively, one may purchase individual items from the following list of supplies. Many find that purchasing a basic kit and supplementing with other materials as needed is often the most cost-effective approach.

- Liquid Latex – commercially available, used as a base layer to protect the mannequin skin from staining or other damage.
- Liquid Skin – can be made as needed for molding lacerations and other skin pathologies. One major drawback is that it cannot tolerate physical contact.
- Simulated Blood – Recipe to follow
- Wood Ash or Crushed Charcoal Dust
- Various brushes, cotton balls, and makeup applicators
- Tongue depressors or popsicle sticks
- Disposable cups or mixing bowls
- Gloves
- Various impalements (lexan pieces, broken wood, fake knife, fake bones)
- Oatmeal
- Petroleum Jelly
- Various Color Wheels (Ben-Nye or similar)
- Scissors
- Cold Cream
- Glycerin
- Spray Bottle
- Tissues
- Wet wipes/Baby Wipes
- Antacid Tablets
- Various Bandages
- Pre-made Simulated Odors (Commercially made; simulated fecal spray, simulated emesis spray).
- A few "throw-away" t-shirts for simulated patients
- One large standard tool box – can be purchased at any home improvement store or discount tool store.

Moulage Instructions and Recipes

In this section, the reader will find some recipes for "liquid skin" and a number of techniques that can be used to create specifics effects that are needed in simulation. These are only some of the techniques and the reader should note that there are many other effects to be had and ways of doing them. The best way to learn these skills and to improve them, is for the simulation expert to practice and not be afraid of trying new things. It's only through trial and error that one will truly develop these skills.

We have included a number of recipes and "step-by-step" approaches for some of the commonly used techniques. The following moulage techniques and skills will be discussed:

Making Liquid Skin

Liquid Skin

Purpose: foundation for molding laceration, impalement, and gunshot wounds.

Ingredients: petroleum jelly, baby powder, acrylic flesh colored paint. Apply over liquid latex to protect the mannequin.

1. For use with mannequin or simulated patient:
   (a) Place some petroleum jelly into a heatable container. You should melt the jelly by heating using a double-boiler technique or by placing in a microwave oven for 10 seconds. You may repeat this step until the jelly

Fig. 13.1 Liquid skin. Ingredients: (**a**) Start with warmed petroleum jelly. (**b**) Add flesh colored paint and baby powder, for colour and to thicken. (**c**) Add baby powder or corn starch to thicken while mixing. Finished "fake skin"

is melted and the consistency is that of a thick, viscous solution (Fig. 13.1a).

(b) Add approximately 2–3 mL of acrylic, flesh-colored paint, and 1/4–1/3rd of a cup of baby powder into the melted jelly (See Fig. 13.1b).

(c) Mix thoroughly until the mixture is the consistency of cake frosting, or thicker, depending on need. You can add some additional baby powder and a tablespoon of cornstarch for the thickest consistency (See Fig. 13.1c).

Abrasion/First Degree Burn

Ingredients: liquid latex, eye shadow, gauze

1. For use on mannequin or simulated patient:
   (a) Take the liquid latex and apply to the area you wish to moulage with a cosmetic sponge. It should cover the mannequin surface completely but in a thin layer that will dry in about 5 minutes.
   (b) Apply make-up (usually eye shadow or skin blush) with gauze dressing (either 2 × 2 or a 4 × 4). You will need various shades of red to give the abrasion "depth" and to mimic the texture of an abrasion (See Fig. 13.2a).
   (c) Once you have reached the desire color/appearance you can "dab" at the abrasion with gauze dressing to more closely mimic the appearance of an abrasion (See Fig. 13.2b).
   (d) To remove the moulaged area, apply liquid laundry soap to gauze dressing and gently scrub the area (See Fig. 13.2c).
   (e) **Pro Tip**: If you mix some kitty litter into the liquid latex and then apply, it will give the texture and feel of "road rash" to the abrasion.

Bruise/Hematoma

Ingredients: liquid latex, eye shadow

1. For use with mannequin or simulated patient:
   (a) Apply liquid latex as you did for the abrasion.
   (b) Take eye shadows (usually best to use red, blue and grey shades) and apply with a cosmetic sponge. You will need to mix the color tones together to get the desired color and age of the bruise.

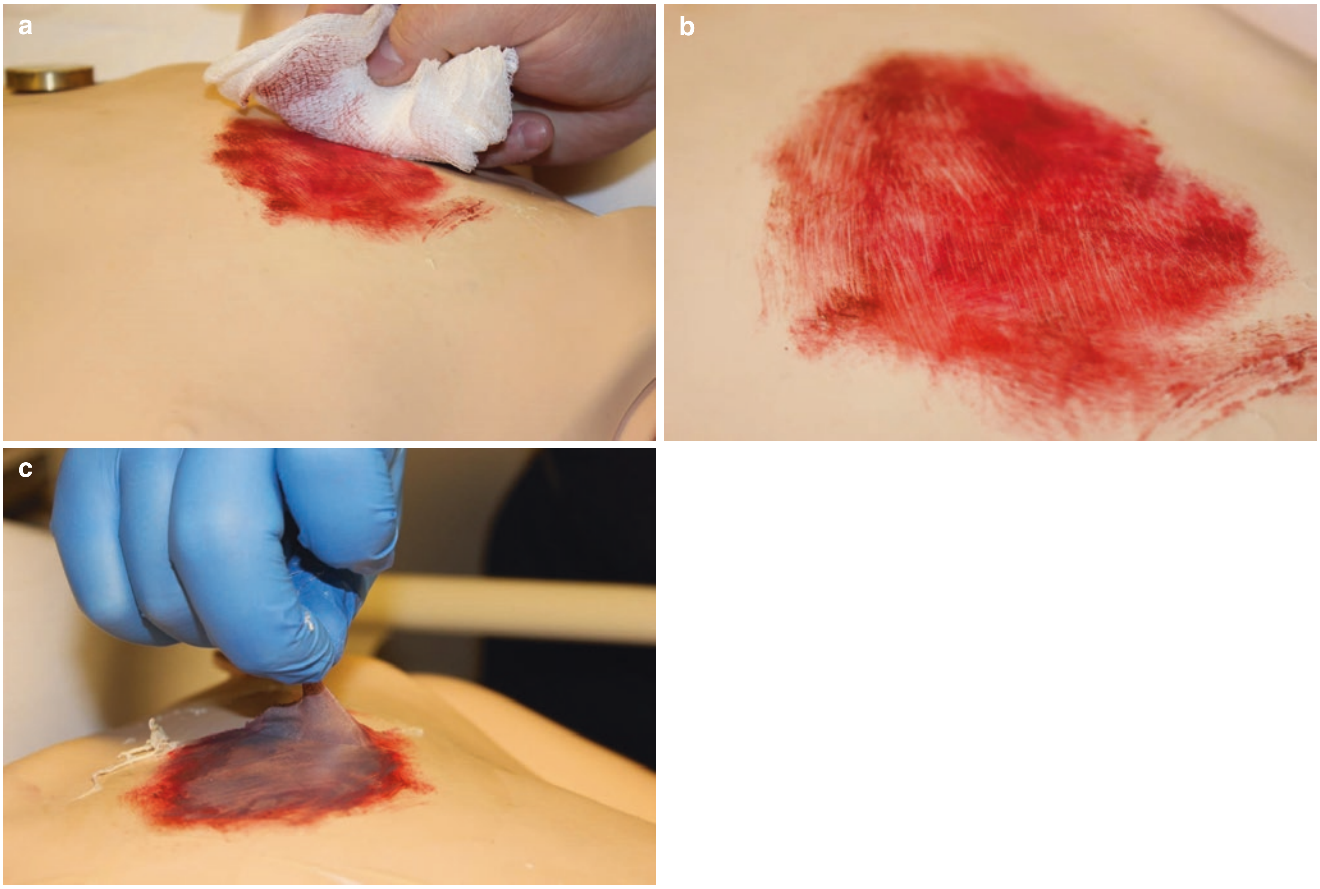

Fig. 13.2 Abrasion/first degree burn: (**a**) brush mannequin with red make up. (**b**) Use gauze squares for desired texture. (**c**) Clean with liquid soap

(c) **Pro Tip**: You should practice mixing the colors together and spend time experimenting with color combinations. This is the best way to learn how to mix and get the desired effect.

(d) Remove with liquid laundry soap and gauze dressing as you did above.

Laceration

Ingredients: liquid latex, liquid skin, simulated blood

1. For use with mannequin or simulated patient:
   (a) Apply liquid latex to protect the mannequin's skin.
   (b) Take large amount of "liquid skin" preparation and apply to the desired area (See Fig. 13.3a).
   (c) Leaving a piled, large central portion, smooth the edges to transition to mannequin's skin.
   (d) Take a rough, straight object (tongue depressor or plastic knife) and make large depression or "cut" to the central area (See Fig. 13.3b).
   (e) Apply blood to the central depression and allow small amounts to leak over the sides and mimic active bleeding from the wound (See Fig. 13.3c–e).
   (f) **Pro Tip**: You can make "blood" by taking clear liquid dish soap and adding red food coloring to give it the desired color. If you add some black coloring, it will mimic older blood**.** Dish soap is thicker and will stay in place better than theatrical blood or other types of fake blood. A recipe is also included in this chapter.
   (g) To mimic "penetrating" injury with glass or other foreign body. You may take a piece of Plexiglas or plastic and stick it into the central part of the "wound", while leaving the rest projecting from the wound. Gently dab with fake blood to mimic bleeding (See Fig. 13.3f, g).
   (h) **Pro Tip**: You can mimic virtually any penetrating injury or compound fracture by having it stick out the central area of liquid skin: use an old and broken chicken bone or a small-diameter pvc pipe to mimic an open fracture; folded aluminum foil to mimic "shrapnel"; any relevant foreign body can be used.
   (i) **Low Tech Laceration Moulage**: Wrap the desired area using gauze rolls and gauze bandages. Then apply theatrical/artificial blood to the gauze. A standardized participant during the simulation session can describe the nature of the wound.

Gunshot Wound

Ingredients: liquid latex, liquid skin, charcoal powder, simulated blood

1. For use with mannequin or simulated patient:
   (a) Apply liquid latex to cover the area of the mannequin or simulated patient that is to be moulaged and make sure that you have significant margins outside the area covered to and let dry.
   (b) Take some of the liquid skin preparation and apply to the area (See Fig. 13.4a).
   (c) Using your finger and/or a tongue depressor, you should shape the liquid skin to the pattern of a GSW (See Fig. 13.4b).
   (d) Mimic the central depression of the GSW by pushing your finger into the liquid skin and make a depression that is 1/8–1/4 inch deep.
   (e) Smooth the edges with finger or tongue depressor to blend in and mimic skin. Soot powder can be created by powdering/grounding down charcoal.
   (f) Gently sprinkle "soot powder" on to the "skin" to mimic GSW powder "stippling" (See Fig. 13.4c).
   (g) Place small amount of blood and "soot" powder in the central depression and mix to create desired effect (See Fig. 13.4d, e).
   (h) Remove using gauze dressings and liquid laundry soap to clean the mannequin.
   (i) **Pro Tip**: if you take small amount of baking soda and ad to the blood just before the simulation session, the wound will "bubble" and you can mimic a "sucking chest wound" quite well.
   (j) **Pro Tip**: always remove these moulage creations immediately after the session is completed!! If not, they will dry, harden and can damage the mannequin and stain the mannequin skin permanently.
   (k) **Alternative GSW**: Use prefabricated gunshots wound from a moulage kit and apply to the mannequin in the desired location. Add a small drop of theatrical/artificial blood in the center of the "GSW" and then place baking soda to mimic a "sucking chest wound".

Fig. 13.3 Creating a laceration with/without foreign body: (**a**) apply "liquid skin" to the desired (art of the mannequin and shape accordingly). (**b**) Use a tongue depressor or similar object, to create the "laceration". (**c**) Pour fake blood into the "laceration". (**d**) If ash or "soot" is applied before and into the fake blood, it causes the wound to appear "dirty". (**e**) Completed "dirty" laceration to the thigh. (**f**, **g**) Insert a piece of plastic or "plexi-glass" to create foreign body. One can substitute bones or pieces of wood or metal, to create the desired effect

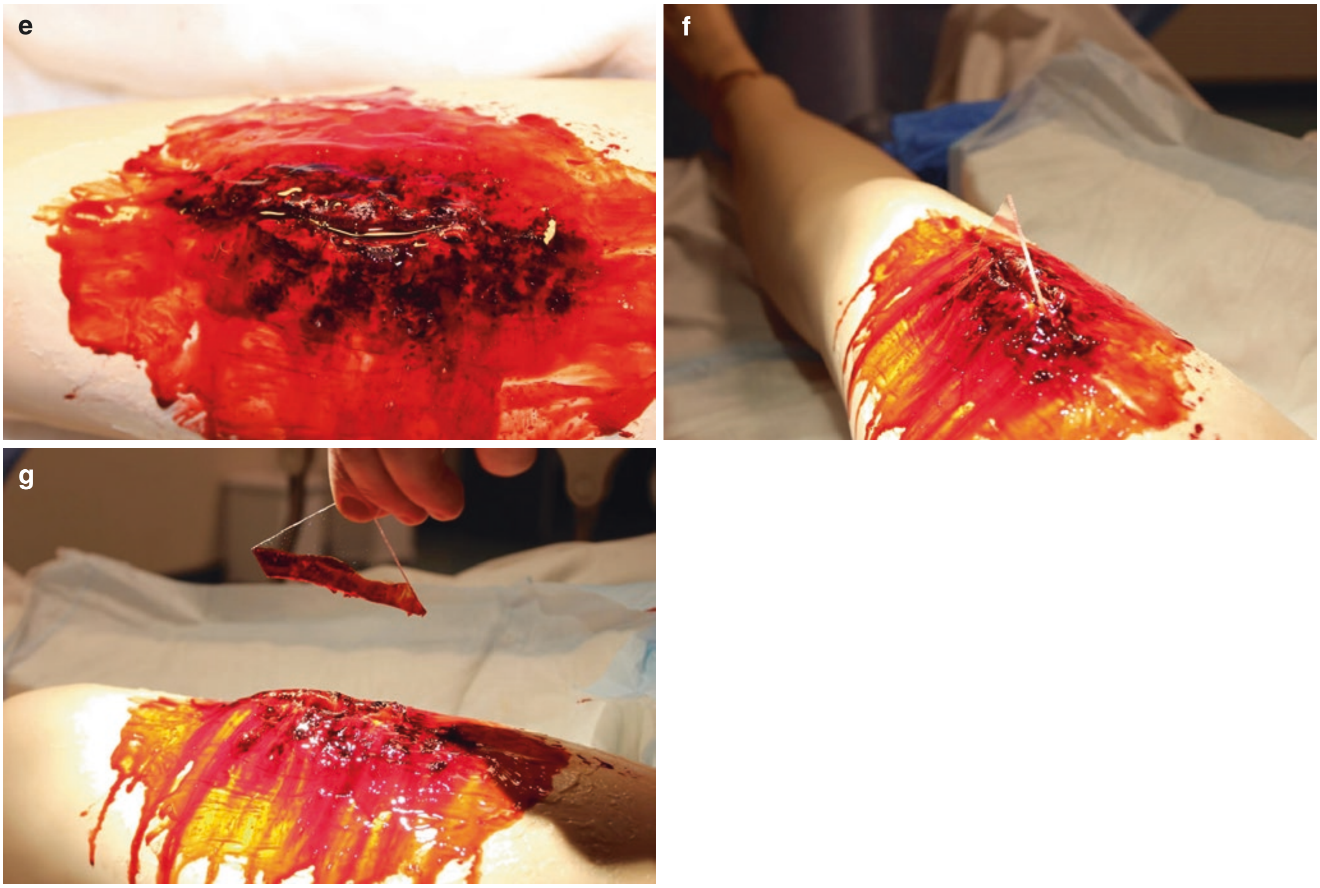

Fig. 13.3 (continued)

Functional IV Line

1. Preferred use on simulated patient; acceptable use on mannequin without IV-capable arm.
   (a) Gather equipment:
      (i) 2 Saline Locks
      (ii) 2 Occlusive Dressings (e.g., tegaderm, etc.)
      (iii) 1 or 2 4 × 4 gauze pads
      (iv) Roll of tape
      (v) Empty IV Fluid Bag (500 mL or larger)
      (vi) IV tubing with at least one port
   (b) Attach IV tubing to IV bag (See Fig. 13.5a).
   (c) Attach 1 Saline Lock to end of IV tubing and clamp shut (See Fig. 13.5b).
   (d) Attach 1 Saline Lock to most distal port available on IV tubing (preferably close to the end of the line) (See Fig. 13.5c).
   (e) Place the Saline Lock with open port in the location that you would like your IV access (typically in area of left or right antecubital) (See Fig. 13.5d, part 1).
   (f) Cover the part of the Saline Lock that is connected to the IV tubing with 1 or 2 4 × 4 pads. Be mindful that the IV tubing, including the clamped off saline lock on the end, should be tucked away under clothing or a gown. See pictures for example (See Fig. 13.5d, part 2).
   (g) Tape and secure IV line under clothing (See Fig. 13.5e–g).
   (h) Let empty IV bag sit at a location lower than the patient to allow drainage and flow (preferably, under a chair or stretcher) (See Fig. 13.5h).

Simulated Blood

Ingredients: red food coloring, distilled water or blue concentrated dish detergent

1. For use in IV bag/Blood bag:
   (a) Mix approximately 10 drops of red food coloring for every 500 mL of distilled water. Add more food coloring to desired depth of color.

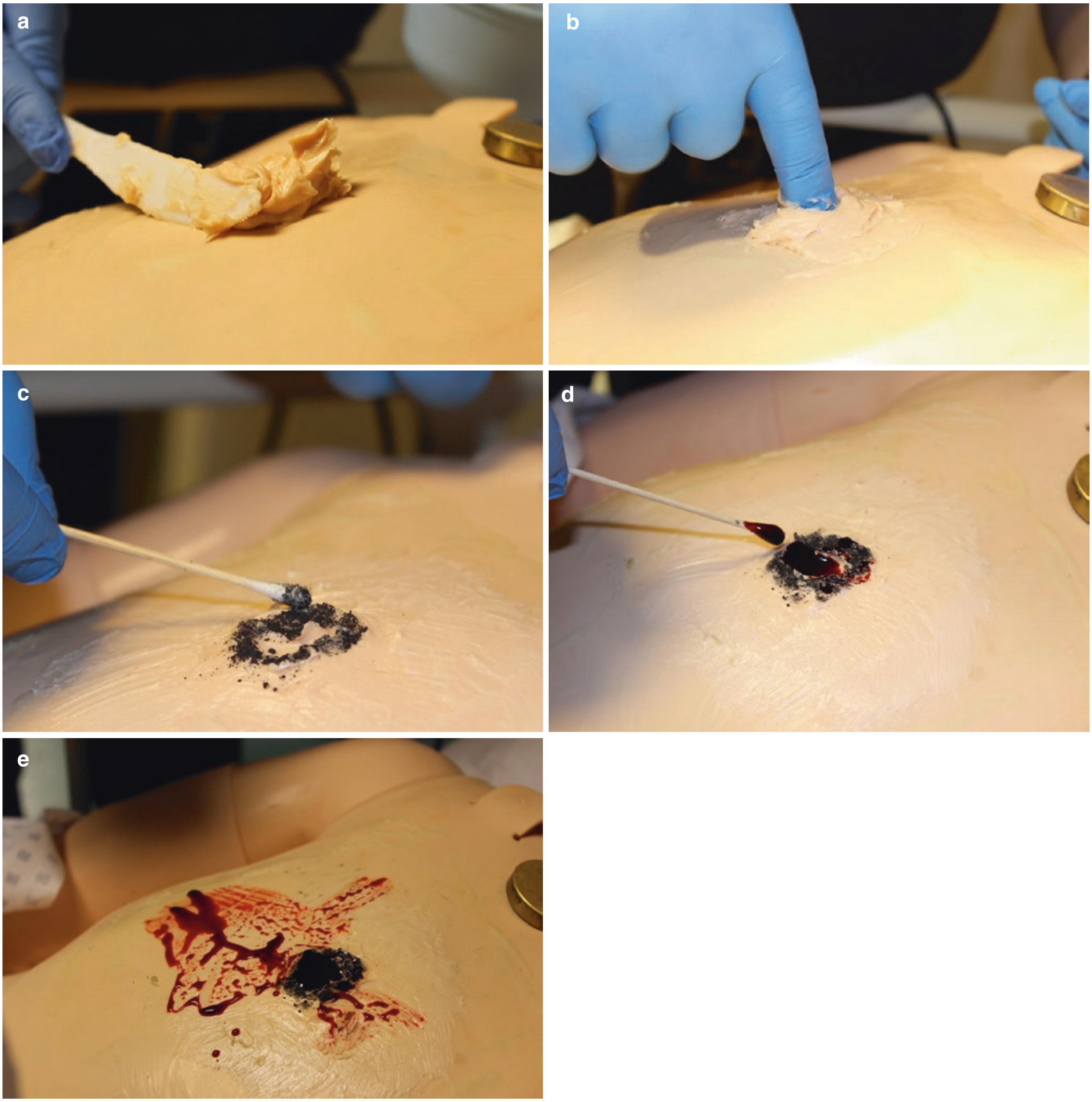

Fig. 13.4 Gunshot wound: (**a**) apply liquid skin to the area. (**b**) Make "bullet hole" using finger. (**c**) Apply fake soot to edges. (**d**) Drop fake blood into the hole. (**e**) Smear some fake blood around the area to complete GSW

2. For use during moulage:
   (a) Find blue concentrated dish detergent.
   (b) Add 5 drops of red food coloring for every 100 mL of dish detergent.
   (c) Add more food coloring to desired depth of color.
   (d) Tip: This can stain, so if using with a simulator, you may want to apply a thin layer of liquid latex to the mannequin first.

Emesis

1. For general use:
   (a) Mix oatmeal (preferably one with fruit pieces, like raisin) with some water to achieve a thicker consistency than you normally would with oatmeal.
   (b) You can add other small pieces of food for a desired effect (corn kernals).

(c) For a more liquidy/milky texture, you can add a small amount of cottage cheese.
(d) For odor, you can combine 1/4 cup grated parmesan cheese with a small amount of lemon juice to saturate cheese and create smell, typically 2–3 tablespoons.

Bruise

1. For mannequin or simulated patient use:
   (a) Use a red and blue makeup color wheel(s) to create the appropriate shade of bruise required.

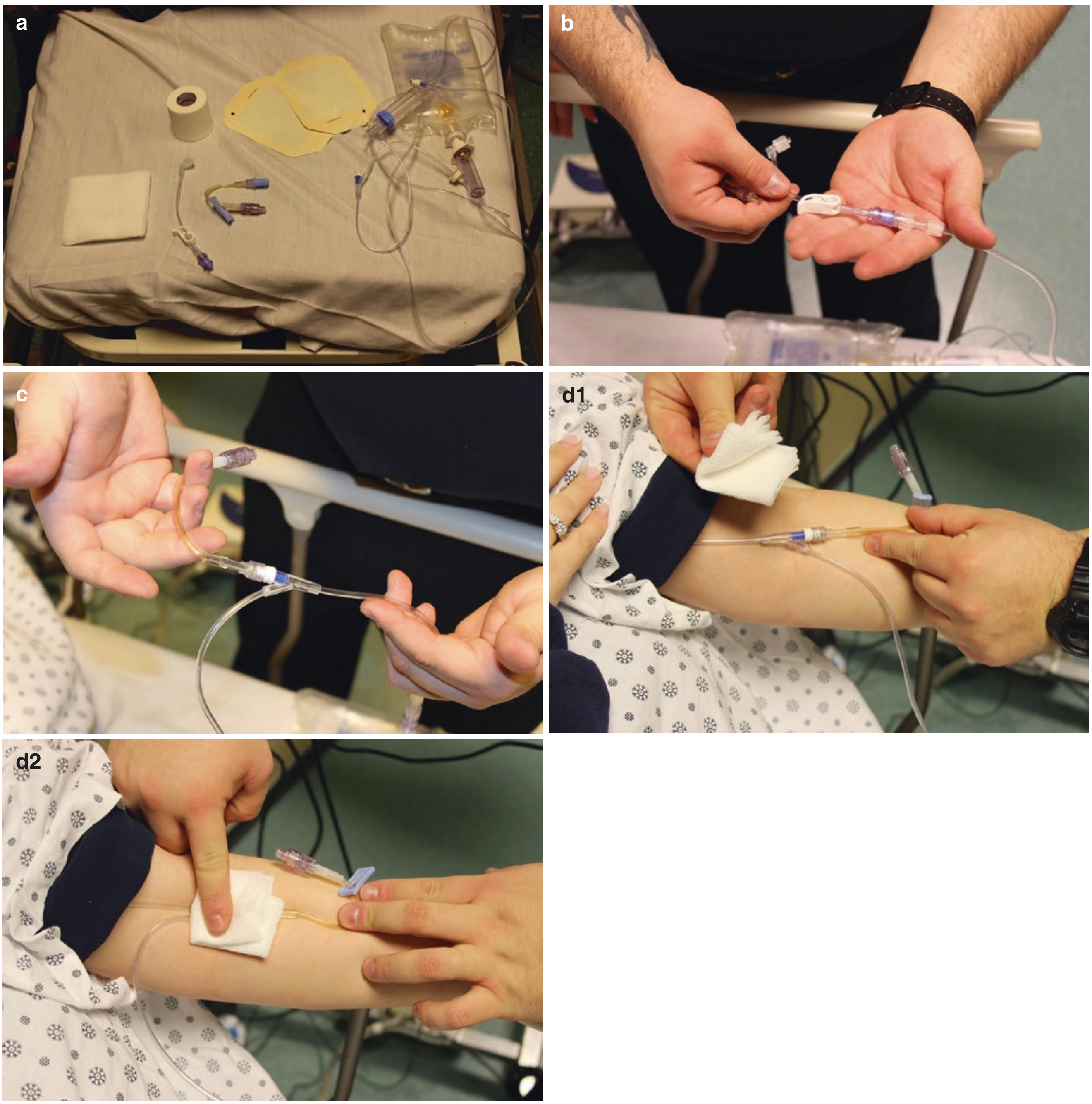

Fig. 13.5 Functional IV line: (**a**) Materials needed to make a functional IV. (**b**) Attach saline lock to end of IV and keep shut. (**c**) Attach second saline lock to the Y-connection site. (**d**) (parts 1 and 2) Tape IV to desired site. (**e**) Ensure excess IV tubing is taped under the gown to the skin. (**f**, **g**) Secure the rest of the IV tubing and IV with tape and dressings. (**h**) IV set up with empty bag. Make sure to place empty bag BELOW the patient to ensure flow through the IV

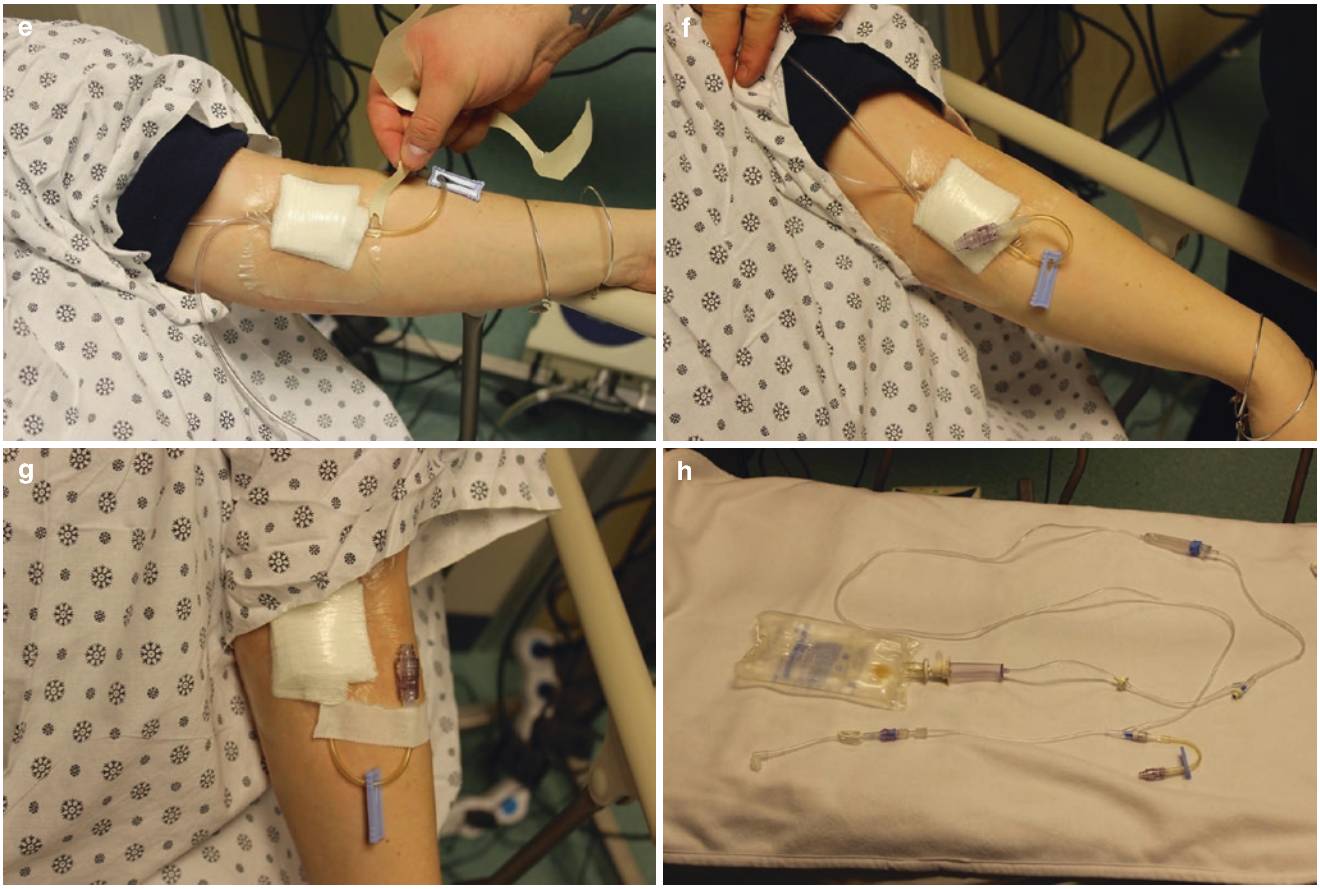

Fig. 13.5 (continued)

(b) Smaller, newer bruises can be on the pinker side, while deeper, older bruises can benefit from some more blue mixed in.
(c) Theatrical makeup sets are very beneficial, but one or two individual color wheels will suffice. As an example, Ben-Nye is a commonly used makeup source in simulation and theatrics.
(d) To protect mannequin, a small layer of liquid latex should be applied prior to makeup application.

Blisters

1. For both mannequin and simulated patient use:
   (a) Apply a small, thin layer of liquid latex to skin.
   (b) Apply light makeup, as needed, to create redness or irritation.
   (c) Apply a dime sized (or larger, if required) drop of petroleum jelly or ultrasound jelly (petroleum jelly is thicker and will stay intact a little bit longer).
   (d) Cover the jelly with a single-ply tissue paper and press down on area surrounding jelly.
   (e) Remove excess tissue.

Diaphoresis

1. For mannequin or simulated patient use:
   (a) Combine 3 parts glycerin to 1 part water in a spray bottle.
   (b) Spray on needed areas, while using caution on mannequin for sensitive areas, such as the eyes or electrical ports.

Cyanosis

1. For mannequin or simulated patient use:
   (a) Apply a very thin layer of a basic cold cream or unscented hand lotion.
   (b) Lightly brush blue color from a color wheel for desired effect.

Infiltrated IV

1. For mannequin or simulated patient use:
   (a) Apply a small, dime-size amount of liquid skin just over an IV site.
   (b) Cover with a clear, occlusive dressing.

(c) Brush on a small amount of red makeup to area surrounding IV site to simulate infiltration and irritation (if desired).

Urine

1. For bed pan or foley catheter bag only (do not use in a simulator's system):
   (a) Combine water and yellow food coloring to desired color.
   (b) For darker urine, you can steep a few bags of tea in the water mixture until it achieves your desired color.
   (c) For urine odor, add about a teaspoon of ammonia for every half-gallon of urine mixture.
   (d) You can simulate "cloudy" urine by adding a few drops of whole milk to the mixture.

Subcutaneous Emphysema

1. For use on mannequin:
   (a) Fill a quart-size plastic sandwich bag with crispy rice cereal.
   (b) OR Fill a quart-size plastic sandwich bag with very finely torn or chopped packing peanuts.
   (c) Place bag or bags under the simulators skin in the chest.

Bloody Stool

1. For basin or diaper:
   (a) Mix cherry pie filling with chocolate pudding until desired consistency is reached.

Burns

1. For mannequin or simulated patient use:
   (a) For first degree – simply apply red shadow from a makeup color wheel to distinguish affected area.
   (b) For second and third degree – Apply a thick layer of liquid latex to skin and let dry. Once nearly dry, pull at some of the areas of the liquid latex to make sloughing. Apply red coloring to burn from color wheel. Apply black shadow or charcoal to areas you want to appear charred. Add small amounts of simulated blood and rub on, as needed.

Conclusion

Moulage is an important tool for creating realism in high fidelity simulation and can add an extra dimension to a simulation session. Selective use of the appropriate moulage techniques matched to learning objectives can make the learner more activated and significantly improve on their experience. But as Dieckmann and others have noted, the desire for realism should not detract from the overall experience for the learner. For example, a laceration created using liquid skin can easily be damaged by contact, becoming quite messy if the learners grab on to it during the scenario. One should only use this technique when learners do not need to move or roll the mannequin as in a trauma resuscitation scenario. Alternative wound techniques that are less realistic may be preferred for certain scenarios because they can withstand more manipulation. For all moulage techniques (whether it be a bruise; an abrasion; or a burn) remember that it would need to last through the scenario and adjust accordingly to add the maximum dimension of realism while minimally impacting the learner's experience.

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Part III

The Practice of Emergency Medicine

Simulation for ED Medical Directors and Administrators

14

Thomas Nowicki, Alise Frallicciardi, and Amy Flores

Background

Emergency department (ED) directors bear a heavy weight on their shoulders in providing for the safety of their patients and staff. In 2008, members of the ACEP Subcommittee on Emergency Department Director Responsibilities released a number of suggested duties for an ED director [1]. Among these numerous tasks are promoting a collegial interdisciplinary environment, monitoring continuing education of medical staff, upholding quality assurance and risk management programs, and assuring emergency department efficiency and throughput [1]. All of these elements can be supplemented with simulation-based education and training to make the emergency department a safer place for patients and their caretakers. This chapter will provide ideas to aid an emergency department director or administrator in incorporating simulation into their practice.

Simulation in medicine evolved from crew, formerly cockpit, resource management (CRM) training in the aviation industry. In the 1980s, the governing body of aviation analyzed multiple poor outcomes. They found an overwhelming theme of technically savvy crew members, who when put in a "complex dynamic" environment were unable to manage their assets successfully. As a result crew resource management training (CRM) was developed and is now required for U.S. aircrews because of its success. It is important to note that there were no randomized trials to support the implementation of CRM as a requirement. CRM entails multiple components, including "full-mission simulations" with subsequent debriefings [2]. This type of training enforced teamwork related competencies in a safe but immersive environment as an alternative to real time high stakes scenarios [3]. Modeled after the aviation industry, anesthesia adopted the Anesthesia Crisis Resource Management (ACRM) curriculum in the early 1990s, which included similar principles to crew resource management in aviation. Analogous to pilots, and similar to emergency physicians, anesthesiologists practice in the operating room, a high intensity, high risk environment, involving multiple personnel of different disciplines making critical decisions in a time-dependent manner [2, 4]. Soon after, the ACRM program evolved into a mandatory credentialing requirement at certain institutions. Because of its success some anesthesiologists are given lower malpractice insurance premiums after participation in the course [5]. Eventually, simulation training expanded to emergency medicine given the similar high stakes work environment [6].

In 2008 and 2017, consensus conferences were sponsored by the editors of *Academic Emergency Medicine* to discuss and refine the future utilization of simulation in emergency medicine education at the undergraduate level, graduate level, and continuing medical education (CME) level. Among the topics considered were how simulation could be used in assessing individual provider competencies and how simulation could have a role in the credentialing of practicing physicians, maintenance of certification and continuing medical education. Questions were brought up on a group level as to how to best achieve effective team training programs and what challenges must be overcome to institute one. On a broader perspective, they discussed how best to incorporate simulation to improve patient safety in a systems based perspective. Ultimately the conferences defined areas where subsequent research in the field of simulation has focused, and many of these concepts, will be outlined in this chapter [7, 8].

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Best Practices

In Situ Simulation

At many simulation centers, the majority of training occurs within the training facility itself. There are many advantages to training in the simulation center setting such as standardization and the ability to create a protected training environment as compared to actual patient care setting. In situ simulation is the term often used to describe training that occurs outside of the simulation center and in the actual clinical setting. It is typical for training resources (mannequins or task trainers) to be transported to a clinical environment and have the exercise performed in this clinical space. In situ simulation can provide great insight into operational and system issues that may not otherwise be identified during daily operations in a high-risk setting like the emergency department. In center based training, these issues may not be easily identified because it is challenging to fully replicate the work flow and operation of a clinical environment. The identification of these threats can help avoid compromises in patient safety. For example, in a study done in The Rhode Island Hospital ED, in situ simulation was used to test the resuscitation environment for critically ill simulated patients in their new ED prior to its opening. It was a small study including two simulation sessions in the resuscitation bay with a small multidisciplinary team including attending EM physicians, resident physicians, nurses and ED technicians. Among some of the issues identified were equipment location and insufficient procedural surfaces, which were amended by ED leadership prior to the opening [9]. These types of simulations can also be done as maintenance drills to ensure standards and identify new issues.

Simulated patient encounters can also be run in different parts of the ED or hospital in order to test the environmental readiness to respond to emergency situations. Drills can be run in rooms not specifically designed for resuscitation in the ED in order to simulate a situation when all resuscitation rooms are occupied. Hospital or office directors can run mock codes in areas not accustomed to these responses but that should be fully capable and prepared if one were to occur. Not only can medical knowledge and skills be trained and assessed in these sessions, but equipment layout and accessibility can be tested too. Imagine, for example, during a drill run in a dental clinic it was discovered that the code cart was properly labeled, but not stocked and lacking in vital resuscitation equipment such as the bag-valve mask. Discovering a preventable error such as this could help avoid a poor outcome in a real emergency situation. These are just some examples of how simulation can help test environmental readiness.

Another study done in the emergency department of Cincinnati Children's Hospital Medical Center evaluated the use of in situ simulation to identify "latent safety threats" (LST's) in a busy clinical environment as well as to reinforce teamwork training. The training was initially voluntary but the ED leadership were so pleased with what the project offered, they mandated participation of all care providers in the ED approximately halfway through the study period. The project involved running simulated clinical scenarios during clinical shifts in order to identify systems issues which threatened patient safety. Appropriate planning was necessary in order to achieve this without placing real patients' safety at risk. Prior to study implementation, the authors met with the ED leadership to discuss a "no go" protocol if ED census or acuity would place patient safety at risk. The Patient and Family Advocacy Board, representatives for ED patients, gave their support of the study with the understanding that it was promoting the practice of providing "safer care." Just prior to the drill, the ED charge nurse was made aware to assure there were no unexpected obstacles to the drill. The drills encompassed both medical and trauma cases, some of which were based on "near misses" or were seasonally dependent, for example hypothermia during winter. Both the drill and the subsequent debriefing held immediately afterward were limited to 10 minutes each. Over the course of the study, one LST was identified for every 1.2 in situ simulation drills run. Examples of threats identified were missing vital equipment, medications missing from the med station and lack of staffing at the med counter. The authors found these drills to be very valuable as the LST's identified were addressed by the ED directors making their ED a safer place [10].

Similar to the purpose of the aforementioned study, simulation drills can be useful to identify system glitches in the care of uncommon patient scenarios. For example, running a drill at a trauma level-one adult emergency department that also receives severe pediatric trauma requires flawless interdisciplinary communication, teamwork and a systematic protocol in order to properly care for their patients. In order to orchestrate smooth operation, monthly drills could be held to remain up to date on the issues an ED may encounter for these low frequency patient visits. Severe pediatric trauma requires the response from multiple professionals including ED attendings, residents, the ED nurses and technicians, the trauma surgery team including the residents and attendings, the pediatric surgery team and the pediatric ED nurses. Drills can be run monthly to identify systemic issues. Equipment deficiencies or knowledge gaps can be identified during these drills. It would be advantageous to identify systems errors in a simulated setting rather than during actual patient care events where safety could be negatively impacted.

When planning in situ simulation it is important to analyze the potential impact of the programming. The goal of many simulations is to improve patient care and staff performance and not hinder it. For example, when planning a mock code in an area of the hospital it is important that faculty and staff are aware that it is a drill in order to prevent activation of protocols and responses not intended such as fire and police responses. The objective of the drill must be analyzed to ensure that vital resources which are not important to meeting the objectives are not utilized. If the drill is intended to test the response system of nurses on a floor unit to a code, it may not be important to call a hospital wide response. It is important to consider disruptions to patient care, employees and unforeseen cost. Planning in situ simulations requires significant preparation and analysis of resources.

The location of training for a simulation program is an important factor in order to match the session objectives with the optimal environment. In situ simulation training clearly offers some advantages when held in the actual clinical environment. It can more effectively test for environmental and systems issues that may not be as easily uncovered in a simulation center. While in situ training is commonly used to help identify issues in the emergency department or hospital setting, it can be challenging to provide similar training to outside facilities or locations. Hospitals that house a simulation center can more easily extend their services to perform in situ simulation in actual clinical areas that are near their simulation center because transport of equipment and staff are simplified. External sites such as nursing homes or external facilities may benefit greatly from simulation-based education, however certain barriers such as cost, equipment and experienced training staff can lead to significant challenges with acquiring this training. To overcome this, some simulation centers are offering “mobile simulation units”. Mobile simulation can be used to describe sessions that are held at a distance from the simulation center, typically where equipment and staff are transported. The mobile team could then provide training in situ, within the site’s actual clinical space, or in a dedicated training room like a classroom.

Skilled nursing facilities (SNF) are evaluated on their hospital re-admission rates and it is of great interest to these facilities to avoid unnecessary re-admissions. Financial penalties may help drive the need for additional training with a goal of decreasing the number of unnecessary re-admissions without compromising the quality of care and safety for these SNF patients. One proposed solution is to send a “mobile team” that can be deployed to local area SNFs to address common occurrences that can lead to residents being sent unnecessarily back to the emergency department or admitted to the hospital. This type of mobile simulation was described and published, opening the door for other programs to replicate and expand upon [11]. In one system, this process involves the organization of a specialized team with simulation expertise and a medical background such as nurses, physicians, and hospital administrators. The team then visits area SNFs to identify major issues specific to the particular site using their patient and environmental data. Subsequently, the providers at the SNF are put through a simulation-based training course to target those specific issues that may lead to unnecessary readmissions to the hospital. Hospitals hold an interest in this type of program because the benefits can be shared, intending to help lower their 30-day readmission rates.

Although holding this type of training within a simulation center can provide superb education to SNF staff, there are several advantages to a model that utilizes a mobile team. One of the most significant barriers to training is often funding and many nursing homes have a limited budget to support staff time to travel to and participate in regular training at a simulation center that can be quite expensive. Likewise, the investment necessary to develop an on-site simulation center at a SNF can be extensive. A mobile team can be specially developed to utilize fewer resources (training team and equipment) to allow easier travel to an offsite location such as a SNF. Additional equipment such as a transport vehicle, however, may be required and this can significantly add to the initial investment required for such a program. These cost considerations are important in determining the best strategy. In the long term, this type of investment and program may save the facility money by bringing the training to the staff and minimizing their travel and paid time. A mobile team may have other advantages, similar to previously stated examples of identifying environmental and systems issues in the emergency department. These concepts of in situ or “on-site training” can also apply in the setting of a SNF. If, for example, the care team at the SNF is asked to retrieve a piece of necessary medical equipment such as a defibrillator, the in-situ training can assess the staff’s ability to effectively retrieve the item in a timely fashion in their actual setting. This benefit extends beyond basic training/assessment about how to use the defibrillator. This type of training has led to the identification of missing, broken, or poorly placed equipment that could be needed in a critical situation [12]. The combination of simulation-based education with debriefings and the ability to test environmental, systems and equipment issues can be very helpful.

While the overall goal of such a program may be to reduce unnecessary hospital readmissions, it can be challenging for the training team to accurately measure the desired outcomes, particularly over short time periods. It may be valuable to select multiple “proxy markers” of success along the way. Various outcome measures can be selected for tracking, ranging from soft data like self-efficacy surveys to hard data such as frequency of emergency department transfers or hospital readmission rates. These types of programs can also serve as a needs assessment helping to identify important training opportunities that align with an ultimate goal. Some of these opportunities can been missed if the training were held in a simulation center. For example, in one program, an issue was identified during a training session aimed to reduce the re-admit rate for congestive heart failure (CHF). An initial needs assessment was performed that directed initial training toward basic patient assessment skills and adherence to treatment protocols for the patient with mild CHF. This facility had a protocol in place to allow the administration of intravenous (IV) furosemide. Some of the training sessions were designed to assess the staff's ability to adhere to their protocol. During these sessions it was discovered that staff were unable to appropriately identify patients and apply the protocol. When staff were attempting to follow the protocol, many decided to break the protocol and transfer the simulated patient to the ED. During exploration of this issue during the debriefing, it was discovered that many of the staff were either not trained or were uncomfortable placing an IV. This led to the near automatic transfer of their patients to an emergency department for this procedure and further workup. This was felt to be a significant barrier to successful utilization of the protocol and was previously unrecognized by the facility. Simply identifying a barrier such as this may help favorably impact the overall outcome measure of a safe reduction in re-admissions. In this case, additional training that had not been initially planned was developed and added to the curriculum to enable the staff to comfortably and effectively place IVs so that adherence to their protocol could be enhanced [13].

Disaster/Epidemic Response

Simulation can also be used to help prepare for disaster situations. Take, for example, an outbreak of a deadly disease, like Ebola. When Ebola concerns escalated in the United States in 2014, many hospitals and systems turned to their educational/simulation centers to assist with preparation. At the time of this concern, widely accepted recommendations were limited for care of the Ebola patient in the US. The use of personal protective equipment, for example, was not standardized and many hospitals were left to develop their own response. There were various combinations of protective equipment proposed at different institutions ranging from standard contact and droplet precautions to chemical/biological agent suits.

An example of this is Hartford Hospital who utilized their simulation center to partner with their local and national content experts in order to develop an "enhanced personal protection equipment kit (EPPE)" [14]. The development of this kit was fairly simple, however, the effective education of a large number of staff members in a short time frame was quite challenging. The concept of "Just in Time" training was not felt to be adequate to meet the needs of a highly reliable organization (HRO) and safe process. This simulation center developed a protocol where they created a checklist-based process and teaching program on the proper donning/doffing techniques for their EPPE kit and then refined the process in real time. Medical providers receiving the training were empowered to provide feedback on the process to help clarify and improve each step. Immediately after each class, serial revisions were made to the checklist and these were incorporated into the next session. The rapid cycling of development occurred over a long weekend during which two-hour classes were offered back to back, 24 hours per day. This format allowed great scheduling flexibility to providers on multiple shifts. It also allowed the process to be perfected very rapidly. Simulation staff felt this process would likely have taken weeks or months to arrive at the final product if the class were offered at a more typical pace. Once staff was trained on the protective equipment, additional simulation sessions were held in situ to test the environment and system response to an Ebola patient. This was a major component of the healthcare system's response preparation. A massive drill was ultimately carried out in the state involving multiple locations where pre-planned simulated Ebola patients were scheduled to present. These patients had to be properly screened, isolated and then transported to a definitive care location. This extensive drill provided many additional lessons, which were then improved and incorporated into procedures and protocols. As an example, the educational program for the formal EPPE donning process stressed that staff utilize a slow and methodical fashion in order to avoid errors. During the drill, the staff were notified only after the simulated patient had arrived to the receiving hospital triggering them to initiate the donning process. When performed in real time, this led to a delayed response by the hospital staff because the patient had arrived in the ambulance bay and had to wait there until the receiving staff had donned their appropriate gear. In order to remedy this issue, a process was developed to alert the receiving team before the patient arrived so they would have adequate time to safely don their gear and meet the patient on arrival [14]. While this could have been pre-planned and built into the overall response, complex processes are rarely perfectly planned on paper. Drills such as this help find correctable errors and process improvements in a safe environment with no risk to the patient.

Team Performance/Interdisciplinary Communication

In the emergency department, strong communication and teamwork skills are essential in maintaining patient safety in a dynamic, high-risk environment. In other specialties with similarly challenging environments, more formalized teamwork training programs have been instituted, specifically in anesthesia and OB-GYN [2, 15]. These programs came after risk management institutions looked at closed malpractice claim cases and adverse event records and found poor teamwork and miscommunication as significant contributing factors to many of these cases. The origins of this type of training stem from the aviation industry in which technically skilled crews were unable to successfully manage resources or communicate as a team when placed in low frequency crisis situations. In the paper by Gaba, et al. in 2001, describing the anesthesia crisis resource management curriculum, they mention several gaps during residency training of anesthesiologists that have to do with critical decision-making and crisis resource management. Among the holes were "lack of systematic training on non-technical skills for challenging situations" and "inability to practice adequately integration of technical and non-technical skills for challenging situations." [2]. Teamwork training in the fields of anesthesia and OB-GYN, has actually amounted to such successful results that physicians who take specific formalized courses receive reductions in malpractice insurance premium costs [6, 15].

The theme of formalized teamwork training came to the forefront after the Institute of Medicine (IOM) published the statement "To Err is Human" in 1999 in which they cite that a substantial number of medical errors lead to patient deaths each year. In analysis of the errors leading to the deaths, it was found that poor communication and teamwork were significant contributors. Following this, multiple groups developed formalized teamwork training programs to try and thwart these errors and improve patient safety [16]. Among these programs, were the TeamStepps™ project lead by the Department of Defense and, specific to the emergency department, the MedTeams™ project by Morey, et al. in 2002 [4, 16]. These programs, although not specific to simulation, have demonstrated a benefit in terms of staff attitudes toward better communication and improved teamwork skills. There is a significant amount of potential for growth in the field of simulation and teamwork training in emergency medicine. In a study done in 2004 by Shapiro et al., they took staff from the MedTeams™ project who had already received didactic training in a formal teamwork training course and randomized them into two groups. After a pre-intervention assessment of teamwork skills, the experimental group was run through an intensive high-fidelity simulation day focused mainly on non-technical skills such as teamwork and communication. They were then observed in the ED after the intervention and their teamwork behavior was rated again. It was found that the experimental group had a positive experience during the simulation training and found it useful to their education. There was a trend towards improved team behavior with the experimental team, although possibly due to the very small number of participants in the study, the difference was not statistically significant. There are many challenges that arise from this type of simulation training because it is very hard to prove a direct benefit in patient outcome. There is currently limited data on how quickly decay of these teamwork skills occurs and how frequently maintenance sessions need to be offered in order to sustain the benefit of this training [17]. Although there can be significant benefits to this type of work, there are challenges to developing simulation based teamwork training such as the resources and time to institute this type of program. Formalized teamwork training itself is important as cited in multiple analyses of adverse events in the ED. Simulation offers a unique way of creating environments in which these skills can be practiced,

Computer Simulation

In medical education, simulation is most often used to describe the use of standardized patients, mannequins, task training, screen based training and even virtual reality training. Although not the focus of this chapter, a different form of simulation exists in computer modeling. Emergency departments nationwide have been struggling with increased patient volumes placing a demand on the system that at times can overwhelm resources and lead to emergency department boarding, crowding and long patient waits [18, 19]. These issues can lead to adverse patient safety and financial consequences [17].

In order to improve operational efficiency, mathematical and computational simulation models have been developed to help predict scenarios when emergency departments can become overwhelmed [18]. In a simplified explanation using the example of one particular study by Hurwitz, et al. in 2014, to achieve a simulated patient platform, assumptions are made based on national averages and estimated times from individual EDs as well as understanding patient flow by interviewing ED providers [18]. Once all of the preparation is completed, "output" values are obtained and compared to actual values to assess the accuracy of the model. Once the model is developed and optimized, different variables can be introduced to examine the effects of additional resources. For example, the addition of one full time physician in a "nationally average ED" was tested, and the response was a reduced mean ED length of stay, however if added to an "average academic ED" there was no significant change in length of stay. Different mock up scenarios can be adjusted to look at the effect it would have on wait times including multiple changes such as adding five ED beds or two nurses, etc. Of course, there are limitations to these computer generated models, including many assumptions about fluctuating patient arrival times, negligible door-to-triage times, among many others [19]. There are many different programs available, all imperfect nevertheless potentially useful in this time of increasing demand and limited resources for overcrowded EDs in this day in age. As these computer models improve, they are increasingly being used to design new facilities and to understand the impact of changes on existing facilities. See Chap. 10 for more details on screen based simulation.

Challenges and Solutions

In order to gain access to or operate a simulation center, it is important to understand some of the challenges these centers face. Early medical simulation training facilities developed in part as a reaction to multiple pressures such as increasingly strict regulations on hospital systems, decreased training time for residents and continuously growing expectations for patient safety. A significant amount of time and energy was spent to convince administrators, investors, and academic leaders that this form of education was worth the investment. There was, however, a paucity of evidence to help simulation leaders prove the value that would result. At the time, many comparisons were made to the format of using simulation based training in the aviation industry. Interestingly, there were no randomized control studies to support simulation in the aviation industry, however it was widely adopted. Although medical simulation is now much more widely accepted and supported, the reality is that most centers still have the need to document their value and financially justify their existence. This is important for an ED director to consider when attempting to develop or gain access to a training facility.

In the business world the concept of return on investment (ROI) is often used as a tool to help decide if a particular investment should be made. This concept may not translate perfectly to the field of medical-simulation. A typical business is focused on financial returns whereas there are few medical simulation centers that operate as profit centers. Simulation centers more often generate types of value that may be difficult to quantify in terms of dollars. While a business may consider non-financial returns such as increasing brand recognition or public perception of the company to be important, these sorts of returns are frequently the most important measures of value for a simulation center. Due to this confusion, the term "return on expectation" (ROE) is frequently cited as the preferred term for simulation centers.

Measures of value provided by a simulation center can be broadly categorized into those that produce revenue through direct income, those that create cost savings and those that provide non-financial value. A CME course offered by the simulation center could represent an example of a program that generates direct revenue through customers who pay a tuition. Other programs may provide financial benefit to the institution by cutting costs and improving operational efficiencies. This can be illustrated in a program designed to educate staff on the proper insertion of urinary catheters in which the measure of value is a decreased infection rate. If the costs of a catheter associate urinary tract infection (CAUTI) are known and the decrease in infection rates can be linked to the training, these figures can be used to determine the financial impact of this program. This type of course can offer an overall financial savings to the institution. Although the end result of these two examples may equally increase the hospital's net margin, it is often more challenging to obtain the initial financial resources to develop a program that provides cost savings because it can be perceived as an investment with uncertain returns.

There are a growing number of examples where medical simulation provides cost savings to a hospital system by reducing complication rates and adverse events. Complications are a major cause of potentially avoidable hospital expenses. In the emergency department, many high-risk, low-frequency procedures are performed in less than ideal conditions, where risk of complication is high. One such procedure is central venous catheter (CVC) placement, which can be associated with catheter related bloodstream infections (CRBSIs) if placed improperly. These infections can lead to poor outcomes for patients including more days spent in the ICU, the hospital in general and increased hospital costs. There have been multiple studies examining the benefit of simulation-based courses in CVC placement, which have led to decreased complication rates and more specifically fewer CRBSIs [20, 21]. As an example, in the observational cohort study led by Barsuk et al. in 2009, internal medicine and emergency medicine residents completed a two-hour simulation course in CVC insertion prior to their rotation in the medical intensive care unit (ICU). The course included a didactic session and hands on training followed by a posttest, where the residents had to acquire a minimum passing score and were retested until it was reached. Subsequently, CRBSIs were tracked over a 16-month period after the intervention and there were fewer CRBSIs in the post-intervention ICU group as compared to the pre-intervention ICU group prior to the study intervention and a control ICU group in the same hospital during the study period [21]. A cost analysis was published after the pilot study was completed by Cohen, et al. in 2010 and it was estimated that net annual savings amounted to greater than $700,000 (adjusted to 2008 dollars), which was a 7 to 1 rate of return on simulation training intervention [22]. This is just one example of a high risk, low frequency procedure, which can be trained in simulation and potentially reduce hospital costs.

The non-financial returns on simulation programs can be difficult to quantify and there is work being done to develop ROI/ROE tools that include these measures into a simulation center's overall value to an institution. The ability to capture all the forms of value and report them as objectively as possible is vital to the development and maintenance of a simulation center. Returns such as patient safety and satisfaction, staff morale and competence, improved teamwork, increased training efficiency and academic productivity may not translate easily to dollar amounts. Recruiting as an example, especially for medical school and residency programs, is felt to be greatly facilitated at sites that incorporate simulation into their training. Informal follow up of residency applicants frequently cite a strong simulation program as an important consideration when selecting programs. This is an example of a return that may add value to the residency training program, however the center's sponsoring hospital may be challenged to quantify this return and justify the cost (Table 14.1).

Interface with Regulatory Bodies

Simulation is already incorporated very frequently into residency training programs to supplement resident education in high risk, low frequency procedures and scenarios. Beyond residency education, simulation is also being used to maintain skills, certification or credentialing for practicing physicians working in the department. Immersive simulation training courses for procedural maintenance of certification are now being offered. Hospitals can offer programs to train and maintain skills in various credentialed procedures such as central venous catheter placement, pericardiocentesis, tube thoracotomy, cricothyroidotomy, lumbar punctures, and the like. Even if the institution does not require regular training to maintain credentials for these procedures, more informal sessions can be held during monthly department or faculty meetings as a formative learning process and for maintenance of skill. In a paper by Vozenilek and Gordon in 2008, they describe how a simulation-based CME course for procedural skills can provide a great setting for "low- stakes opportunities for assessment, feedback, and practice-based improvement." [23] This type of simulation is not only useful for low frequency procedures through task training, but with cognitive training scenarios as well. Examples of simulation compatible scenarios that could be useful to help prevent skill decay include difficult trauma airway management and procedural sedation complicated by aspiration or cardiac arrest. Simulation offers a unique and realistic way to practice these scenarios and skills in a safe, controlled and reproducible environment.

Another example of procedural training in simulation is emergency ultrasound. Given that the use of ultrasound has become mainstream and in some cases the standard of care in the field of emergency medicine, ultrasound simulation can supplement education and bring everyone up to speed more quickly. Virtual reality (VR) ultrasound trainers have been developed as an aid in teaching ultrasound and how to incorporate ultrasound findings to assist with diagnosis.

Table 14.1 Return on investment from the Center for Education, Simulation and Innovation (CESI)

ROE category	ROE metrics
Financial (savings)	Malpractice premium reduction
	Decrease acuity of care
	Decrease complications and risk of medical errors
	Decrease training time or cost
	Reduce instructor time
	Reduce patient length of stay
	Reduce preventable hospital readmissions
	Other
Financial (revenue)	Training revenue (internal program)
	Training revenue (external program)
	Facilities rental
	Contracted program - grant, joint development
	Professional services / consulting
	A/V facilities (virtual training, conferencing)
	Other
Patient outcomes	Enhance patient safety
	Reduce length of stay
	Reduce preventable readmissions
	Enhance patient satisfaction score
	Improve patient outcomes (program specific)
	Other
Staff	Improve technical competency
	Improve communication competency
	Promote teamwork, trust, & confidence
	More efficient training
	Help ensure adherence to protocols
	Meet CME/credentialing requirements
	Staff recruitment and satisfaction
	Other
Admin / risk management	Core measures from 'balanced scorecard'
	Target high priority area for administration (e.g. safety officer)
	Standardization across healthcare system
	Enhance reputation and branding goals
	Grants
	Growth simulation programs market share and capabilities
	Academic/research/publications
	Community service
	Other

Modified with permission from CESI, Hartford Hospital

These virtual reality trainers can display abnormal findings and teach probe orientation and placement. These skills can be especially useful for attending physicians that are further removed from residency training or who are not as adept at using ultrasound in clinical practice. VR trainers could even be used as an adjunct for assessment of ultrasound skills to credential emergency physicians in ultrasound. Successful training that leads to proficiency would help faculty acquire the proper images and produce accurate interpretations. These would be important steps in helping pave the way for the billing of point of care ultrasound in the department.

Simulation training is generalizable and extends well beyond physician training. Simulation training has rapidly become a key element of nursing education and assessment. One institution revamped a nursing competency assessment day during which key elements of knowledge and skill were confirmed each year for the entire hospital's nursing staff. The old program relied on multiple stations, each focusing on a single element, such as how to turn on a defibrillator and deliver a shock. The institution's simulation center developed a new program, which extracted several of these stations and combined them to form a realistic patient encounter where a team had to care for a patient in cardiac arrest. This newly developed session required the nursing team to be able to string together multiple actions and apply them as they would in a real patient encounter. Interestingly it was discovered that the passing rate dropped significantly with this new assessment method. The overall knowledge and skill of the nurses likely remained the same, however new elements were being assessed such as teamwork, communication, and medical decision-making. These elements were unable to be assessed by the old method where each skill was broken down into a focused station. It was felt that this new format provided a more accurate assessment of the nurse's actual clinical ability. Nurses were required to pass the program as measured by a patient centered outcome: the simulated patient's survival. Another important change for this new program was that nurses were assessed as a team rather than as an individual. This meant that if the simulated patient did not survive, the entire team failed together. Additional training was provided when a team did not pass and they were allowed to retest until passing [24]. Although not necessarily considered certification or credentialing, this type of program begins to approach a "high stakes" assessment as their frequency grows in the future.

Conclusions and Take-Home Points

Simulation based medical education has become commonplace and is beginning to have objective impacts including patient outcomes and financial benefits such as lowering malpractice premiums. Despite this progress, there are many unanswered questions that require further research, development and exploration. Groups such as the Society for Academic Emergency Medicine Consensus Conference have attempted to organize the many existing needs.

When designing a simulation program, it is important to consider the location and type of simulation to best match up with a program's goals and objectives. In-situ simulation, held within the actual care setting can be used to assess factors that would otherwise be missed. This type of simulation explores beyond the typical cognitive aspects of care to include the environment, team dynamics and equipment. System issues can be unmasked when performing in-situ simulation that would go unrecognized in a traditional simulation center. Mobile simulation is a growing area that helps facilitate in-situ simulation, particularly for sites such as skilled nursing facilities that might not otherwise have reasonable access.

A major challenge in operating a simulation center relates to the justification of the center's existence. It can be costly to develop and maintain a simulation center. Some returns on this investment are easy to track such as direct profit from a training program. However, other returns may be much less obvious. There is no current standard about how to track and report these returns. Many centers are focused on the development of a ROI or ROE tool that can be widely applied.

While much of simulation based education has focused on "low stakes" and formative assessment, there is constant development to allow formal "high stakes" assessment. This type of simulation is emerging within courses for credentialing and maintenance of certification. The field of simulation based education continues to grow and evolve. It is a field that can clearly assist the ED director in meeting the various challenges of running a safe, efficient Emergency Department.

Take Home Points

1. Simulation can assist the ED director in many existing administrative challenges.
2. In Situ simulation can be utilized to identify process, environment, equipment and other system failures that may not be identified in a simulated environment.
3. Mobile simulation teams enable simulation to be utilized outside of large centers and expand the reach of this educational modality.
4. Simulation can be utilized to train for disaster responses and identify fatal system errors.
5. Simulation can be effectively used for team training in various environments
6. Computer based simulation programs can be used to assist in staffing and patient flow models
7. Simulation centers must consider the return on investment or return on expectations of programs in order to justify their value.
8. Simulation can be utilized in credentialing, licensing, maintenance of certification and other "high stakes" environments to assess healthcare staff.

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Simulation in Undergraduate Medical Education

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Background

Simulation in medical education is not a new concept, but it is now being transformed with new simulation technology and integration into all levels of medical student education. In addition to its use in teaching and assessing basic clinical and procedural skills, simulation has been used in additional instruction areas such as physiology, teamwork, patient safety, and communication. Simulation is a broad term that includes computer-based programs, high fidelity simulators, task trainers, and standardized participant encounters. High fidelity simulation, using computerized mannequins have the potential to offer our students a more engaging and potentially worthwhile learning experience.

Students who are unable to engage in direct patient care situations now have the ability to participate in simulated patient care through a variety of modalities. The most recent LCME standards are broader in scope than previously required but still state that medical schools must have comparable educational experiences that they have defined as "Learning experiences that are sufficiently similar so as to ensure that medical students are achieving the same learning objectives at all educational sites at which those experiences occur (Element 8.7)" [1]. Simulation provides the emergency medicine educator with the opportunity to provide an equal experience for all participants thereby meeting educational objectives. For instance, not every student may participate in a resuscitation or have the opportunity to ventilate a patient with a bag-valve-mask in the clinical setting due to the acuity of patients and our unscheduled environment but every student can participate in a simulation experience.

Current use of simulation in medical schools is fairly high according to a recent AAMC survey [2]. In this survey of 133 medical schools, 90 (68%) responded. The medical schools used some form of simulation in 84%, 91%, 94%, and 89%, respectively for years in school from 1 to 4. EM clerkships embedded within medical schools used simulation 65% of the time and for those within teaching hospitals, 71% of the time. Simulation was used by medical schools for educational purposes (86%), assessment (71%), as well as QI and research (40%).

Simulation plays a role in the education of students during clerkships. In one study published in 2014, a 2010 survey of emergency medicine clerkship directors found 75% of respondents incorporated simulations into their educational programs with a mean (±SD) number of hours on simulation of 5.0 (±3.8) hours per rotation. In this survey the types of simulation experiences was not described however the respondents noted that simulation was primarily used to teach diagnosis and treatment [3]. Another survey of 75 EM clerkships noted that fewer than 25% of didactic hours used any form of simulation [4]. While these studies are not recent it appears that simulation does play a signficant role in education for students on their EM rotations.

Evidence for the use of simulation in EM student education is growing. Studies have reported that students rank simulation experiences as excellent when compared to more traditional educational approaches [5, 6]. Studies have demonstrated that simulation improves student knowledge base, abilities, and confidence level [7–11]. For instance Steadman et al. noted that students trained with simulation were able to perform better in acute care assessment and management skills compared to a problem-based learning format [10]. In should be noted that several studies were not able to detect a difference between simulation based education and didactics [12, 13]. These studies provide the EM student educator with

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some, although not conclusive, support for inclusion of simulation based training in their educational programs either as a replacement for didactics or as a supplement. When examining the broader literature regarding the use of simulation the data supports its effectiveness. Cook et al. in their meta-analysis noted that when compared to no intervention there was a favorable effect [14]. When simulation based education was compared to non-simulation instruction the effect is slightly favoring simulation. Therefore the literature supports the role of simulation based education.

Best Practices

Ultimately, the role of simulation-based education is to put the student into clinical scenarios that they may not otherwise be able to participate in with real patients and to standardize those experiences. This is especially true for rare clinical scenarios and procedures, or in critical situations where patient-safety concerns would preclude an active level of student involvement. Instead of just watching from the sidelines in the ER or running through a case presentation, students in the simulation center are provided with the opportunity to actually care for the "patients". This provides optimal teaching while allowing real patient care processes to take place in a safe environment.

The Clerkship Directors of Emergency Medicine have outlined in their national curriculum for the fourth-year emergency medicine clerkship a set of general competencies and procedure skills [15]. They list nine areas of procedural exposure including: access, airway management, arrhythmia management, gastroenterology, genitourinary, orthopedic, infection, trauma management, and wound care. A student may not necessarily be exposed to all of these procedures during a typical four-week clerkship. The simulation environment allows students the opportunity to meet these requirements. For instance, at our home institution we use a simulation program that combines a procedural lab and several high fidelity simulation sessions to meet our educational objectives. We have several required procedures in our curriculum that can be met during our procedure lab including suturing, splinting, and basic airway management. Our learning objectives for acute care resuscitation (adult and pediatric) and toxicology are guaranteed through use of simulation since it is unlikely that every student will be able to observe or participate in these patient encounters.

At another institution, a third year syllabus for emergency medicine students was developed in 2011 [16]. In a subsequent publication the working group developed a curricular guide that included educational methods and evaluation [17]. Simulation was included as an educational and assessment method for many of the learning objectives in this third-year emergency medicine curriculum. Another recent study used simulation to teach medical students how to deliver a death disclosure. They noted an increase in knowledge, comfort and confidence [18]. Yet another study sought to teach students how to evaluate a patient with altered mental status, one of the core emergency medicine clerkship objectives, noted similar increases in knowledge, comfort and perceived competence [19]. While none of these studies provides conclusive data to support using simulation to teach and assess the core clerkship objectives, there is a growing body of evidence supporting simulation as a means to teach students core material.

Keys to Development of a Successful Simulation Program

Specific details regarding the components necessary to run a simulation program are covered elsewhere in the book. However, there are elements that are unique to undergraduate medical education that need to be discussed. Particularly important are an understanding of the resources available and how the program fits into the educational mission of your institution.

Resources

A successful undergraduate simulation program requires both expert leadership and a cadre of talented educators willing to give of their time. Expert leadership requires a combination of skill-sets and knowledge that most often requires a team approach. The team should include one or more faculty with expertise in simulation and assessment (perhaps fellowship-trained), and also needs to include faculty with a clear grasp of the curricular learning objectives. For the case of an EM clerkship, this might include not only the clerkship learning objectives, but additional longitudinal (cross-clerkship) medical student learning objectives. In many departments an ideal team might be the EM clerkship director and a fellowship-trained (or otherwise expert) simulation director. The simulation director brings the practical skills of case design, technical operation, and case debriefing, whereas the clerkship director brings the curricular objectives, and a greater familiarity with the learner's knowledge base and clinical skills. While having a simulation director within EM is certainly most ideal, there is no reason a successful team can't involve a non-EM simulation expert.

While expert leadership is critical, a successful and ongoing undergraduate simulation program will likely require a core group of dedicated and talented educators. The size of the group will depend on a number of factors including the number of learners and frequency/repetition of sessions. As opposed to a 3 or 4 year post-graduate program, the typical EM clerkship is 4 weeks in duration, with some as short as 2 weeks. Most of these repeat throughout an "academic year" that might range from 8 to 12 calendar months. The LCME requires that all students within and institution receive comparable educational and evaluative experiences, which requires at least some consistency in the number of types of simulation exposures throughout the year (particularly when assessment is involved). The number of learners and perhaps monthly repetition of sessions will very often exceed the capacity of the expert simulation faculty and require the broader involvement of a department's core educators. These faculty should have enthusiasm, general educational talent and a willingness to volunteer their time. They should be content experts and have a clear understanding of the key learning objectives. In addition, faculty development on important debrief skills should be a component of their training prior to participation in simulation based teaching activities.

Understanding your resources is vital to assisting with creation of the program. Schools and centers with large simulation centers may be able to accomplish more and meet more curricular objectives. If your institution lacks those resources much can still be accomplished but goals will have to be adjusted and modified to better match available resources. Nationally, simulation centers are operated differently depending on financial resources. Each institution has invested differently in facilities, equipment and staffing. A 2011 Association of American Medical Colleges survey addressed the spectrum of medical school and teaching hospital investment in simulation based education [2]. The majority of medical schools and teaching hospitals have a centralized simulation facility, 77% and 59% respectively. In addition to the standard simulation activity within a center many simulation activities occur in situ at the point of health care delivery, including ambulatory, inpatient, and field experiences. The vast majority of medical school simulation centers, 87% are funded by the medical school. Other sources of financing include grants/foundations, revenue generated by courses or services offered, philanthropy, or a combination of sources. This means that in certain circumstances a program might have to pay for use of a center. The amount of staffing at medical school simulation centers ranged with an average of 8.1 FTEs and a median of 5 FTEs. The types of positions ranged and included administrators, course directors, curriculum authors, program directors, educators, trainers, operation managers, research personnel, simulation technician, and standardized patient educators. This survey exemplifies that there is no one way to run a simulation center. Each center is unique and the educator who is planning on using simulation in their course needs to be aware of their center's facilities, equipment, staffing, and costs.

Educational Mission

Curriculum Integration

The most important step in the development of a successful simulation program for undergraduate medical education is to develop a curriculum that integrates simulation into the learning objectives. For instance, a learning objective could be, "By the end of this session the student will be able to treat life a threatening ventricular arrhythmia". In this case, the simulation program might include a high fidelity simulation of a ventricular fibrillation arrest requiring the student to assess the patient, recognize the life threatening dysrhythmia and treat it appropriately with defibrillation. Creating clear learning objectives in advance and integrating simulation appropriately are necessary for a successful simulation learning experience. One example from our institution is the use of simulation to teach toxicology during the fourth year clerkship. The simulation experience has replaced the standard lecture based powerpoint presentation. In advance of implementing these sessions we developed a set of learning

Table 15.1 Toxicology learning objectives and critical actions

By the end of this simulation session students will be able to:
A. Primary
1. Develop and demonstrate an approach to the adult patient with suspected overdose of unknown medications
2. Recognize common toxidromes
B. Secondary
1. Discuss the diagnostic work up of an unknown overdose including obtaining serum acetaminophen and salicylate levels
2. Demonstrate an understanding of gastric emptying methods
3. Discuss the appropriate use of activated charcoal
4. Discuss the proper use of enhanced elimination techniques like multidose activated charcoal, whole bowel irrigation and hemodialysis
5. Utilize closed loop communication
C. Critical actions
1. Obtain a temperature reading in the suspected overdose patient
2. Obtain the medication history from the patient's family member and EMS
3. Recognize the correct toxidromes
4. Order the appropriate diagnostic studies including serum acetaminophen and salicylate levels
5. Consider administering activated charcoal with sorbitol
6. Do not administer ipecac and do not perform gastric lavage
7. Do not administer haloperidol
8. Consider whole bowel irrigation or multidose activated charcoal for a sustained release preparations
9. Admit patient to the ICU
10. Consult renal for hemodialysis

objectives and a key critical actions for formative feedback (Table 15.1).

Typically, whether it is an existing or brand new curriculum, there are a set of educational objectives. Once these have been developed the simulation leaders need to work with the course developers on the best way to integrate simulation. This process needs to be done in a step by step manner. Important things to consider are, what type of simulation is needed, the venue, type of simulators, degree of fidelity, and formative versus summative assessments to be used. One framework for integration of a curriculum with simulation was published by Motola et al. [20]. The authors of this framework divided up the planning into four phases which included: plan, implement, evaluate and revise. Whether you use this system or another, it is important to work with the curriculum developers in advance to delineate all the details of the simulation based education program.

Formative versus Summative

When developing your session a key consideration is to decide whether the simulation will be for formative assessment or whether it will be used for summative assessment. Summative assessment (particularly higher-stakes assessment) will require more formalized, standardized, and reproducible processes as well as examination security that limit the instructive potential of the cases. Consider the example of teaching versus evaluating wound closure skills using a basic simulation model. It would be relatively easy to put together a teaching session for suturing skills using discarded needle drivers and scissors, expired suture material, and pigs feet. The cost per student would be minimal and the program can be implemented with a relatively small faculty to student ratio. It could even be taught by upper level students and residents further decreasing the faculty time burden. Assessing suturing skills in a formal setting to standardize the evaluation and keep it equivalent for all students will necessitate more resources. The assessment should occur in a standardized environment with trained evaluators. This cannot typically be done in the ER setting. Faculty or a trained evaluator will have to observe students' performance and assess the performance using a standardized and validated rubric. If necessary these sessions could be taped and watched later by faculty, but this adds additional costs or use of resources. The more rigorous the assessment the more resources will be necessary to insure the reliability and validity of those assessments.

Challenges and Solutions

Although establishing a simulation program within an existing or new curriculum can be challenging there are good solutions that can be used to overcome those hurdles. A survey of clerkship directors noted that a major limitation was limited faculty time (88.7%) and clerkship hours (47.2%) as the barriers to implementing simulation training for medical students. Financial resources and technical expenses were also factors that limited use of simulation for EM clerkship education [4].

As noted in the survey having enough faculty time to run simulations can be a challenge. Faculty time to run students through simulation may be limited due to the nature of simulations and other responsibilities of faculty. Several options exist to overcome these obstacles. Although not optimal, larger simulation sessions can be used for formative sessions. Typically a case based simulation may be done with only 3–4 trainees but a course director may consider using larger groups and rotate the students who are in contact with the simulator. There is evidence to support learning outcomes among the observers if there is value attached such as role briefing, use of observer tools and including their perspectives in debriefing [21]. If you have several faculty or other instructors available several stations can be set up and smaller groups of students can rotate through the stations. Simulation faculty do not always have to be the instructors. Use of other faculty residents, upper level students or properly trained staff can replace a faculty. A significant portion of any simulation whether using task trainers or high fidelity simulators is the time for setup and clean up. If staff exists that can help eliminate these time consuming aspects of simulation.

Finding time during a typical 4 week clerkship can be difficult. One optimal solution is to replace the classic didactic lectures with simulation. Instead of teaching pediatric emergencies using PowerPoint one could run through several pediatric simulation scenarios, using simulation as an opportunity to flip the classroom. One could provide access to the lecture or an article in advance and then use simulation to reinforce the clinical aspects of the case material.

The cost of running a simulation program can also be a major challenge for most educators. One of the major costs occurs when an educator envisions a large scale simulation with high fidelity simulators. Time and money spent can be significant for a high fidelity simulation. This includes time to develop the cases, expensive simulation equipment requirements, use of standardized patients, and more. High fidelity may be extraneous for the learner who is still attempting to master more basic skills. A novice can acquire skills at a lower level of fidelity in comparison to an experienced learner who may require a higher level of fidelity to meet skill acquisition goals [22]. A review article comparing low versus high fidelity learning noted no significant advantage of high fidelity over low fidelity simulation [23].

Depending on your setting, the space to run simulations may be nonexistent or limited. In addition, any existing space may require commuting time. There is no one size fits all solution. Moving a whole set of lectures and simulation time to 1 day may help alleviate concerns about commuting. The ratio of learners to a simulator may have to be higher than desired or if you have several instructors you can rotate learners through several stations. For instance the students could practice a low fidelity simulation and then rotate into the simulation room for a full scale patient experience. If a simulator exists but there is no simulation center then the simulation can occur in the hospital. Keep in mind that additional equipment and supplies should be provided and accounted for in the case of in situ simulations to minimize costs to the hospital. Safety needs to be highlighted for in situ simulation confirming that the simulation does not interfere with ongoing patient care and simulated medications and other equipment do not get used for actual patient care, Coordination between educators and hospital administrators needs to occur to guarantee a safe and effective in situ simulation and obtain buy-in from all participants.

Interface with Regulatory Bodies

Simulation in emergency medicine can be a useful mechanism to meet certain regulatory standards. The LCME is the accrediting agency for medical schools. As noted earlier, medical schools must have "Learning experiences that are sufficiently similar so as to ensure that medical students are achieving the same learning objectives at all educational sites at which those experiences occur (Element 8.7)" [1]. Another standard (6.2) for required clinical experiences states that: "The faculty of a medical school define the types of patients and clinical conditions that medical students are required to encounter, the skills to be performed by medical students, the appropriate clinical settings for these experiences, and the expected levels of medical student responsibility". Once a program defines the clinical conditions, the students are required to see those types of patients or perform those skills. Achieving this standard is not always possible for a student due to the variability in clinical opportunities. Simulation experiences can be used to replace those clinical experiences and meet that standard. For instance, a student may never have the opportunity to care for a patient with an aortic dissection. If listed as one of the required encounters this could be achieved via a simulation case. This same condition and opportunity might apply to procedures such as endotracheal intubation.

The standards (8.6) also require monitoring of completion of required clinical experiences, "A medical school has in place a system with central oversight that monitors and ensures completion by all medical students of required clinical experiences in the medical education program and remedies any identified gaps". Again simulation sessions provide a standardized approach to ensure that all students encounter required patient presentations.

Simulation, especially when using standardized participants (SP), can be used to teach and assess communication skills. The standard (7.8) on communication skills states that "The faculty of a medical school ensure that the medical curriculum includes specific instruction in communication skills as they relate to communication with patients and their families, colleagues, and other health professionals.". SPs provide a unique opportunity to teach communication skills. SPs in their traditional role can act the part of the patient, however as a standardized participant they can play family, consultant, nurse or any other healthcare provider.

Sample Case (See "Appendix 1, Chapter 15 Supplemental Case Scenario")

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Simulation in Graduate Medical Education

16

Charles N. Pozner and Andrew Eyre

Introduction

Emergency medicine is a particularly complex and challenging specialty. Not only are emergency medicine clinicians expected to diagnose, stabilize and treat patients presenting with any medical or surgical emergency, but they are also tasked with managing the pace and volume with which these patients arrive. During the course of an emergency medicine training program, residents must achieve competence in a number of domains including technical skills, teamwork, communication, medical knowledge, and multi-tasking. Medical simulation has emerged as a popular, exciting, effective, and valuable educational tool that is particularly well-suited to the training needs of emergency medicine residents [1, 2].

In 1999, the Accreditation Council for Graduate Medical Education (ACGME) established the "Outcomes Project" and identified patient care, medical knowledge, professionalism, systems-based practice, practice-based learning, and interpersonal and communication skills as the six "Core Competencies" of any graduate medical education training program [1, 3]. When this project was initiated, it was the start of a multi-step and long-term redesign of how graduate medical education training programs maintain accreditation. The primary goal of this process was "to accelerate the ACGME's movement toward accreditation on the basis of educational outcomes [4]." This restructured system, termed the Next Accreditation System (NAS), was implemented by emergency medicine training programs in 2013. Created as a combined effort between the ACGME and the American Board of Emergency Medicine, the Emergency Medicine Milestone Project provides programs with a method for assessing the competency and progress of trainees in specific key elements of emergency medicine practice. In addition to providing a system for individual trainee assessment, these 23 milestones, categorized by the six core competencies, allow the ACGME and program leadership to ensure that a residency training program is producing well-trained physicians. The Milestone's Project recognizes and suggests simulation as an appropriate assessment method for many of the milestones [5]. As a result, simulation is playing an ever-increasing role in resident education and assessment [1, 2, 6].

As simulation's role in emergency medicine training and continuing education grows, so has its recognition and presence within emergency medicine's national and international organizations. In 2009, the Society of Academic Emergency Medicine (SAEM) formed the Simulation Academy. Similarly, the American College of Emergency Physicians (ACEP) Education Committee has convened a simulation subcommittee [2]. Both the SAEM and ACEP national meetings now include simulation-based activities. Initiated as a collaborative effort in 2009 with the SAEM Simulation Academy and the Clerkship Directors in Emergency Medicine (CDEM), the Council of Emergency Medicine Residency Directors (CORD) maintains an extensive library of oral board and simulation cases for public use [2]. Together, these emergency medicine organizations, committees, and events have helped to distinguish and solidify simulation as a valuable tool for resident training.

As with all specialties, emergency medicine training programs encounter numerous challenges when providing comprehensive, high-quality residency education. Trainees are now working fewer hours and thus managing the care of fewer patients and performing fewer procedures, especially on off-service rotations, than they had prior to the establishment of work hour restrictions in US residency programs. Similarly, the changing culture of healthcare has increased focus on patient safety making the learning model of "see one, do one, teach one" far less acceptable [7]. It is no longer appropriate for a

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novice operator to fumble their way through a procedure or resuscitation and simply "learn by doing" when patient safety may be compromised [8, 9]. Additionally, technology and the emphasis on minimizing invasive procedures have truly changed the practice of emergency medicine and have reduced the opportunity to perform many procedures. Examples include video laryngoscopy resulting in a reduction of both failed intubations and the need for cricothyroidotomies. Diagnostic peritoneal lavage has mostly been replaced by the performance of the FAST exam. The incidence of pericardiocentesis, once employed both diagnostically and therapeutically, has decreased due to the introduction of bedside ultrasound. While such procedures have become less commonplace and residents are performing fewer procedures during training, residency training programs must nonetheless ensure that their graduates achieve competence in all core areas of emergency medicine, both technical and nontechnical. Simulation can offer a solution to many of these challenges [8, 9].

Simulation enables trainees to learn and practice without exposing them or their patients to untoward events [8, 9]. Residents can be afforded the freedom to make mistakes and grow professionally without jeopardizing patient safety. Similarly, in an era of decreased work hours and patient encounters, simulation can ensure that trainees are exposed to and have to manage a variety of pathologies, and perform critical low frequency yet high yield procedures. While there is no control over which types of patients present to the emergency department during any given shift, faculty can dictate the experience and outcomes for any particular learner in the simulated environment. Between partial task training, large group scenario-based cases, individualized coaching sessions, resident assessments, online modules and standardized patients, simulation provides educators with the flexibility to teach a wide array of cognitive, psychomotor, and behavioral skills.

As the "front door" of the hospital, it is often the emergency department and emergency medicine providers that are the first to encounter and manage new threats or unexpected situations. Simulated exercises, such as mass-casualty drills or infectious disease isolation practices, can be employed in response to the changing local or global environment. Similarly, simulation can be used to remediate or address a particular problem that arises for an individual, group, or institution. While simulation is utilized at some level in nearly all emergency medicine training programs, given its flexibility, popularity, and effectiveness, its use is likely to grow as technology progresses, new modalities are introduced, and familiarity increases.

Best Practices and Successful Programs

As simulation has matured as a teaching modality, the number of innovative and creative uses of simulation in emergency medicine training programs has flourished. Once employed sporadically within many residency training programs, simulation has now been embraced due to the flexibility that it affords in providing trainees with a wealth of experiences and learning opportunities. This section will highlight some successful uses of simulation in emergency medicine residency programs.

University of New Mexico's 3-Year Curriculum [10]

In order to address the needs of a three-year emergency medicine residency, Steven McLaughlin and his colleagues from the University of New Mexico developed an integrated, case-based simulation curriculum that highlights graduated complexity and learner responsibility (McLaughlin [10]). Interns begin the program with an introduction and orientation and then, throughout the year, must participate in five simulation cases, each highlighting core emergency medicine topics such as acute myocardial infarction, anaphylaxis, and airway management. Similarly, post graduate year 2 learners must complete five cases throughout the year. These cases however are clinically more complex and begin to incorporate a host of social, ethical, and systems-based issues such as equipment failure, refusal of care, and medical errors. The progressive case complexity continues into the post-graduate year 3 curriculum where learners are expected to manage a number of more difficult situations such as multiple patient scenarios, unexpected procedural complications, and administrative issues. Additionally, the third year residents are asked to assist faculty with cases for junior learners in order to hone their own teaching, supervisory, and debriefing skills.

Harvard's Integrated 4 Year Curriculum [11]

In 2004, the Brigham and Women's Hospital/Massachusetts General Hospital Harvard Affiliated Emergency Medicine Residency Program introduced a four-year curriculum that fully incorporated simulation-based learning modules into the didactic program. The residency curriculum is partitioned into core modules, with each module presented over 2 years; thus exposing the residents to the entire curriculum twice over the course of their four year training program. Learning objectives for each module were identified and it was determined which educational strategy best met the objective; partial task training, interactive small group discussions, computer-based simulation, or scenario-based cases. These 3–4 hour simulation sessions replaced much of the lecture-based didactic curriculum and generally occur every other week. Typically, residents rotate through three to four simulation stations. Groups may be divided by post-graduate year or remain heterogeneous with senior residents given a supervisory role. Each simulation session centers around two simulated cases, supplemented by procedural or small group activities. Not only are the scenarios designed to discuss and review the management of the particular case presented, they also afford faculty an opportunity to take advantage of an engaged, 'teachable' learner to present associated new content. Each simulation session is designed by a faculty Course Director under the mentorship of simulation center curriculum specialists. Additional faculty are recruited and prepared to facilitate individual stations. While the resources required to manage this curriculum, including faculty and simulation-center time and effort, are extensive, this model has produced enormous benefits for learners. In addition to replacing passive lectures with active, engaging, case-based learning, this integrated simulation curriculum fosters the exposure to and repetition of communication, organization, systems-based practice, and leadership skills across the continuum of residency education.

Residency Boot Camps

As the use of simulation has increased, many specialties have developed and implemented concentrated learning programs ("boot camps") to rapidly and efficiently teach learners procedures either at the beginning of the residency or when assuming new responsibilities. Many GME programs in Emergency Medicine have adopted this approach. The Harvard Affiliated Emergency Medicine Residency at Brigham and Women's Hospital/Massachusetts General Hospital introduced a procedural "boot camp" for incoming interns [12]. During this 2-day program, interns work closely with faculty to practice core intern-level emergency medicine procedures including intubation, lumbar puncture, central venous catheterization, tube thoracostomy, arterial line placement, paracentesis, and peripheral intravenous access. In addition, they return to the simulation center at regular intervals throughout their intern year for deliberate practice sessions on these same procedures. These sessions enable the learners not only to refresh and refine their skills, but also to share experiences and ask questions based on their actual clinical experiences. While most traditional "boot camps" take place in isolation, the design of this particular program provides learners with a longitudinal experience, starting with pre-course reading and review, then a core procedures workshop, followed by regular practice sessions.

Multiple Encounter Simulation

Emergency physicians are typically required to care for multiple patients simultaneously; including the critically ill or injured. These situations require a unique set of skills including multi-tasking, prioritization, delegation, and resource allocation. While traditional single-patient simulation scenarios support the learning of a wide range of clinical and team-work skills, they usually fail to incorporate or highlight the skills necessary to manage simultaneous patients. A variety of residency programs have begun to develop scenarios involving multiple patients. Leo Kobayashi and his colleagues from Brown Medical School provide a description and guide for creating what they call "multiple encounter simulation scenarios [13]". While designing and executing multiple patient scenarios can be resource intensive and more difficult than traditional single patient cases; they provide learners with another level of fidelity and allow instructors to focus on an expanded set of learning objectives.

Teaching Senior Simulation Program

Recognizing that many of their graduates will be moving on to academic careers, the Harvard Affiliated Emergency Medicine Residency requires each fourth year resident to act as the "teaching senior" during a four-week block. In addition to providing formal educational programs, the resident is expected to mentor junior residents in the emergency department; assisting with procedures and providing individualized instruction on the management of cases. As part of this program, each resident is paired with a faculty member and tasked with designing and facilitating a simulation-based session for rotating medical and physician assistant students [1]. As a result of this process, senior residents are introduced to the "other side" of simulation. Specifically, they learn how to assess knowledge gaps, create objectives, design and write up a simulation case, work with simulation specialists to operate high fidelity simulators, and to facilitate a debriefing session. With the help of the assigned faculty member and curriculum specialists, the resident is mentored through this process; with direct feedback provided at the conclusion of their simulation session. This program introduces senior residents to the preparation and skills necessary to design and facilitate a successful simulation session.

Mass Casualty

As the world is experiencing an increase in both natural and human-made disasters, it is critical that emergency medicine residents receive education on mass or multiple casualty incident response and management. Emergency physicians are expected to enact well-coordinated plans, perform effective triage, prioritize resources, and maintain clear and effective communications in order to deliver a safe and effective system-wide response under stressful conditions. Given that it is unlikely that each resident will participate in a mass casualty incident during training, simulation is an invaluable tool to bridge this experiential gap. The Harvard Affiliated Emergency Medicine Residency employs simulation to introduce a number of topics within their disaster and mass casualty incident module. For example, residents learn and practice the donning and doffing of various levels of personal protective equipment. They also perform decontamination of a simulated patient using the actual equipment available at the institution. In a particularly novel session, residents are tasked with performing rapid triage on a large influx of patients, as may be required during a large scale incident. These simulated patients include actors and simulators presenting with a wide range of complaints and injuries, ranging from the uninjured bystander, to a critically ill child. This exercise leads learners through the extremely difficult decisions that must be made when resources are overwhelmed and care cannot be provided in the standard fashion.

Morbidity and Mortality Review

Morbidity and mortality conference is a valuable case-based conference that is designed to analyze medical errors and review unexpected patient outcomes with a focus on quality improvement and education. Traditionally, a single individual, often a resident, prepares and presents the case to an audience of faculty and residents and then facilitates a discussion. In an effort to make the morbidity and mortality conference more interactive and engaging, members of the Northwestern Division of Emergency Medicine demonstrated that it was feasible to incorporate simulation into this long-established venue [14]. Instead of simply verbalizing the history, physical exam, vital signs and pertinent data, the resident recreates the case employing actual patient data and attempts to reenact the interactions of those involved in the case. This video-taped case is then presented to the residents and faculty. At critical junctures, the audience is invited to discuss the case and, using an audience response system, assess the resident's clinical performance on a number of core clinical competencies. The authors of the study surveyed the participating residents and found that the "augmented" morbidity and mortality conference was generally well received and beneficial. While perhaps simulation is not the most appropriate modality for all didactic sessions, the ability of simulation and other interactive strategies to enhance the educational value of traditionally passive strategies are a demonstration of the versatility and applicability that simulation has to offer.

Resident Assessment

While simulation serves as an extremely valuable teaching tool, it can also be used as a method for assessment. Simulation provides the opportunity to assess learners in a standardized and reproducible way, which is often not possible in the actual clinical environment. In addition to procedural skills, simulation can be used to evaluate a number of the ACGME core competencies, such as communication skills, medical knowledge, and medical decision making. Some training programs employ simulation to assess decision-making and psychomotor competency as a prerequisite for advancement. Assessment tools, such as checklists, observer rating scales and other metrics can be surprisingly difficult to use and must be vetted. As Bond points out, while such assessments can be extremely beneficial, they must be designed and implemented with extreme caution, especially if being used for certification or advancement [6].

Challenges and Solutions

Challenges

As with the implementation of any new methodology, residency programs face a variety of challenges related to the introduction or enhanced use of medical simulation. The most obvious is the existence of appropriate simulation technology. Although simulation is commonly perceived as a technology, it is in actuality an educational strategy. Although some investment is necessary, it is a common misconception that in order to employ simulation successfully one needs to make an exorbitant investment in the technology. In reality the technology turns out to be far less important than the people developing the curriculum and the faculty delivering it. Below, we will describe some of the common barriers and possible solutions to integrating simulation into a residency program.

Buy-in

The successful implementation of medical simulation most often requires a top-down approach. Because some investment of capital, space, and faculty time and commitment are required to be successful, the support of administrative leadership must be obtained. Due to the widespread and successful adoption of simulation, this has become much easier. However, in order to develop a sustainable program, the commitment of hospital and/or departmental leaders is essential. Leadership needs to recognize the value of simulation in the context of an increased commitment of resources, including faculty. When approaching administration, one should have a clear understanding of the needs of the program. Although one should develop a comprehensive strategy, one must avoid the temptation of presenting this all-encompassing strategy early in the process. These authors recommend starting with a project that can be successfully implemented and one that will provide obvious value that is easily and enthusiastically perceived by administrators, faculty and residents. Leveraging the success of this initial offering, one can then more easily lobby for expansion of the program.

Cost

If a simulation facility already exists in your institution, the marginal cost of implementing simulation into your residency program will likely be affordable. If there are no resources available at your institution, one must consider developing your own or using local extramural resources if available. One must be sure to consider all of the costs of each option. For the local option these include the cost of simulators, physical space, supporting equipment, and staff. For the extramural option one needs to consider the fees charged for use of the facility as well as the added time and expense required for travel. One may also consider in situ simulation; however, the cost of simulators, disposable equipment, and use of clinical space must be factored into the decision. Regardless of the option chosen, one must also consider the cost of curriculum and faculty development, as well as the faculty time required to both prepare for and teach each session.

Time

Lectures have been the traditional educational strategy employed in presenting the didactic elements of the emergency medicine curriculum. Although very efficient (a single instructor can present to 5 or 5000 participants depending on the size of the auditorium and the quality of its audio resources), the adult learner is less likely to benefit from this strategy than from the active, small group learning that takes place when employing simulation. However; the enhanced effectiveness of simulation must be balanced with the additional staff and time required to conduct most programs. The de novo preparation of a simulated curriculum should not be significantly more time intensive than that of a lecture. That being said, without the support of non-faculty staff to program the simulators and prepare (and break down) the simulated environment, the time required to implement a simulation program can be significantly longer than that of a lecture. Successful simulation programs most often have non-clinical staff to perform these functions.

One must also consider the number of faculty (and their time) needed to conduct a simulation-based program. There is typically a need for additional faculty to implement a simulated curriculum as compared to a lecture-based format. For instance, if a three-hour program for 30–40 residents was presented in a lecture format, 3 hours of faculty commitment would be required. If the program was to be presented using a simulated format, one would typically divide the residents into 4 groups of 8–10; with residents rotating between simulation-based stations. This format would require 3 additional faculty members for 3 hours each; increasing the time commitment from 3 to 12 hours. This is not trivial and must be taken into consideration when contemplating switching to a simulated format. The authors feel that, although lecture-based education is clearly a more efficient model; the small group, adult-learning based paradigm employed in simulation more than makes up for this added expense.

Curriculum Development

Like any successful curriculum; design of a simulation-based curriculum typically requires a thoughtful approach in order to provide maximum value. Many believe that merely developing a scenario that mimics an actual clinical presentation is all that is required; and in some cases this may be enough. However, considering who the learners are, their knowledge gaps, and then writing specific educational objectives to close those gaps are extremely important and often underutilized first steps in simulation-based curriculum development. Once these objectives are defined, scenarios may then be designed around the objectives that will meet the needs of the learners. This thorough preparation increases the likelihood that learners will receive the intended instruction when attending simulation-based programs. These aren't skills that clinicians are typically taught and most often require the mentorship of persons well-versed in curriculum development; ideally with a background in simulation. Programs and instructors must also be evaluated in order to maximize quality.

Faculty Development

Successful faculty development often separates successful from unsuccessful programs. Teaching in a simulated environment has several different characteristics than teaching in a lecture-based format. Although similar to the interplay that takes place during bedside teaching, simulation-based instruction has differences that must be taken into consideration when contemplating its adoption. In a lecture, the lecturer is unilaterally driving the flow of information. In the small group simulation setting, there is multi-directional flow of information; at times moving the discussion to areas not anticipated by the faculty. It is more likely in these environments that a faculty member will need to admit a lack of expertise; something that can be unsettling to clinicians. This can often be mitigated by developing well-designed objectives-based curriculum in which the learners are more likely to arrive at predictable branch points in a scenario. Although psychomotor and content-related curriculum is commonly in the bailiwick of most emergency physicians, the non-technical skills that best lend themselves to instruction through simulation often require a skill set not typically present. In the majority of cases, faculty new to the simulation environment will need instruction and mentoring in both curriculum development and curriculum delivery; an issue that often does not receive the level of consideration necessary to implement a successful curriculum.

Sample Session Curriculum

Simulation sessions must be designed to meet the specific needs of the program, learners, and/or faculty while working within the constraints of available time, equipment and resources. While there is an enormous variety in how sessions can be designed and implemented, this sample curriculum describes a three hour simulation session for the entire residency as part of the pulmonary module (see "Appendix 1, Chapter 16 Supplemental Case Scenario"). In this session, the residency is divided into four groups with mixed levels of experience. The groups rotate through each station during the course of the session (Table 16.1).

Table 16.1 Sample curriculum outline

Time (min)	Station title	Description	Learners	Faculty
20	Simulation case 1	Patient with pulmonary embolism leading to COPD exacerbation	Group 1 (split in half, 5 residents maximum)	1
20	Simulation case 2	Patient with pneumonia leading to ARDS	Group 1 (split in half, 5 residents maximum)	1
40	Skills station 1: Chest tubes and pigtail catheter insertion	Chest tube and pigtail placement with partial task trainers	Group 2 (10 residents maximum)	1
40	Skills station 2: Ventilator management	Hands on practice with ventilator management and alarm troubleshooting	Group 3 (10 residents maximum)	1
40	Skills station 3: Lung ultrasonography	Didactic and hands on practice for lung ultrasonography	Group 4 (10 residents maximum)	1
10	Wrap-up Evaluations	Complete computer-based evaluations of session	All residents	1

Skills Station 1: Chest tubes and pigtail catheter insertion

At the conclusion of the station the participant should be able to:

Objectives:

- Understand and verbalize indications for chest tube placement
- Demonstrate ability to identify landmarks for chest tubes and pigtail catheters
- Demonstrate ability to successfully place a chest tube or pigtail catheter

Session Description: Participants will receive a brief didactic lesson (less than 10 minutes) from faculty discussing indications for a chest tube, selection of chest tube type and size, relevant landmarks and anatomy, and steps for successful placement. Participants will then practice on partial task trainers or high fidelity simulators with faculty supervision and real-time feedback.

Skills Station 2: Lung Ultrasound

Objectives: At the conclusion of the station the participants should be able to:

- Demonstrate appropriate technique for lung ultrasonography
- Identify common findings in lung ultrasound
- Understand and verbalize indications for thoracentesis
- Demonstrate ability to perform an ultrasound-guided thoracentesis

Session Description: Participants will receive a short didactic lesson (approximately 20 minute) from faculty discussing techniques for lung ultrasonography, common findings in lung ultrasonography (including lung sliding, lung point, pleural effusions, A-lines and B-lines), indications for thoracentesis, and how to use ultrasonography for thoracentesis. Participants will then practice on partial task trainers or high fidelity simulators with faculty supervision and real-time feedback.

Skills Station 3: Ventilator Management

Objectives: At the conclusion of the station participants should be able to:

- Demonstrate an understanding of ventilator settings and common adjustments
- Describe possible ventilator associated complications
- Identify and troubleshoot various ventilator alarms

Session Description: Participants will receive a brief review and overview of the ventilator including where to obtain specific information, where to view settings, and how to adjust settings. Participants will then be presented with short, one-line patient scenarios and will be asked to interpret an alarming ventilator and change the ventilator settings appropriately. Participants will also be provided with ventilator tracings and asked to correlate these tracings with specific pathology.

Integration into Existing Curriculum

Simulation is a valuable, flexible, and increasingly utilized tool for medical education. It can be a valuable adjunct to bedside education; however, it should not be considered a substitution for education that can take place at the bedside. With that in mind, anyone designing a simulation session or integrating simulation into an existing curriculum must first examine the existing educational model and perform a needs assessment to determine where simulation can and should be incorporated. While simulation can be used to address a wide variety of educational needs, there are topics that are best suited to non-simulation modalities.

Initially, curriculum designers need to decide what topics will be best delivered using simulation and those topics that may be better suited to alternative educational strategies (e.g. lectures, discussions, self-directed learning, etc) [11]. While lectures serve as an efficient vehicle for knowledge transfer, simulation allows for application of knowledge and higher level thinking, as described in Bloom's taxonomy [15]. Additionally, it is important to have a solid understanding of the time commitment and resources available to carry out a simulation-based program. These factors will help to frame the overall type of curricular content that can be created. For example, if you don't have access to partial task trainers of sufficient quality and quantity, then it does not make sense to build simulation-based procedural sessions. Alternatively, if there is easy access to high-fidelity mannequins, partial task trainers, ultrasound equipment, and standardized patients, there will be more possibilities and flexibility for program design. Similarly, if a residency can only commit to a few hours of simulation a year as opposed to weekly sessions, the program and curriculum designs will be vastly different.

Another important consideration in designing a simulation session is the need for sufficient faculty involvement. Effective simulation sessions require significant planning and preparation, as well as dedicated and committed faculty. For procedural training, learners will need close supervision and coaching, ideally with small faculty to learner ratios. For scenario-based simulations, much of the learning is dependent on the quality of the debriefing and discussion. Often, faculty need to be encouraged to participate and provided with the tools necessary to succeed with a modality that is foreign to many.

As simulation becomes more prevalent, there are an ever-increasing number of resources to rely on and a wide range of models to review. There are programs that are very simulation dense and programs that only employ it occasionally. For programs looking to build simulation into their curriculum or enhance its presence, it is prudent to investigate how various institutions have utilized simulation. Ultimately, the details of any simulation program are determined, at least in part, by the educational needs, resources, and commitment of the sponsoring institution.

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17 Emergency Nursing Continuing Professional Development Using Simulation

Jared Kutzin, Krista Kipper, and Wendy Dahl

The first use of simulation in nursing can be traced back to 1910 when the principal of Hartford (CT) Hospital Training School of Nurses, Miss A. Lauder Sutherland, asked Mrs. Chase, a local doll maker, to make a mannequin that allowed trainees to practice basic nursing skills [1]. Sutherland had become dissatisfied with the straw-filled "dummies" they had been using and wanted a more realistic and durable "doll" that nursing students could use to learn bedside skills [1]. While nursing has been using a form of simulation for over 50 years, the current trend of healthcare simulation can be traced back to Stephen Abrahamson, PhD. In 1967, Abrahamson along with colleagues at the University of Southern California (USC) created the first computerized patient simulator, known as Sim One [2]. As computers became more powerful and physiological parameters could be programmed, patient simulators became more sophisticated [2]. While these first applications only tangentially relate to the needs of today's emergency nurse, the use of simulation in healthcare has a long history.

Simulation in emergency nursing is a natural fit given the knowledge and skills an emergency nurse must master. However, the first use of simulation specifically for emergency nurses is hard to ascertain. A literature review does not clearly identify the first use of simulation for the emergency nurse. This may be due in part to the interdisciplinary nature of the emergency department and the emergency nurses involvement with various simulations, ranging from basic skills training to disaster preparedness simulations, which are required by accrediting organizations such as The Joint Commission, State Health Departments, or other regulatory bodies. One of the first reports of simulation in emergency nursing comes from a poster presented at the 1999 Emergency Nurses Association (ENA) Scientific Assembly. That poster, presented by Patricia Morton, titled "Development and Implementation of a Patient Simulation Laboratory for Teaching Emergency Nursing" outlined four recommendations for using simulation laboratories to teach emergency nurses [3]. The poster included [3]:

1. Increase use of simulation as a teaching method for students
2. Formation of partnerships between clinical setting and schools of nursing for the purpose of sharing the resources of a simulation laboratory for learning
3. Increase use of simulation as a method to validate nursing competencies
4. Research to investigate the outcomes of simulation as a teaching method.

Today, the most common form of simulation an emergency nurse may participate in are the American Heart Association's (AHA) Basic Life Support (BLS), Advanced Cardiac Life Support (ACLS), and Pediatric Life Support (PALS) courses. The BLS course, which focuses on high quality Cardiopulmonary Resuscitation (CPR), was developed in the 1960's based on Dr. Peter Safar's research in resuscitation [4]. In 1958, Dr. Safar and Dr. Bjorn Lind approached the Laerdal company to build a tool for the practice of airway and resuscitation skills [5]. From this meeting, the Resusci-Anne mannequin was developed, a mannequin extremely familiar to emergency nurses because of the requirement for CPR training every 2 years.

Though likely the most commonly used simulator, the Resusci-Anne mannequin is just the beginning of simulation for nurses in the emergency department. Additional simula-

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tion modalities include part-task trainers (e.g. intravenous catheter placement arms, urinary catheter trainers), high-technology mannequin simulators, standardized patients, computer-based simulators, and virtual reality simulators. Each of these modalities can be used with emergency nurses to enhance their education and improve their competency.

Beyond the required AHA courses that utilize simulation, the Emergency Nurses Association's (ENA) Trauma Nursing Core Course (TNCC) and Emergency Nurse Pediatric Course (ENPC) also utilize various forms of simulation. Historically, the simulations in these programs took the form of a skills station that was more knowledge-based than hands on practical assessment. These stations typically utilize static (low-technology) mannequins where the learner is asked to verbally state the actions they would perform. While neither high-technology mannequins nor high-fidelity immersive environments are required in the TNCC or ENPC courses, their use is becoming more common. The integration of skills stations in the TNCC and ENPC coursess enhances the educational curriculums and because these courses are routinely completed by emergency nurses, exposure to simulation may be more common among this subset of nurses than nurses working in other care areas.

In recent years, an increased number of publications have detailed the use of simulation in emergency nursing. Much of the evidence for simulation in emergency nursing comes from the academic setting where faculty prepare undergraduate nursing students for emergency scenarios. Most common are respiratory or cardiac arrest scenarios in which students are expected to respond to and resuscitate a high-technology mannequin suffering from an acute medical emergency. This work has then been translated into curriculums for new graduate nurses preparing for careers in the emergency department and for other outpatient settings where emergencies may occur [6, 7]. Research has demonstrated the value of simulation from both the clinical educator perspective as well as the newly licensed nurse perspective [6]. Further research has demonstrated the value of standardized patients in improving the emergency nurses' ability to quickly and accurately determine the triage level using the Emergency Severity Index (ESI) [8]. Other studies have demonstrated the value of simulation training in the pediatric emergency setting, both in increasing the retention of knowledge as well as improving staff nurses' ability to recognize and intervene with deteriorating pediatric patients [9]. Additional studies have also demonstrated support for simulation in improving adherence to the Surviving Sepsis Guidelines [10].

The field of simulation continues to grow and the use of simulation in the education of emergency nurses cannot be overlooked. The future of simulation in the emergency setting is only limited by the availability of resources, dedicated staff and educator time, and the imagination of curriculum developers. The remainder of the chapter will describe examples of programs that have been implemented successfully with emergency nursing staff. These programs include:

1. Emergency Triage
2. Trauma Center Development
3. Emergency Preparedness
4. Cardiac Arrest Systems Testing
5. Rapid-cycle Deliberate Practice for Cardiac Arrest

Emergency Triage

Emergency nurses across the country are routinely tasked with quickly and accurately triaging patients who arrive through the doors of the emergency department. With over 120 million visits to U.S. emergency rooms each year and only 18% of them being seen within 15 minutes, the majority of patients are being left to wait in the waiting room of our nation's hospitals [11]. Due to the increasing number of patients waiting longer in waiting rooms, the accuracy of triage acuity level is critical. Over-categorization (over-triage) and under-categorization (under-triage) both pose threats to the patient and the healthcare system. Over-triaging uses scarce resources and potentially limits the availability of open beds for other patients with more severe injuries or illnesses [11]. Under-triaging leaves the patient at risk for prolonged wait times and the possibility of decompensating while waiting in the waiting room [11]. The purpose of triaging patients in the emergency department is to prioritize patients according to acuity in order to identify which patients need immediate intervention and which patients can wait to be seen. The Emergency Severity Index (ESI) is a 5-category system initially developed in 1999 with widespread dissemination and adoption occurring in the early part of the 2000's [12]. While classifying patients as level 5 (low priority) needing zero (0) resources and level 1 (requiring immediate life threatening interventions) is relatively easy, the challenge arises when trying to classify a patient as a level 2, 3, or 4. Typically level 4 patients can be seen in a non-acute section of the emergency department, while level 2 patients need to be seen within a few minutes of arrival. Level 3 patients are often patients who are deemed stable enough to wait a short amount of time, but need to be seen and have resources provided to them. Misclassification of a patient either higher or lower may lead to inefficient or untimely care.

ESI triage is best performed by an experienced emergency nurse who understands emergency medical conditions and the resources needed to treat them [11]. Triage is such a critical skill, many emergency departments prevent new nurses from working in triage for at least 6 months. However, training and orienting the emergency nurse to the triage role, including processes and algorithms, is vital to their success in the emergency department as well as to the health and safety of the patient's seeking care.

At HealthPartners, a large, urban, level one, trauma center located in the Midwest United States, the triage orientation process for novice nurses includes the completion of standardized online learning modules, clinical time under the guidance of a preceptor, and a four-hour simulation-based triage course. The objectives of the triage orientation program are to:

1. Demonstrate the triage of patients in no more than 5 minutes
2. Evaluate if the patient is "sick" or "not sick"
3. Correctly assign the proper Emergency Severity Index (ESI) level
4. Implement and Activate "codes" specifically used within the emergency department

The triage course begins with didactic content, which is presented in a slide format to provide background and specifics for assigning an Emergency Severity Index (ESI) level. The course then proceeds to an interactive "Jeopardy-style" game to review the content previously learned. Finally, the course culminates in a simulation experience.

The simulation scenarios were developed to incorporate a variety of ESI levels with attention to situations that border between two ESI levels. Classifying patients in ESI level 3, 4, and 5 correctly, requires the nurse to accurately determine the number of resources the patient will utilize [11].

To address the challenge of accurately determining the ESI level of patients, nine encounters were created based on realistic situations. The encounters are facilitated in a rapid sequence, each lasting 5 minutes or less, with a debrief following each simulation.

Planning and coordination are essential for the facilitation of each of these encounters. Providing a sense of reality is not only important to the "suspension of disbelief" but also to maintain the flow of the program. The simulation room is set up to represent the appearance of a typical ED triage space, with the emergency nurse waiting for patients to arrive. The electronic medical record training environment was utilized to replicate the triage documentation process. To facilitate the scenarios, the patients utilized in this program included live actors, mannequin simulators, and hybrid simulations (utilizing both mannequins and live actors together). It is ideal to have a cadre of standardized patients available to play the variety of patients entering the triage area. This allows the triage nurse to be immersed in the scenario and to avoid them interacting with the same person playing multiple roles in the various scenarios. However, due to possible staffing constraints, with planning, this program can be conducted with a minimum of two simulation staff members or standardized patients. Two individuals can rotate as the standardized patients or standardized participants for the hybrid simulations (those that include a mannequin and live actor as a family member). In the hybrid scenarios, the standardized participant who is not participating in an acting role is able to operate and be the voice of the mannequin. Wigs, changes of clothing, and additional moulage applied to the patient help set the scene in a realistic manner.

Examples of the nine patients used in this simulation are listed in Table 17.1 including the age, gender, condition, simulator type, and ESI level.

Table 17.1 Examples of the nine patients used in this simulation

Age	Gender	Condition	Simulator type	Vital signs	Meds	Allergies	Past medical history	Settings	ESI
30	F	Pre-Eclampsia	Standardized Patient (SP)	BP 160/110 P 84 RR 18 SpO2 98% Pain 8/10	None	None	None	Baggy dress Ankle swelling 2 + edema (moulage – ice pack under large socks) Unaware of pregnancy Last menstrual cycle 5 months ago	2
4	M	Asthma	Hybrid Pediatric mannequin with SP parent	BP 102/64 P 124 RR 72 SpO2 97% Pain 0/10	Albuterol	None	None	Decreased breath sounds bilaterally, wheezes bilaterally	2
3 week	F	Sepsis	Hybrid Newborn mannequin with SP parent	BP 70/48 P 184 RR 44 SpO2 98% Temp 100.5	None	None	None	Baby not crying Mom reports decreased feeding	1–2

(continued)

Table 17.1 (continued)

Age	Gender	Condition	Simulator type	Vital signs	Meds	Allergies	Past medical history	Settings	ESI
68	M/F	Neutropenic chemo	SP	BP 98/56 P 110 RR 18 SpO2 96% Pain 5/10	Chemo Med to increase blood count MVI Zofran	PCN	Cancer	Clinic instructed to come for nausea & vomiting	2
24	M	Finger laceration	SP	BP 122/74 P 88 RR 12 SpO2 98% Temp 98.6 Pain 4/10	None	Sulfa PCN Ibuprofen Morphine Toradol	Immunizations 6 years ago	Finger with laceration with blood wrapped in duct tape.	4
44	F	Differentiate anxiety versus cardiac	SP	BP 118/68 P 102 RR 24 SpO2 98% Temp 98.5 Pain 0/10	None	None	Hysterectomy	Hijab Complains of not wanting to leave house, anxiety, & palpitations Going through a divorce	3
56	M/F	Stroke	2-SP One as patient & one as the family member	BP 154/96 P 88 RR 16 SpO2 96% Pain 0/10	None	None	Cerebral palsy	Patient in wheelchair Garbled, slurred speech with word finding problems Last known normal 2 hours ago Right arm drift Family member brings patient & leaves to park car	2
45	F	Atypical myocardial infarction	SP	BP 174/102 P 100 RR 20 SpO2 96% Temp 98.5 Pain 2/10	Glyburide	None	Diabetes Obesity	Obese suit Complains of shortness of breath Stretch neck and rotate head Recent toothache	2
32	M	Fall from a roof	SP	BP 90/58 P 112 RR 24 SpO2 91% Temp 97.5 Pain 8/10	None	Sulfa	Appy 15 years ago	Patient: Neighbor brought in Abrasion to head with slight bleeding will have increased shortness of breath Holding Lt chest Forgetful	1

Evaluation data from the above program indicated that one-hundred percent (100%) of the participants thought the course was valuable and a worthwhile use of their time. Future, additional evaluation opportunities would include tracking:

1. the length of orientation for a novice nurse prior to course implementation and following
2. accuracy in ESI level assignment once in triage
3. time from triage to ESI level determination in the emergency department

Trauma Center Development

In 2012, the New York State (NYS) Department of Health (DOH) announced that trauma centers in New York would have to be verified by the American College of Surgeons (ACS) [13]. Previously, the state DOH would designate a hospital as a “regional” or “area” trauma center. This change required a rigorous review of policies and procedures at hospitals around the state. At a 500 bed tertiary care center in suburban New York, a new trauma center was constructed to augment the emergency department, in order to prepare the facility for the verification site visit, scheduled to take place in early 2016. In early 2015, as preparations for the new trauma center were being developed, the Simulation Center was utilized by an interprofessional team (nurses, emergency physicians, trauma surgeons, facilities management, hospital leadership, etc.), to mock-up and stage the layout of the trauma bays. By placing tape on the floor, moving stretchers around, and placing equipment into approximate locations, the design of the yet to be built trauma center could be confirmed or modified.

At this time, it was also recognized and decided, that the emergency nurses who would be staffing this new facility would not only need training in how to operate in the new environment but would also need to be "credentialed" to work in the new trauma unit. A series of trauma workshops were conducted in the Simulation Center while the trauma facility was being constructed. Over an 8-month time period, a designated group of approximately 40 emergency nurses completed online modules and in-person simulation training sessions. In conjunction with the emergency department nurse educators, emergency department nurse managers, and the trauma program coordinator, the staff nurses were scheduled every other month to either complete an online module or attend an in-person simulation session focused on the topics covered in the online module. Leadership buy-in was essential to facilitate having 40 emergency nurses participate in this training as the time necessary for them to be off the unit was a significant cost.

As the 8-months of training came to a close, the finishing touches of the trauma unit were being completed. Before being officially opened to patients, the staff responsible for treating patients in this new unit were brought together to discuss the operations. The team involved the staff nurses, trauma physician assistants, trauma surgeons, emergency physicians, nurse managers, radiology technicians, patient care technicians, and respiratory therapists. During this operations meeting, in-situ simulations were conducted to assess the new unit and identify any potential challenges which could be mitigated prior to accepting the first patient. By conducting an in-situ simulation focused on process improvement, a number of operational considerations were discussed and solutions determined, including:

1. Appropriate signage for EMS personnel entering the unit to indicate which button opened which set of doors, which prevented confusion among the care team and subsequent delays in care.
2. Location of the EMS and ED stretchers to best accommodate personnel and equipment, which improved the handoff between EMS and ED providers and kept staff safe during patient transfers (safe patient handling).
3. Privacy concerns related to glass doors without curtains, which improved the care environment for patients, families, and providers.
4. Equipment (monitors, IV attachments, etc) needed to move the patient throughout the department (CT scan) and hospital (admission or other testing), which prevented delays in care and improved the safety of the care provided.

By conducting in-situ simulations prior to the opening of a new unit, the system in which care is provided could be reviewed, analyzed, and improved.

Emergency Preparedness

While identifying opportunities for improvement prior to opening a new unit is important, so is identifying opportunities for improvement on an ongoing basis. Many emergency department personnel are involved with mass-casualty incident (MCI) type drills, since these are required by regulatory agencies. These large-scale simulated events are conducted to ensure that the systems that are in place to respond to a disaster (internal or external) are clearly documented, easily implemented, and sufficient to meet the needs of the organization and community. While these events often fall outside of the scope of simulation centers and are often the responsibility of the emergency preparedness personnel, experienced simulation programs can enhance the drills by supporting the emergency personnel in the planning, implementation, and evaluation of such exercises.

Historically, these large scale MCI events included volunteers who were hastily collected (often students or new employees), who gather in a location a few minutes before the event was set to take place, and are given limited instructions or guidance about the cases or how to act. Moulage, if used, is often quickly applied by individuals with limited to no experience in conducting simulations. In many events, patients are given large cards to wear around their necks so that providers can easily read and obtain the necessary information about the patient, limiting the actual interaction with the patient and reducing realism. This reduction in fidelity makes the exercise of limited value from a clinical diagnosis and management perspective and may not provide valuable information about the ability of the organization to respond to a disaster, since the employees involved may not be fully invested in the drill.

While the traditional disaster exercises are valuable to uncover communication issues (limited radio coverage, lack of WiFi access), process issues (locked doors, limited availability of extra beds), and transportation issues (movement of patients through the emergency department to the operating room) the lack of fidelity often reduces engagement by the clinical staff and misses a clinical training opportunity. Including the simulation center staff and equipment can increase the fidelity of the drill by introducing skills such as intravenous line placement, chest tube placement, and patient assessment with realistic responses (breath sound changes, pupil changes).

Simulation staff can ensure that a wide variety of well-trained standardized patients are available, can assist with writing appropriate scripts and scenarios for the standardized patients, moulage the standardized patients, and utilize high-technology or mid-technology mannequins when the patient condition requires. By incorporating simulation educators into the mass-casualty exercise the ability to assess clinical decision making and clinical operations is greatly expanded. Instead of just assessing the environment of care and non-clinical operations, evaluators can assess whether the staff appropriately manage critical patients, adding an important dimension to the exercise.

Cardiac Arrest Systems Testing

In addition to the large-scale mass casualty exercises described above, routine tests of the system also yield opportunities for improvement. In-situ simulations facilitated in the emergency department or other areas of the hospital that the emergency department staff may be required to respond to are immensely valuable. Examples include conducting emergency response scenarios in outpatient settings, such as on the hospital loading dock or outpatient testing areas. These drills result in identifying components of the response that could be improved, such as equipment needs (stretchers, backboard, c-collars, oxygen, defibrillator/monitor, AEDs, and medications), identifying cardiac arrest response personnel (which team members from the emergency department respond), and environmental improvements (wayfinding, signage, and access to restricted areas). Integrating simulation into the process improvement program of an institution provides the opportunity to not only discover but also correct deficiencies in a timely manner that could otherwise negatively impact a patient's care.

Rapid-Cycle Deliberate Practice for Cardiac Arrest

While emergency nurses are the focus for this chapter, all nurses working in hospital settings need to be familiar with how to manage a patient in cardiac arrest. This is especially true for the emergency nurse. Although the emergency nurse often has the advantage of time to prepare for the arrival of a patient in cardiac arrest, sudden cardiac arrest in the hospital and emergency department may occur.

Responding quickly to a patient in cardiac arrest requires immediate actions on the part of the nurse and a coordinated team response. It is well documented that completing a BLS or ACLS every 2 years does not provide adequate retention of cardiopulmonary resuscitation (CPR) skills. The American Heart Association (AHA) 2015 guidelines state that "given the rapidity with which BLS skills decay after training, coupled with the observed improvement in skill and confidence among students who train more frequently, it may be reasonable for BLS retraining to be completed more frequently by individuals who are likely to encounter cardiac arrest" [14]. While the optimal retraining time period cannot be determined, retraining nurses between bi-annual re-certifications is highly recommended. The AHA also states that, "the use of high-fidelity mannequins is encouraged for programs that have the infrastructure, trained personnel, and resources to maintain the program" and "training with a focus on leadership and teamwork principles should be incorporated in advanced life support courses" [14].

In an effort to meet these recommendations and adhere to educational principles, NYU Winthrop University Hospital implemented a resuscitation training program for nursing staff which utilized the principle of rapid cycle deliberate practice (RCDP) [15]. Rapid cycle deliberate practice is best utilized when teaching a set of skills/actions that must be taught and implemented in a specific order. It breaks the training into small chunks of information and forces learners to repeatedly perform the skills to perfection. This process of rapidly covering material and practicing it over and over allows learners to progress from novice to competent in a dramatically shorter time frame.

Because responding to a cardiac arrest in a hospital is different from responding to a cardiac arrest in the community, additional steps were added to the training session for the nursing staff. These additional steps include lying the patient's bed flat, placing a backboard under the patient's torso, putting the side-rails of the bed down, and moving the head of the bed away from the wall [16].

To begin, a patient simulator is sitting on a stretcher. Four to five nurses are introduced to the mannequin and the environment and are advised of the abilities of the mannequin and the objectives of the scenario. The scenario objectives include:

1. Adhering to the AHA BLS algorithm
2. Demonstrating high-quality CPR
3. Demonstrating appropriate teamwork and communication during a cardiac arrest

Following this brief introduction, all but one of the nurses leave the room and wait in the hallway, to act as the responding team. A single nurse begins in the room and assesses the patient who is unresponsive with a heart rhythm of ventricular fibrillation (VF) [16]. This nurse must follow the first few steps of the BLS algorithm, including checking for responsiveness, checking for breathing, checking for a pulse, calling for additional help, lowering the side-rails of the bed, and starting compressions. After approximately 20 seconds (or when the team arrives to assist) the scenario is stopped and the team is quickly debriefed (2 minutes or less) about the first few steps. Following the debrief, the room is reset, a new "primary" nurse is identified to begin the scenario, the remaining nurses leave the room, and the scenario is started again, from the beginning. During this second rotation, the primary nurse is expected to improve upon their colleagues performance from attempt one and then continue through the next few steps of the algorithm. The instructor then stops the scenario, debriefs the team about the second set of steps and then resets the room and continues with a new "primary" nurse. This cycle continues until all of the nurses have had a chance to be the "primary" nurse and all of the steps in the algorithm have been reviewed. This rapid cycling and deliberate practice has been shown to assist the learners in improving their skills and enhancing the retention of the process [16].

While this was done with BLS skills in this setting, the concept can be translated to any process that has a predetermined set of steps that need to be followed, such as the trauma assessment process.

Challenges and Solutions

There are many challenges when attempting to conduct simulation training for emergency nurses. First is ensuring that appropriate educational personnel are available and trained in simulation. It is vital that the educators involved with the program be knowledgeable in the topics being taught and skilled in debriefing and facilitating. In addition, it is important to involve current emergency department leaders and educators in the program so that current evidence-based practice (as well as facility specifics) can be discussed.

Second, when conducting simulations in a simulation center, getting protected time for staff is necessary. Often, staff time is not dedicated for simulation training and staff are instead "released from clinical responsibilities" for the predetermined time. If their time is not protected and dedicated to training, it can be challenging for the participants to be fully engaged as they are often preoccupied with their clinical responsibilities. Simulation is an expensive resource, dedicating staff time to education in the simulation center is essential when implementing a program.

A third challenge when conducting simulations with emergency nurses is the need for fidelity. Because emergency nurses are often experienced nurses working in stressful environments, with high acuity patients, they are especially sensitive to subtle cues. This necessitates the need for clear objectives and highly realistic simulation scenarios. The equipment utilized during the scenarios must replicate what the nurse will find in their clinical environment and the mannequin cues must be realistic for the learner to "suspend disbelief". When training novice nurses, placing a darkened area on the chest of a mannequin simulator to simulate a gunshot wound may be sufficient. However, with the experienced emergency nurse, the wound must look and feel realistic and must be able to be palpated. Emergency nurses may attempt to palpate or manually explore the wounds. Regardless of whether this is clinically appropriate or not, giving the nurse the opportunity to make this decision and then discuss the action and frame of reference for it during the debrief is critical.

In addition to having high quality moulage, simulation educators must think through their scenario in greater detail when training emergency nurses. Emergency nurses may look for associated injuries, including exit sites and want to know information about the type of weapon, caliber of ammunition, number of bullets fired, and distance fired from. This requires the mannequin operator or standardized participant to be knowledgeable regarding these facts and the moulage to be consistent. This all adds to the realism that the learners will experience, but also requires the simulation education to more fully develop their scenario and curriculum as compared to educational programs for more novice nurses.

Unique challenges exist when conducting in-situ simulations for emergency nurses. First, finding a "good" time to do in-situ simulations in an emergency department is challenging due to the unpredictable workload, staff shortages, and unexpected critically ill patients such as traumas or cardiac arrests. Because of this, in-situ simulations may be interrupted at any time by real patients seeking care. Second, conducting in-situ simulations in the emergency department may unnecessarily stress patients if precautions aren't taken. Stress may occur from seeing the simulated patient (mannequin) enter the emergency department on a stretcher or from hearing the care team respond and provide treatment to the simulated patient. Finally, it is important that debriefings occur in a private area, away from patients so that an open and honest review of the events can be conducted without having patients hear about both the successes and opportunities for improvement. Finding this space in close proximity to the in-situ setting, especially in the emergency department can be challenging.

Simulation adds an incredible amount of value for both the novice and experienced emergency nurse. There are many topics the emergency nurse can learn through simulation, from triage to trauma to interprofessional education. However, the value of simulation is not limited to the clinical knowledge and skills but can be broadened to process and system improvement as well. To facilitate the use of simulation in the emergency setting, healthcare leaders must recognize the value and dedicate the time, money, and resources to not only supplying the equipment and space, but dedicating the time for staff to attend the training opportunities.

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18 Simulation in Emergency Medical Services

Scott Goldberg, Vincent Storie, and Andrew Eyre

Background

The field of out-of-hospital medical care and emergency medical services (EMS) is uniquely challenging and continuously evolving. Providers must be competent not only in the medical care of a complicated patient population but must also be well versed in affective domains including teamwork and communication. Medical knowledge must be complemented by proficiency in technical skills and procedures, and all of this must be accomplished while practicing in a resource-poor, unpredictable, and often austere environment. Simulation has emerged in recent years as an ideal modality to facilitate EMS education in a variety of physical environments and cognitive domains and has been increasingly deployed in both initial and continuing educational curricula for EMS providers.

The field of EMS is relatively young within the broader medical landscape. While the practice of field medicine in the United States dates back to the Civil War, the modern coordinated EMS system we currently employ was not established until as recently as the 1960s. In 1966, the National Academy of Science released the seminal report *Accidental death and disability: the neglected disease of modern society* [1]. This document shaped our current system of emergency medical services in fundamental ways. Based on report's recommendations, the National Registry of Emergency Medical Technicians (NREMT) was founded in 1970 as a centralized, standardized certification agency for EMS providers. Currently, the NREMT is responsible for certifying EMS providers in 46 states, with all states recognizing NREMT certification as a means to obtaining state licensure [2].

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The practice of EMS medicine includes providers at a variety of levels of experience and training. The National Highway Traffic Safety Administration (NHTSA) defines three general categories of EMS providers: emergency medical technicians (EMTs), advanced EMTs, and paramedics [3]. Emergency first responders include police and fire personnel with additional training in basic medical care of the acutely ill or injured patient. Educational standards for each level of training are proscribed and training programs accredited by the Committee on Accreditation of Educational Programs for the Emergency Medical Services Professions (CoAEMSP). Once certified, providers must demonstrate continued proficiency through a continuing education process, meeting specified educational criteria in knowledge and skill performance.

Over the past several decades there has been a growing trend towards increased use of simulation in healthcare education and EMS is no exception. Simulation allows for a standardized training curriculum that can be tailored to meet the needs of varied EMS services and different levels of EMS provider training and proficiency. Importantly, simulation also affords opportunities for training in skills not commonly practiced by EMS providers in the field, such as endotracheal intubation of pediatric patients. Further, as has been repeatedly demonstrated in several healthcare arenas, simulation can decrease the rates of medical errors amongst EMS providers [4]. Most importantly, simulation allows providers the opportunity learn and practice without the risks associated with actual clinical care.

Simulation is particularly useful for practicing skills or managing situations which are uncommon in practice. Such rare events make it challenging for practicing providers to maintain competency and pose challenges for students looking to gain clinical experience. Simulation provides access to these otherwise limited skills and scenarios. This is perhaps most well documented for airway management, and simulation training has become a staple means for airway skill training in most paramedic training programs [5].

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Simulation has also emerged as a frequently used educational modality in EMS for training in the management of multiple casualty incidents (MCIs). EMS providers are often the first medical professionals to arrive at the scene of an MCI and must be competent in both triage and treatment of MCI patients. Fortunately MCIs are rare events, though this allows for limited real-world experience in the management of these unique and often complicated patient care environments. Regular simulated practice can improve performance in MCI scenarios and should be a regular part of a simulation curriculum. Options even exist for asynchronous learning and practice through MCI-based serious games [6].

As simulation continues to emerge as an integral component of EMS training, additional applications of simulation will continue to develop. Currently, most training programs use simulation primarily for formative evaluation, but simulation is being increasingly used for summative evaluations and high-stakes testing [7]. In fact, the NREMT is now using simulation as part of its national certification examination.

Web-based programs, virtual or augmented reality, and serious games are also becoming increasingly utilized modes of simulation. These modalities may be particularly useful in providing training in low-frequency events, such as multiple-casualty events [6]. These platforms allow self-paced learning and can be uniquely tailored to a specific educational objective. As the capabilities of this relatively new model improve, so too will its prevalence in ongoing EMS training.

Internet-based online learning platforms are also emerging as a means to engage EMS providers in continuing education. Most online learning platforms offer continuing education in traditional didactic format. However, a growing sector now offers interactive, case-based learning. This model offers many of the benefits of simulation training with the benefits of self-paced, distance learning and its associated cost savings. Unfortunately, this type of training is less effective for practicing the technical and procedural skills in which EMS providers must maintain competency.

Sample Curriculum

When developing a curriculum for simulation in initial EMS education, basic practices of sound curricular development apply. The material covered in lecture should, whenever possible, be reviewed and reinforced in simulation the following class session. The progression of simulation cases over time should allow for graduated student responsibility, and the difficulty of simulation cases should increase linearly over the course of a given module. It is important to note that not all content lends itself easily to simulation. Lecture, case reviews, small-group discussions, and critical reading of key texts remain integral components of paramedic education. Wherever possible, though, simulation should reference, build upon, or elaborate material covered using other modalities.

Given the inherent complexity and multidimensionality of real prehospital clinical encounters, most simulations and their associated learning objectives must be edited, restricted, and tailored to be both achievable and educationally meaningful at a given student's level of development. Students should not be expected to utilize skills or apply knowledge that they have not yet encountered in their education, and the incorporation of such into a simulation runs the risk of distracting and detracting from more immediately relevant learning. Having pre-defined, specific, measurable learning objectives for every simulation is an effective means of guarding against this type of derailment. Explicitly informing students of the learning objectives *prior to* the simulation, as appropriate, has also shown benefit in avoiding distractions.

The Sample Curriculum in Appendix 2b is an example of one particular educational module in a paramedic training program. Simulation sessions are designed to highlight and reinforce learning objectives introduced during didactic and small group sessions. Each simulation session builds on the previous material. A consequence of this graduated approach is that the same scenario may, at different times in the program, present very different educational opportunities. Course planning can leverage this by having students complete similar, or even repeat, scenarios at different points in time, modifying the complexity and difficulty of the simulation accordingly. Cases may be made more complex, for example, by incorporating more differential diagnoses, adding additional available treatment options, or by changing the patient's response to a given intervention.

Integrating Simulation into Existing EMS Education

High fidelity simulation programs can be expensive and high-quality curriculum design can be time consuming. While almost all EMS programs have access to at least some simulation equipment [7], use of this equipment is variable. Further, for the majority of programs, additional support specific to simulation education is limited [7], including access to program coordinators and simulation technologists, or dedicated faculty and administrative time for implementing simulation programs. As such, the integration of simulation into existing EMS education can prove challenging for many programs.

There are two main avenues by which simulation may be used for EMS provider education. Simulation may either be used as part of an initial training program for certification of EMS providers or it may be employed for the continuing education of practicing EMTs, paramedics, and other EMS professionals. While most EMS services have a continuing education program for active providers, these programs can be enhanced with the integration of a simulation curriculum.

When considering the use of simulation in an existing EMS education program, it is important to first identify which educational objectives will be most conducive to learning through simulation. Although simulation is an extremely valuable and flexible educational modality, not all content is best delivered through simulation. The choice of which topics should be taught using simulation will vary depending on whether the program is designed for initial certification or for continuing education. Anatomy, physiology, pathophysiology, the clinical manifestations of disease, and the general goals of and approach to therapy are best initially covered in lecture or case-discussion. The elements of patient assessment including history taking, physical exam, interpretation of findings, and formulation of a differential diagnosis, delivery of specific treatments, patient monitoring, and principles of systems-based care are better suited for coverage in simulation. Affective competencies, such as teamwork and leadership, professional and therapeutic communication, professionalism, and quality assurance and improvement, are likewise discussed and reinforced in nearly all simulations.

Currently, simulation is used primarily for formative evaluation and skill development [7]. However, simulation can also be used for summative, or high stakes, testing as well. Training programs might consider developing simulation cases for summative testing at the conclusion of various educational modules or might include successful performance in simulated care scenarios as a requirement prior to progressing on to clinical experiences. The use of summative testing with simulation in paramedic training programs will be even more important as the NREMT increasingly includes simulation as a component of national certification examinations.

As part of their initial training, paramedic students must spend a certain amount of time in clinical experiences, gaining hands-on patient care experiences. Additionally, established providers must likewise maintain proficiency with several uncommon yet high-risk skills and scenarios. Airway management, obstetrical deliveries, and management of pediatric patients are some examples. Unfortunately opportunities to practice these skills are increasingly challenging to obtain for a variety of reasons [8]. Simulation can be an asset in filling this void. High quality simulation is an adequate substitute for, and in some cases may even be superior to, clinical time for certain skills and scenarios [9, 10].

For established providers, simulation-based continuing education must balance the needs and priorities of the agency with those of the learner. Most states mandate a specific number of continuing education hours across a variety of topics. While these requirements can generally be met through traditional didactic sessions, establishing a simulation program produces superior outcomes as compared to traditional classroom hours [11, 12]. Most training programs already employ task trainers to teach technical skills to some degree. Building off an existing framework and curriculum, the use of simulation can be gradually expanded as program resources allow to incorporate high-fidelity simulation, more robust case-based training, and other more novel simulation modalities.

Prior to embarking on the development of a simulation program, an EMS agency must first perform a needs assessment to identify educational targets. This process will involve feedback from administrative and field leadership, quality officers, existing training personnel, and field providers. The current educational program should be examined and gaps identified. A nascent simulation program should target those educational objectives felt to be the most important, but should also focus on objectives with clear, achievable outcomes. In addition to this needs assessment, additional targets for simulation-based education will come from the EMS agency's quality improvement (QI) program. A robust QI program not only serves to identify and avoid potentially dangerous patient care scenarios but will also serve to identify training gaps amongst providers. As an example, a QI program might quantify the number of intubations performed by each provider, all septic patients cared for, or all EKGs interpreted. Providers not meeting an agreed-upon number of cases in these domains might be offered the opportunity for additional training, ideally through simulation.

Enhanced use of simulation comes with additional expense in equipment, staff, and time. For those without their own simulation equipment, there are several ways by which EMS agencies can leverage existing local or regional simulation resources to improve their educational agendas. One such option is to partner with local academic institutions including colleges, universities, nursing schools, medical schools, or paramedic schools. These educational institutions may have simulation resources including space, equipment, and expertise that can be used by an EMS agency looking to develop a simulation curriculum. Further, local hospitals, particularly those with residency programs, may be able to provide additional support and resources. Interprofessional training is an added bonus of such a partnership, such as practicing handoffs in trauma or medical emergencies.

Overall, integrating a simulation curriculum within an existing EMS educational program can be a challenging task. However, by leveraging existing resources and progressing slowly, a sound simulation program is achievable by any EMS organization. Once established, a simulation program is a valuable asset to any EMS educational program, either initial or continuing.

Challenges and Solutions

While simulation in EMS has many of the challenges faced by more traditional simulation programs, some challenges are unique to the practice of field medicine. EMS providers come from a variety of backgrounds, creating a diverse group of learners. The environments in which field providers practice is likewise highly varied and simulation curricula must incorporate this breadth of practice environment. Resources in EMS education are often limited, including faculty training and ancillary staff support. Yet all of these hurdles are surmountable, and well-executed simulation programs for the EMS professions provide learners with a unique and valuable experience not easily obtained by other means.

Simulation is defined as "a technique that creates a situation or environment to allow persons to experience a representation of a real event for the purpose of practice, learning, evaluation, testing, or to gain understanding of systems or human actions" [13]. The creation of a realistic environment can be a particular challenge for EMS simulation as compared to more traditional health professions. In hospital-based medicine, providers come from a variety of specialties, yet the environments in which medicine is practiced are fairly homogeneous and limited to a few well-described care areas, such as the OR, clinic space, or an office. The EMS provider, by contrast, will be exposed to extremely varied practice environments. Paramedics must be facile with providing care in a patient's home, on the side of an interstate, or in the back of a moving ambulance or helicopter. Almost every patient encounter will occur in a unique environment, which makes a single simulation "room" insufficient to provide a realistic learner experience.

Fidelity is defined as the level of realism associated with a particular simulation activity [13]. Fidelity spans a variety of domains including the physical, psychological, social, and cultural. While fidelity is an essential component of all simulation, the components for EMS may be different than those for traditional healthcare providers. In addition to the challenges in creating physical fidelity discussed above, the psychological fidelity of a scenario might likewise differ from that of a traditional healthcare provider. As an example, it can be challenging to create an atmosphere that recreates the stress of providing medical care for a victim of a gunshot wound in a potentially hostile environment or treating a pediatric patient in cardiac arrest in front of multiple hysterical family members. Some simulation programs go so far as to specifically address this psychologic fidelity through "stress inoculation," or the development of comfort by working in a progressively stressful environment.

EMS simulation programs should focus on the environment in which the target audience is likely to practice. This may involve building a simulated ambulance or helicopter in which scenarios can be run. Care environments such as model apartments should also be considered. Creating these environments does come with some upfront cost that might be challenging for some programs. However, existing simulation centers can turn a simulation suite into a "patient apartment" for little cost. For scenarios occurring within the confines of the ambulance, in situ simulation using an out-of-service ambulance is a cost-effective alternative to more permanent structures. Some programs have even elected to retrofit an ambulance as a "mobile simulation center," capable of providing education and training at locations across a geographic area.

EMS learners come from a variety of backgrounds and have variable experiences. For initial training, providers may have little to no background in the healthcare industry, may have been working for many years and are looking for a change, and may or may not have obtained a bachelor or associate degree. Established providers will also have varied backgrounds, from the new recruit with only several months on the job to the seasoned veteran with decades of experience. All will be undergoing the same continuing education program, working together in the simulation lab as they do in the field. Making the educational objectives salient to this varied cohort of learners is paramount. Clearly defined education objectives with measurable outcomes can help to level the playing field. Buy-in from both providers and staff is also essential, as changing existing educational paradigms will inevitably be challenged by some learners.

Simulation staff are generally of two varieties. Simulation technicians, tasked with the "nuts and bolts" of a simulation program, including set-up of the space and machines, running any high-fidelity simulators, performing routine maintenance, moulage, preparing documents, and other such tasks. Simulation educators are responsible for developing the educational content, moderating simulation sessions, and facilitating feedback. Unfortunately, most EMS-based simulation programs have little or no staff specifically dedicated to the support of simulation [7]. While not essential, having dedicated simulation technicians allows educators to focus on the task of engaging learners. Having dedicated educators, with decreased field work expectations, allows educators to spend an appropriate amount of time developing and delivering high quality educational content.

Of course, not all programs will be able to afford the cost of additional personnel dedicated to simulation. Before hiring additional staff, the program must weigh the benefits gained against the amount of time needed to run the simulation program. Larger EMS systems or paramedic training programs with a heavy reliance on simulation may find simulation technicians more cost effective than using EMS personnel for the performance of certain technical and maintenance tasks. However, smaller programs may not be able to justify the cost of hiring a full or part-time simulation technician. EMS simulation programs may also consider reallocating existing staff to simulation tasks. For example, supervisory staff or field training officers may be able to provide just-in-time training on new equipment or may provide brief educational interventions based on the outcomes of quality improvement efforts.

Educators often work long hours for variable compensation and this is particularly true in the field of EMS. Dedicated staff educators are limited in the EMS professions and the training these educators have on curriculum design, educational theory, and evaluation are highly variable and often limited. In fact, lack of faculty training is cited as one of the primary reasons simulation is not used by many EMS programs [7]. For a simulation program to succeed, faculty must have some training in both design and execution of simulation curricula as well as some background in educational theory. Simulation programs might consider providing faculty members with initial, as well as ongoing, education and training in the execution of high-quality simulation and debriefing. Depending on the size of the program, this may be done in house, or the program may consider partnering with local training programs, colleges, universities, or other established simulation centers who may provide this training.

When designing any EMS simulation program, it is important to consider any special patient populations that the providers may encounter. Pediatric patients account for only 13% of all paramedic calls [14], and as such comfort in managing these patients is poor amongst EMS providers [15]. Unfortunately, simulation experience in pediatrics in quite limited in the EMS professions. While almost all paramedic programs have access to adult patient simulators, less than half use infant simulators and less than one in five has access to a neonatal patient simulator [7]. Simulation curricula should be sure to include modules addressing pediatric patients in both initial and continuing education. This should include a combination of procedural skills including pediatric airway management, as well as pediatric-specific medical scenarios including neonatal resuscitation. Nontechnical skills, such as interacting with challenging parents, should likewise be included.

Interface with Regulatory Bodies

The Committee on Accreditation of Education Programs for the Emergency Medical Services (CoAEMSP), a field-specific committee of the Commission on Accreditation of Allied Health Education Programs (CAAHEP), is the largest accrediting body for paramedic education in the United States and has reviewed and accredited over 500 programs across 48 states as of 2017 [16]. Although licensure requirements for paramedics are determined at the state level, most states have adopted the standards of the National Registry of EMTs (NREMT) and utilize the NREMT examination process in paramedic licensing [17]. CoAEMSP-accredited programs have demonstrated higher pass rates on the NREMT credentialing examination [18–20], and the NREMT has required the successful matriculation from a CoAEMSP-accredited program as an eligibility requirement for National EMS Certification at the paramedic level since 2013 [21].

While there is no explicit CoAEMSP requirement for a simulation curriculum as part of a paramedic training program, the use of simulation can aid students in meeting several CoAEMSP requirements. Students in CoAEMSP accredited paramedic programs must achieve and report an established minimum set of procedures and skills [22]. Students may not encounter all skills that are uncommon in the prehospital environment, such as neonatal resuscitation, during their clinical or field internships; successful performance of these skills in a simulation setting can satisfy the requirement and allow students to demonstrate minimum standards of competency even if real-world clinical experience is limited [22].

Further, and perhaps more importantly, technical and non-technical skills may be practiced in a simulated patient encounter, incorporating performance into the overall sequence of patient care. Skills can be practiced in a safe learning environment without exposing patients to potential management errors. Like technical skill performance, CoAEMSP requires students to document a minimum number of patient encounters for a variety of specific presentations and disease processes (e.g. respiratory distress, psychiatric disorder). Simulated encounters can be used to satisfy these minimum requirements [22], which may be particularly useful in ensuring adequate exposure to seriously-ill pediatric patients, which constitute a fraction of overall real-world EMS encounters.

After completing a requisite training program, paramedics must obtain certification from state regulatory agencies in order to practice. This generally require a paramedic candidate to pass both a cognitive and a psychomotor examination. Most states have adopted the standards of the National Registry of Emergency Medical Technicians (NREMT) in setting these testing requirements [17]. The NREMT cognitive exam is a computer-based, adaptive multiple-choice exam. The NREMT psychomotor exam is a day-long in-person session that evaluates candidates in six areas: two oral scenarios, trauma patient assessment, dynamic and static cardiology, and an integrated out-of-hospital scenario [23]. The integrated out-of-hospital scenario was introduced to the NREMT practical exam in 2016 to more accurately and holistically evaluate a candidate's performance as the team leader in a patient encounter [17]. The format of the integrated out-of-hospital scenario is a simulated patient encounter with either a high-fidelity patient simulator or live patient in which the candidate is required to assess and manage the patient, including the performance of any necessary psychomotor/technical skills and delivery of a transfer of care report. Candidates are evaluated on leadership and scene management, patient assessment and management, interpersonal relations, and integration of available evidence into a field impression and transport decision [24].

Given its recent introduction, outcomes data for the integrated out-of-hospital scenario are sparse, although the most recent testing results published by the NREMT show no significant difference in pass rates for the psychomotor exam since the introduction of the integrate out-of-hospital scenario [25]. However, it is reasonable to expect paramedic curriculum rich in simulation experiences will improve student performance on the NREMT psychomotor exam. As the objective of the integrated out-of-hospital scenario is to evaluate a candidate beyond technical skill performance, deliberate practice would be insufficient to train students in the nontechnical leadership, interpersonal, and clinical decision-making skills needed to meet testing requirements. Simulation, on the other hand, is particularly well-suited to providing students with exposure to precisely these qualities and is therefore aligned with the objectives of the NREMT exam.

See Sample Cases in "Appendix 1, Chapter 18 Supplemental Case Scenarios"

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Part IV

Subspecialties of Emergency Medicine

Pediatric Emergency Medicine

19

Frank Overly, Marleny Franco, and Linda L. Brown

Background

Pediatric emergency medicine is a unique subspecialty within emergency medicine (EM) that has evolved over the past four decades. Early in their careers trainees will hear the refrain "Children are not little adults". This resonating principle emphasizes that there are many differences that must be considered when caring for ill and injured pediatric patients. These differences include anatomy, pathophysiology and psychosocial to name a few [1]. The evolution of pediatric emergency medicine has led to board certified subspecialists, pediatric emergency departments and educational curriculum designed to train residents, fellows and other medical providers on how to best manage these unique patients. Along with the development of these training programs has come the evolution of pediatric medical simulation. As with many pediatric related devices and systems, pediatric simulation trailed adult simulation. The first high fidelity infant mannequin was not introduced until 2005 almost 50 years after "Sim One", the first high fidelity adult simulator, was developed in Southern California. Since that time multiple pediatric mannequins have been developed, ranging in size from neonates to school age children. The strengths and limitations of these pediatric simulators are discussed later in this chapter.

The healthcare team charged with caring for pediatric patients is challenged with a wide scope of practice ranging from well appearing infants with concerned parents to critically ill or injured children with significant morbidity or mortality. Often these patients are undifferentiated, without a clear diagnosis, and may present with only a vague chief complaint or an abnormal physiologic state. The PEM team needs to be skilled in rapid assessment and stabilization which requires pediatric-specific medical knowledge and reasoning, effective communication and procedural skills that can include airway management and vascular access among others. The Pediatric Emergency Department (PED) is similar to other clinical settings where low frequency and high stakes events occur, including operating rooms and intensive care units. Medical simulation has become an accepted training modality for these types of clinical environments that require high quality, high reliability care [2, 3]. In addition, simulation-based medical education has been shown to be effective for acute care, resuscitation and other learning objectives including communication and team performance [4–6]. For these reasons, PEM has embraced simulation and leveraged it for a variety of learners across a spectrum of clinical settings. In this chapter, we will review how simulation can be used in PEM within training programs for residents, fellows, practicing PEM and EM physicians as well as for the interprofessional team as a whole. Training programs can include didactics, hands on opportunities for practice, and assessment tools looking at knowledge, core competencies and milestones. This chapter will also review various strengths and limitations of pediatric simulation equipment, and finally the additional drivers behind using simulation in PEM, including quality measures, improved patient outcomes and systems testing.

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Best Practices

Providers of pediatric care – pediatric emergency medicine physicians, emergency medicine physicians, residents, pediatric critical care physicians, pediatric advanced practice providers, pediatric nurses, and paramedics – are typically required to obtain and maintain multiple certifications to manage seriously ill or injured children. These include completion of the American Heart Association's (AHA) Pediatric Advanced Life Support (PALS) course. This course is comprised of a combination of online tutorials, video instruction, classroom didactics, skill stations, and simulated pediatric emergencies aimed at teaching and reinforcing concepts of pediatric resuscitation [7].

Since life-threatening situations requiring resuscitation in pediatric populations are rare, retention of knowledge and skills of pediatric resuscitation is of the utmost importance. In recent years, studies have shown that PALS knowledge and skills decay within 6 months, well before the two-year mandatory recertification [8, 9]. The need for knowledge and skills retention becomes more salient after taking into account recent changes in pediatric resident education that contribute to decreased exposure to emergent patient stabilization opportunities. These changes in trainees educational experience include work hour restrictions, increased presence of fellow or attending oversight in hospitals, and increased emphasis on primary care training by professional organizations. An unfortunate consequence of these changes has been the decrease in competency in key resuscitation skills among senior pediatric trainees [8].

In an effort to augment learning and retention of resuscitation skills, many institutions have begun to integrate high-fidelity simulation into PALS training which has led to increased realism of scenarios and improved cognitive performance among pediatric house staff compared to learners who received instruction using a standard low-fidelity mannequin [10, 11]. High-fidelity mannequins provide learners with physical exam cues, particularly the presence or absence of pulses, which convey a state of critical cardiovascular insufficiency and prompt learners to apply one or another PALS resuscitation algorithm. [10] Moreover, simulation creates the opportunity to teach and reinforce concepts and skills to an interprofessional group of learners, such as pediatric residents, respiratory therapists and nurses, while also improving the teamwork and communications skills necessary to undertake the complex task of a pediatric resuscitation. Among interprofessional learners, the integration of simulation into PALS has also been shown to be beneficial. Significant improvement in skill performance has been noted among experienced pediatric critical care nurses and respiratory therapists who underwent a PALS recertification course that was enhanced with high-fidelity simulation [12].

Simulation has also been successfully integrated into the Neonatal Resuscitation Program (NRP), which was established in 1987 by the American Academy of Pediatrics (AAP) and the AHA, and is regarded as the evidence-based standard for teaching neonatal resuscitation to providers who care for newborns [13]. Up until 2011, the NRP curriculum addressed knowledge and technical skills by relying on lectures, videos, and skill stations. However, in 2011 the 6th edition of the NRP embraced a simulation-based curriculum, replacing lectures with skill stations and simulated scenarios and moving the required written examination online to be completed *prior* to the course. In doing so, the AAP and AHA placed their focus on teaching the complex behavioral skills, not merely the content knowledge, necessary for resuscitation of the newborn [14].

Published studies on the impact of simulation on NRP or neonatal resuscitation in general show mixed results. Although some studies have found no difference in resuscitation performance among nurses [15], and no change in timing to critical events among pediatric residents [16], the majority of studies clearly show that simulation yields superior neonatal resuscitation skills. Sawyer at al (2011) found improvements in positive-pressure ventilation, time to acquisition of vascular access, time to administration of first IV medication, and overall NRP performance among pediatric and family medicine residents participating in deliberate practice using simulated scenarios [17]. Similarly, improvement in number of critical actions, overall resuscitation performance, and provider confidence were documented among EM residents who underwent simulation-based training compared to their counterparts who received only the standard EM curriculum which was lecture based [18]. Pediatricians and midwives practicing in maternity wards also showed improvement in technical skills, teamwork, and time to critical actions after a simulation-based course [19].

In addition to enhancing PALS and NRP, simulation can play an important role in the training and assessment of EM residents and PEM fellows. In recent years, the American Council for Graduate Medical Education (ACGME) developed "The Milestone Project" which lists "the knowledge, skills, attitudes, and other attributes for each of the ACGME competencies organized in a developmental framework." [20] The milestones serve as a framework for determining trainee performance within the ACGME's six Core Competencies: patient care, medical knowledge, practice based learning and improvement, systems based practice, professionalism, and interpersonal skills and communication [20]. While the ACGME makes recommendations on how training programs may evaluate each milestone, programs ultimately choose the assessment tool. Among the milestones for EM and PEM trainees, several lend themselves to be tested with simulation. PEM milestones that can be tested with simulation include:

> Emergency Stabilization: Prioritizes critical initial stabilization action and mobilizes hospital support services in the resuscitation of a critically-ill or injured patient and reassesses after stabilizing intervention.

> General Approach to Procedures: Performs the indicated procedure on all appropriate patients (including those who are uncooperative, at the extremes of age, or hemodynamically unstable, and those who have multiple co-morbidities, poorly defined anatomy, high risk for pain or procedural complications, or sedation requirements), takes steps to avoid potential complications, and recognizes the outcome and/or complications resulting from the procedure.

> Provide leadership skills that enhance team functioning, the learning environment, and/or the health care delivery system/environment with the ultimate intent of improving care of patients [21].

Testing of milestones can be accomplished on an institutional or multi-institutional level. For instance, in February 2014 Dr. David Salzman from the Northwestern University Feinberg School of Medicine led a simulation-based assessment collaboration in which second-year EM residents from six programs in Chicago, IL were tested on skills related to nine of the 23 ACGME milestones [22, 23]. Collaborations such as this one may become more common in the future.

In PEM, high-fidelity simulation can enhance training by providing opportunities for practice of the management of high-stakes medical scenarios which occur relatively infrequently even at high-volume, high-acuity urban teaching centers [24]. Thus, it is not surprising that 63 percent of PEM fellowships in the US and Canada have integrated high-fidelity simulation-based activities into their curricula [24]. Boot camps are additional educational opportunities that utilize simulation to complement PEM fellows' and nurses' training and will be discussed further in the next section.

PEM Simulation Curriculum and Training Programs

Within PEM it is a necessity to train a variety of learners, including pediatric residents, EM residents and PEM fellows. The educational objectives for trainees are outlined by medical organizations such as the ACGME, The American Board of Pediatrics, and The Royal College of Physicians and Surgeons of Canada. In an attempt to meet the educational needs of these trainees, multiple groups have developed curricula and several have published information related to development, content, implementation and outcomes related to their programs and experiences.

One of the first published curriculums was created by Adler et al. in 2009. This modular curriculum was developed to teach PEM topics to EM residents with a focus on the "ABCDE" mnemonic (Airway, Breathing, Circulation, Disability, and Exposure/Environment) [25] (See Table 19.1). The team used content maps and assessment domains to develop the six educational and three evaluation case scenarios and then carefully scripted them to standardize the intervention and allow for the measurement of outcomes. Data from the curriculum evaluation phase found a correlation with performance and post graduate year but did not detect a direct improvement in scores related to the educational intervention.

Stone et al. developed, implemented and evaluated a standardized simulation-based PEM curriculum for pediatric residents. This curriculum was designed in nine modules, using Kern's framework for medical education and a modified Delphi process with ten subject matter experts. They then mapped basic resuscitations skills into specific simulations within each module (See Table 19.1). The curriculum was implemented over a 9 month period with weekly 30 minute sessions. Following each simulation, the participants were debriefed and provided a summary of the module's learning objectives. [26, 27] The overall performance of teams was assessed pre and post intervention using the Simulation Team Assessment Tool (STAT) which assesses basic resuscitation, airway/breathing, circulation and teamwork [28]. Results showed a statistically significant improvement in each domain, except circulation [26].

A group of PEM physicians led by Drs. Cheng and Banks have worked towards establishing a national PEM fellowship simulation-based acute care curriculum in Canada. The original published curriculum was designed as a 2 year program, with weekly simulation sessions from a library of 43 different PEM based cases (See Table 19.1). The curriculum was divided into Year One with six core modules designed for first year fellows and Year Two with six subspecialty modules designed for second year fellows. As fellows rotate in the PED, they attend two of the sessions and a database records the scenarios they run in order to prevent repetition. Their curriculum also included advanced training for PEM fellows interested in developing skills as a simulation educator. This curriculum is an excellent example of incorporating Crew Resource Management(CRM) skills and Interprofessional education(IPE) and as an example of how to develop, revise and implement a standardized curriculum for a PEM fellowship program [29].

A follow-up study aimed to identify content for a simulation-based national curriculum for all Canadian PEM training. Starting with an initial list of 306 topics, the study group completed three rounds of the Delphi method using a four point Likert scale:

Table 19.1 Topics and scenarios for PEM based simulation curricula

EM residents	Topics
Adler et al	Airway and breathing
	Breathing
	Circulation
	Disability
	Exposure/Environement
	Scenarios
	Shock: septic, cardiogenic shock/coarctation or cardiomyopathy
	Tachycardia: SVT, TCA overdose with wide complex tachycardia
	Altered mental status: DKA, beta-blocker overdose
	Trauma: non-accidental trauma, mvc
Pediatic residents	**Topics**
Stone et al	Resuscitation basics
	Airway and breathing
	Circulation
	Teamwork
	Core topics
	Scenarios
	Asthma, anaphylaxis
	Seizure
	Septic shock, hypovolemic shock
	SVT, V-fib
	Abdominal trauma, closed head injury
PEM fellows	**Topics**
Cheng et al	Respiratory
	Cardiac
	Shock
	Blunt trauma
	Environmental emergencies
	Infant/neonatal
	Toxicology
	Endocrinologic
	Oncologic
	Nephrologic
	Neurologic
	Penetrating trauma
	Scenarios
	Asthma, asp pneumonia, upper airway obstruction, acute chest syndrome
	SVT, unstable V-tach, V-fib, PEA/asystole
	Septic, hypovolemic, anaphylactic, cardiogenic
	Abdominal, head, orthopedic, thoracic
	Drowning, hypothermia, electrical injury, smoke inhalation, carbon monoxide
	Nonaccidental trauma, bronchiolitis, congenital diaphragmatic hernia, congenital heart disease
	Sympathomimetic, anticholinergic, cholinergic, opioid toxidrome
	DKA, adrenal crisis, thyroid storm
	Mediastinal mass, hyperleukocytosis/stroke, tumor lysis syndrome
	Hypertensive emergency, acute renal failure/hyperkalemia, hyponatremia
	Status epilepticus, coma/depressed level of consciousness, combative/encephalopathy
	Thoracic, neck, spinal cord, abdominal

1 = Best taught using methods other than simulation.
2 = Can be taught using simulation.
3 = Should be taught using simulation.
4 = Definitely should be taught using simulation.

This process yielded 85 topics scoring between 2–3 and 87 topics scoring between 3–4. 48 topics received a final score of 3.5 or greater and these where defined as “Key Curriculum Topics”. These “Key Curriculum Topics” were grouped into four separate categories: (1) crisis resource management, (2) resuscitation, (3) trauma, and (4) medical procedures. This research provides a very comprehensive list of potential content for all PEM fellowship simulation-based curriculum [30].

“Boot camps” are another modular form of education where trainees attend an intensive educational experience, often at the beginning of a training program, to assist in developing a foundation of knowledge and skills for specific subspecialties [31–33]. In general, boot camps can be an effective way to pool simulation resources for a region and not duplicate training efforts between multiple institutions. Dr. Kevin Ching and others have developed a PEM specific boot camp titled BASE camp which provides a 2 day simulation-based learning opportunity for first year PEM fellows, pediatrics nurses and child life specialists. BASE camp has incorporated procedural training with task trainers and cadavers in addition to high-fidelity simulation to create a progressive learning experience covering topics ranging from teamwork, to airway management, to trauma care. This PEM boot camp has also incorporated interprofessional education (IPE) by including a nursing curriculum in addition to the physician track. Other boot camps have also been developed for continuing medical education for EM faculty.

Just-in-Time (JIT) training is a specialized form of education aimed at focusing the training just prior to actual patient care. An example of this was developed and described by a PEM group who evaluated JIT training around the procedure of infant lumbar punctures [34]. Although the study demonstrated improved confidence, it uncovered challenges that arise when incorporating educational strategies into a busy work environment. In addition to lumbar puncture, airway management skills and CPR are examples of other procedures that have been taught using JIT training formats and could be implemented in the PEM setting [35, 36].

In a study by Hunt et al., pediatric residents who participated in a high-fidelity simulation utilizing Rapid Cycle Deliberate Practice (RCDP) showed sustained improvements in multiple measures of performance for advanced life support skills [37]. RCDP is a simulation strategy that gives learners deliberate practice opportunities to improve their resuscitation skills [37]. When an error is observed in a simulation, the scenario is interrupted so that instructors can provide expert directed feedback. Learners are then given as many opportunities as necessary to retry the skill or behavior until mastery is achieved. According to Ericsson, after an initial phase of learning is followed by period of gaining experience, fewer mistakes are committed, and the learner is able to perform at a higher level [38].

Incorporated into many of the curricula mentioned previously are specific procedures performed in the PED setting. Procedural training, on either human patient simulators or specifically designed task trainers, can serve two main purposes. It is a helpful process to allow novice learners to practice certain invasive procedures in a controlled learning environment, promoting patient safety and addressing the ethical issues related to novices practicing procedures on real patients. Procedural training can also be used to allow clinicians the opportunity for training through deliberate practice to maintain or hone certain skills that are not performed routinely. The following is a list of the more common procedures performed in the PED setting which can be simulated:

- Access: intravenous insertion, central venous access, intraosseous insertion
- Airway: bag mask ventilation, nasopharyngeal airway, oropharyngeal airway, direct laryngoscopy, video assisted laryngoscopy, endotracheal intubation, laryngeal mask airway insertion, Bougie, transtracheal jet ventilation, surgical airway
- Resuscitation: chest compressions, cardioversion, defibrillation, pacing
- Trauma: splinting, suturing, needle decompression of tension pneumothorax, chest thoracostomy tube placement, pericardiocentesis, FAST ultrasound, disaster triage
- Diagnostic/therapeutic: lumbar puncture, urinary catheterization, nasal packing for epistaxis

The final and overarching area in PEM where simulation can have a clear impact is communication and professionalism. Traditional medical education has focused a majority of resources on the pathophysiology and anatomy of medicine, but over the past several decades, studies have shown that effective teamwork and communication can reduce medical errors and improve the care provided in the ED setting [5, 39]. Simulation has embraced this, and a critical aspect of many simulations includes the importance of CRM principles in high functioning teams. The rising implementation of IPE, where professionals from different backgrounds train together, into PEM simulation curriculum is reflective of this increasing focus as well. In-situ simulation is an excellent example of a type of simulation where nurses, physicians and respiratory therapists can participate in an IPE session and reflect on team performance after providing care to a simulated pediatric patient in the PED setting.

The PED can present clinical situations which create difficult discussions ranging from informing a family their child has died to disclosing to a family that a medical error has occurred. Simulation has been used to allow residents and PEM fellows an opportunity to practice difficult discussions and review effective strategies in managing these challenging situations. Other topics with difficult discussions that have been described in simulation literature are non-accidental trauma, domestic violence and new diagnoses [40, 41].

Pediatric Simulators and Challenges

As with all of simulation, the technology and availability of pediatric simulators and task trainers continues to evolve and improve. Although there are no simulators available to represent every size and age of pediatric patient, there are high and low fidelity simulators representing a variety of pediatric categories, including newborn/neonatal, infant and school age. Some of these simulators are advanced, wireless, tetherless, with simulated movements (seizures), chest wall rise, central and peripheral pulses. The mannequins and task trainers attempt to demonstrate how pediatric airways are more anterior, which can be a challenge in real life and a valuable skill to practice in the simulated environment. Certain mannequins and task trainers are designed to allow intraosseous placement and IV insertion which are also critical skills for providers and staff to develop and maintain.

Although the current mannequins have many pediatric features, they also struggle to simulate certain physical exam findings, such as skin color, respiratory distress and mental status. In PEM, these findings can be particularly important and are often a major driving force behind critical clinical decisions. For example, PEM physicians cannot rely solely on vital signs as an indicator of clinical deterioration in pediatric patients with sepsis, as changes in vital signs, e.g., hypotension, are often late and ominous findings [10]. As previously discussed, computer-driven high-fidelity simulators are able to convey many aspects of the physical exam including chest rise, lung sounds, vocalizations, pupillary response, pulses, heart sounds, cyanosis, among others. Advanced mannequins can even produce bodily secretions from the eyes, ears, nose, and mouth. However, current pediatric mannequins are not always able to effectively convey physical exam cues that are important in the evaluation of pediatric patients, such as overall clinical appearance (toxic versus non-toxic), skin findings (pallor, mottling, rashes, diaphoresis, capillary refill, temperature), mental status alteration (the smiling and babbling older infant versus the non-interactive ill older infant), signs of respiratory distress (head-bobbing, retractions, see-saw breathing), and subtle or focal seizure activity.

Certain pediatric simulators are also lacking in the ability to perform realistic chest compressions and ventilations due to the mechanics and electronics stored within the chest cavity and limited space due to the smaller simulator. As technology continues to improve, the manufacturers may be able to address these limitations in future pediatric simulators.

Solutions

While waiting for technology to evolve solutions that attempt to address the aforementioned challenges are being utilized, including the use of printed photos and videos. Photos, which can be produced upon examination of the skin by the learner, can be beneficial in providing visual aids for skin appearance such as mottling, rashes, or pallor. Video of a similarly-aged child in respiratory distress can compensate for the limitations of the mannequin in this arena, helping the learners to suspend disbelief and improving the fidelity of the scenario. In addition to multimedia adjuncts, simulation educators often utilize a "standardized participant," a person assigned to play a specific role – such as the bedside nurse or technician – who is tasked with not only performing the duties associated with that role (e.g., administration of medications, etc.) but has the more important task of helping to guide the scenario [42]. As this person is familiar with the goals of the specific simulation exercise, the standardized participant can convey to the learners, upon request, the portions of the physical exam that are not evident on the mannequin. Additionally, the standardized participant ensures that the learners are not confused by the mannequin's limitations. For instance, in a scenario whose goal is the management of severe asthma, a standardized participant may clarify the breath sounds if the learner states that he/she hears stridor when it should be wheezing. A helpful way to make sure this happens is to instruct the learner to speak out loud the physical exam findings they hear and see on the mannequin. This way, the standardized participant can be sure to correct them if they are not hearing the mannequin correctly.

Another useful tool used by simulation educators in PEM is the standardized patient (SP) or a well trained standardized participant, who can play the role of a family member. Because of the lack of or limited verbal capacity of many pediatric patients, PEM physicians must become competent in eliciting a focused history of presenting illness from family members. The integration of SPs into simulated scenarios creates the opportunity for learners to practice history-taking, provides another person to help supplement cues for parts of the physical exam not well conveyed by current mannequins, can infuse the sense of urgency usually found in a worried parent's voice and demeanor, and enhances the realism of the scenario.

Systems Testing

Simulation can be an invaluable tool to assess the systems and processes of care for children at a given institution or within a new emergency department. *In situ* simulation takes place in the actual clinical environment, allowing the healthcare team to practice caring for "patients" in their own space, with their own equipment and resources. It has been shown to deliver high levels of realism and participant satisfaction [2, 43]. This unique simulation modality is being increasingly used to assess the preparedness of hospitals to care for patients and has been shown to efficiently and effectively assess the systems and processes of care in a variety of institutions [44–46]. In 2006, Hunt, et al. used *in situ* simulation to evaluate the care of a pediatric trauma patient presenting to a spectrum of emergency departments in North Carolina. Interprofessional teams were assessed as they managed a simulated 3-year-old patient after a fall. Not only were the investigators able to gather information on certain aspects of the quality of care delivered but also on several system level issues, including the lack of appropriate sized equipment (cervical collars) and inadequate preparation for safe transport to CT scan [47]. Similar methods have been used to assess the systems and processes of care and evaluate for latent safety threats in both established and new clinical environments [44, 46, 48]. Across all EDs, but especially in institutions with lower pediatric volumes where pediatric specific systems are rarely tested, this could be an invaluable tool for quality improvement.

It is important to acknowledge, however, that there are unique challenges associated with *in situ* simulation. These include the need to provide actual clinical space and equipment. In areas where the space for clinical care may be limited, this will require significant planning on contingencies for what to do when an actual patient arrives. It is very important that these discussions occur prior to the day of the simulation and involve physician and nursing leadership. Topics should include: *Will we use our own equipment and medications?* This will require thought as to the availability of replacement equipment, how to access medications if a computerized system is used and the costs associated with replacement. *If not, how can we be sure that the "simulation equipment and medications" are not used on actual patients?* This will require special labeling and storage of the "simulation medication and equipment", as well as clear checks of the clinical space at the completion of the simulation to confirm that no "contamination" takes place. *Will the "on call" medical team be participating in the simulation? If so, what will happen if a patient arrives for care?* Back-up providers or a plan to halt the simulation based on pre-set criteria are possible solutions. *If other staff will be utilized, how will they be paid?* These are just a few of the unique logistical challenges associated with in-situ simulation related to incorporating training sessions into the working schedule of a busy clinical setting. Acknowledging these potential challenges and not allowing training sessions to affect patient care is important for staff buy-in and long term success [45].

Sample Case (see "Appendix 1, Chap. 19 Supplemental Case Scenario")

Future Directions

Pediatric emergency medicine has been very successful in utilizing simulation for a variety of objectives as described in this chapter, but there are certainly opportunities for expansion in the future. The pediatric specific features of mannequs will hopefully improve in the coming years, resulting in increased fidelity and the potential for more realistic scenarios. Educational programs and learners could benefit from more standardized simulation curricula teaching PEM specific milestones and procedures. Additional simulation-based research can assist with improving the care provided to ill and injured children. As PEM simulation matures, it may reach a point where it could be used for measuring and determining the competency of critical skills ranging from airway management to trauma resuscitation. There could be a time in the future where simulation may even be part of the interview day for PEM fellow applicants or the certification process for PEM physicians. The field of PEM simulation has come a long way in a short time and promises great things in the future.

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Trauma

20

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The field of medical simulation can trace its existence back to military origins- particularly the technology of computerized flight simulators [1]. The first patient-like mannequins for airway and resuscitation skills practice were introduced in the 1950's [2], with the first "high-fidelity" patient simulators that resemble those used in today's modern simulation labs first utilized in the 1980's [3]. One of the major influences behind today's modern medical simulation technologies has been the US military. During the Gulf War in the early 1990's, Army medical personnel (largely from the civilian reservist pool) were perceived by the commanding medical officer, Dr. Richard Satava, as not having the necessary skills and experience to care for traumatic injuries seen during battle [4]. Due to these concerns, greater emphasis was placed on developing simulation technology and programs to train and prepare Army medical personnel similarly to other highly skilled military personnel, such as fighter pilots. An emphasis on high fidelity simulation as a medical educational tool for these personnel soon followed. See Chap. 24 on Combat Medicine to read even more about the use of simulation in the military. Today's computerized, life-like simulators offer the opportunity to re-create realistic trauma patient experiences, and practice procedural skills required of practitioners caring for the injured patient.

As trauma patients are acutely and often critically injured, appropriate procedural skills acquisition as well as experience managing these patients is difficult to obtain for most learners. As medical education continues to trend further away from the "apprenticeship model of training", new teaching modalities must be found. Further, as patient safety initiatives continue to define what learners in the medical education environment can or cannot do, first-hand experience and "practice" in a trauma center becomes increasingly limited [5]. This fact demonstrates one of the most important attributes of simulation. The simulated trauma patient encounter with or without specific procedure task-training allows for both non-diagnostic and diagnostic cognitive errors to occur in an environment that promotes learning and maintains patient safety [6].

A medical student or intern can practice the complex management of a critical and unstable trauma patient, be allowed to make mistakes without dire consequences, and ultimately learn from those experiences. This training sequence thus reflects the change from the long-held mantra in medical education of "see one, do one, teach one" to a "see one, simulate one, do one" mentality.

Best Practices

As an educational training tool for traumatic injuries, simulation offers a number of important attributes. Any practitioner with experience caring for the critically injured, whether at a busy metropolitan trauma center or in the rural/community setting can attest medical knowledge alone is not sufficient for effective, quality care. Task management, decision-making, effective communication, and teamwork are but a few of the non-technical aspects of trauma care better known as crisis resource management (CRM). The use of simulation to teach CRM is well-documented [7]. An example of this concept in training is not only exemplified in a team resuscitation but also can be represented by multi-patient disaster drills. Participants must delegate leaders and responsibilities, communicate in a clear manner, and

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correctly utilize available resources. Multiple scenarios can be utilized and the exercise continued until participants display competence in any number of core measures. Mistakes can be identified and performance practiced until a higher level of mastery is obtained. Attempting to provide the same feedback during a "live" scenario is very difficult to accomplish real-time. This training relies on the preface that non-technical skills practiced in the simulation environment translate into the clinical setting. This concept has been supported in the findings of a systematic review that concluded, "CRM skills learned at the simulation center are transferred to clinical settings, and the acquired CRM skills may translate to improved patient outcomes, including a decrease in mortality" [8]. To read more about this, see Chap. 5 on CRM.

Trauma simulation can also be effectively utilized for teaching important interdisciplinary communication skills [9]. Frequently, trauma resuscitation involves multiple team members from different subspecialties and/or levels of training. In these regards, trauma can be viewed as a "team sport." Much like a successful football team requires many hours of practice for the coaching staff to communicate the play call to players on the field, all members of the trauma team must likewise have role clarity with clear and concise interactions. Physicians and providers from different specialties (Emergency Medicine, Surgery, etc.), nursing staff and technicians often do not have the same knowledge base or level of experience [10]. However, it is imperative that all healthcare personnel involved have a shared mental model for success and are focused on the same task, and findings from the primary and secondary surveys are clearly communicated to the team leader to allow for optimal situational awareness. The simulation environment can be effectively used to learn and sharpen these important skills that promote situational monitoring and closed loop communications. For the team leader, organization is essential. Roles for all team members must be specifically delegated, expectations of those roles clearly defined, and vital information conveyed to the team. In a high-fidelity simulation this can be practiced and, equally importantly, assessed [11]. Examples of objective communication skills requiring practice include: team leader's role delegation, accurate and timely relay of physical exam findings, and the effective use of closed-loop and directed communication.

Critical trauma resuscitation procedural skills can likewise be taught and practiced effectively in the simulated environment. Traumatic airway management, cricothyrotomy, chest tube insertion, hemorrhage control and emergent vascular access are but examples of critical procedural skills easily practiced and assessed through simulation [12–14]. Cadaver specimens, full simulation mannequins, task trainers, animal models, computer software programs, and online interactive trainers are some of the possible modalities utilized, with numerous commercial products available for each. Through the concept of deliberate practice, participants can repetitively practice these crucial skills in a deliberate practice type of model, receive performance feedback, and are able to demonstrate improved performance in the simulated environment [15]. Because of the continued simulated repetition of emergent medical procedures, proficiency can be documented and often times, mastery is obtained.

Sample Curriculum

The following section offers an initial guide for a potential trauma-based simulation curriculum. This could be used for medical students, residents, or other multi-disciplinary learners with minor changes made to the level of detail. For medical students, this sample trauma curriculum can serve as an introduction to the types of traumatic injuries a practitioner may encounter. For resident education, more stringently defined objectives and critical actions can be employed. The addition of these objective measures adds the ability for rigorous and meaningful feedback for the participants.

I. Head Trauma/Traumatic Brain Injury (TBI)
   (a) Types of TBI
   (b) Management Principles/Objectives/Critical Actions
      1. Airway management
      2. Maintenance of cerebral perfusion pressure
      3. Expedited imaging
         Imaging Interpretation
      4. Prompt neurosurgical intervention when appropriate

II. Spinal Cord Injury (SCI)
   (a) Types of SCI
   (b) Management Principles/Objectives/Critical Actions
      1. Spinal immobilization
      2. Spinal precautions while securing airway and during secondary exam
      3. Appropriate and thorough motor/sensory exam
      4. Appropriate and expedited imaging
      5. Neurosurgical/Spine consultation

III. Chest Trauma
   (a) Types of chest trauma
      1. Tension pneumothorax
      2. Open pneumothorax
      3. Flail Chest
      4. Massive hemothorax
      5. Cardiac tamponade
      6. Aortic/Great vessel injuries
   (b) Management Principles/Objectives/Critical Actions
      1. Recognition of traumatic chest injury during primary survey
      2. Prompt intervention (i.e. needle decompression, chest tube, etc.)

3. Recognition of shock/proper use of blood products
4. Expedited disposition (i.e. safe for imaging vs. Emergent transport to the operating room)
5. Role of ED thoracotomy

IV. Abdominal Trauma
(a) Types of abdominal trauma
1. Blunt vs. Penetrating
2. Hollow organ vs. solid organ injury
(b) Management Principles/Objectives/Critical Actions
1. Adherence to ABC's
2. Thorough physical examination
3. Proper use, technique, and interpretation of the ultrasound FAST examination
4. Recognition of shock and proper use of blood products
5. Appropriate and expedited imaging
6. Expedited disposition (safe for d/c, OR, transfer, etc.)

V. Musculoskeletal Injuries
(a) Types of injuries
1. Closed fractures
2. Open fractures
3. Joint dislocations
4. Compartment syndrome
(b) Management Principles/Objectives/Critical Actions
1. Adherence to ABC's
2. Thorough physical exam
3. Appropriate and thorough motor/sensory exam
4. Immobilization of affected extremity
5. Prompt reduction of joint dislocation
6. Antibiotics for open fracture
7. Prompt and appropriate consultation with orthopedic surgeon

VI. Burns
(a) Types of Burns
1. Thermal
2. Electrical
3. Chemical
(b) Management Principles/Objectives/Critical Actions
1. Prompt ABC evaluation, emphasis on early airway management
2. Vascular access
3. Appropriate fluid resuscitation
4. Recognition of partial thickness vs. full thickness burns
5. Calculation and documentation of percent body surface area involved
6. Emergent fasciotomy/escharotomy when appropriate
7. Proper communication with and transfer to a burn center

Integrating into Existing Education

As stated previously, trauma simulation can be used as an educational modality for the complete spectrum of learners. For a medical student clerkship, it will likely be the first, and possibly only, "hands-on" trauma training they encounter. Scenarios can be run to reinforce learning objectives from didactic lectures, or the lecture itself may be presented utilizing video recorded simulated cases to teach a core trauma curriculum. Beginner level material, such as how to properly log-roll a patient, trauma-specific primary and secondary survey, cervical spine immobilization during intubation, bag-valve-mask ventilation, and vascular access are but a few of the skills that can be taught to medical students. Likewise, behavior can be modeled for appropriate close loop communications in a high energy, high intensity simulated resuscitative encounter. Anything from formal cases with specified goals and objectives to procedure based skills labs are likely to be well received by medical students [16]. Simulation can be used for individual assessment and feedback, or groups of students can work together during the simulation scenario and be evaluated as a team. Medical students may prefer the group approach as it relieves some of the stress associated with individual assessment for the less experienced novice. This thought may be particularly true when dealing with less seasoned learners who may be rapidly overwhelmed by complex critical care and trauma scenarios. A review article published in 2017 by Borggreve et al., "Simulation-based trauma education for medical students: A review of literature" summarized the relevant publications on this topic [17].

The utility of simulation for residency training is well documented [18]. When transitioning from medical school to post-graduate training, a physician in training is quickly thrust into an environment where they are now the decision maker rather than the observer. This progression in responsibility can be particularly challenging in the high-intensity/high acuity environment of trauma care. One helpful practice during this transition is to use simulated trauma cases prior to the start of a rotation that is heavily focused on the initial care and stabilization of trauma patients. A "first exposure/introduction to trauma" session affords some desensitization to the high stress events through the simulated cases while providing deliberate practice of ATLS management through repetitive performance of these scripted skills. This exercise can assist learners in gaining the necessary confidence to then increase their comfort in delegating tasks and integrating into a team. Likewise, necessary procedural skills such as managing the trauma airway, chest tube insertion, and FAST exam can be learned and honed in the controlled simulation environment.

Trauma simulation certainly has a role outside traditional medical education. Continuing medical education (CME), has begun to adopt simulation into various curricula, with documented benefits [19]. Participants not regularly exposed to the acute presentation of the poly-trauma patient gain exposure to low volume/high risk scenarios such as traumatic brain injury or penetrating trauma. Uncommon, yet essential, procedures such as lateral canthotomy, control of arterial bleeding, and emergent escharotomy can be recreated with task trainers and incorporated into the training until competence is displayed or personal levels of comfort are met. In regards to physician licensing and credentialing, simulation is playing an increasingly important role which is expected expand across most specialties [20]. One area of potential further growth for trauma simulation would be incorporation into credentialing courses such as ATLS®.

Challenges and Solutions

The challenges inherent to creating a high-fidelity trauma simulation are not dissimilar to the other specialties in medicine. The ability to re-create the high-intensity environment experienced in the clinical setting is the obvious goal. One may argue that few medical settings equal the adrenaline-inducing chaos of the critically ill poly-trauma patient. The obvious challenge, therefore, is to mimic the sights, sounds, distractions and interactions in the most realistic manner possible. The U.S. Navy has begun training corpsmen with scenarios carefully designed to depict combat and/or real-life operational situations, commonly referred to as an immersive learning environment [21]. Using live actors as patients and visual/auditory special effects (explosions, gunfire, sirens, etc.), student participants are subjected to battlefield-like conditions during pre-deployment training. The goal is to acclimate the corpsmen to the unique rigors of field/operational situations, as well as to gauge their ability to respond to this unique and hostile environment. This immersive learning environment can be likewise utilized for high-fidelity trauma simulation. Realistic wound moulage on live, trained actors, multiple victim scenarios, loud auditory distractions, and difficult interdisciplinary interactions are some of the available means to make the simulation more "real" for the participants. If possible, in-situ simulation scenarios in the trauma Center or actual ED bed where acute trauma patients are received and treated can add to the level of realism, with improved clinical outcomes [22–24]. Amiel et al., specifically, showed that by augmenting simulation center based learning with in-situ trauma bay scenarios, the participant's performance measures including procedural skills and communication processes showed improvement. The authors specifically commented that "bringing the simulator to the trauma bay reduces obstacles such as differences in equipment and the partially simulated environment. In addition, the hospital's support systems such as radiology, laboratory, blood bank and other services are on call, ready to assist the team during training sessions."

Interface with Regulatory Bodies

No matter the level of training or experience obtained, every physician or medical practitioner faces credentialing exams and ongoing CME activities to maintain certification. A strong trauma simulation curriculum can aid in these endeavors. For example, a bank of mock oral board cases can be used as preparation for the ABEM national oral board test. Procedural task trainers may be utilized for documentation of procedural proficiency. Full scenario, multi-disciplinary simulation may be helpful in preparation for a trauma center certification site survey.

Similarly, trauma simulation can be used in EM residency programs to augment the educational curriculum and aid in documenting how the milestones are taught and assessed. Any of the six core competencies can be easily assessed using simulation. Additionally, many of the 23 new EM-specific milestones are readily and reliably assessed in a simulated environment. Because of this ability to control the environment and provide repetition, simulation may actually be easier to accomplish and document learner competencies during simulation sessions than actual patient encounters. However, it must be clearly understood; though high-fidelity simulated trauma scenarios may come close to mirroring a real life situation, and the educational benefits of simulation have been well documented, simulation can not replace real-time, live trauma resuscitations and trauma rotation experiences. Rather, to be used in the most effective manner, trauma simulation should supplement and reinforce rigorous clinical training and experience.

Sample Cases (see "Appendix 1, Chapter 20 Supplemental Case Scenarios")

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EM Critical Care

21

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Critical care, a specialty defined by its severity of illness and little room for error, provides an ideal backdrop for simulation training. Many of the critical disease states seen in resuscitation centers and intensive care units (ICU) may be relatively uncommon in actual practice. Simulation can provide repeated exposure to these complex conditions in a safe training environment, with the ultimate goal of improving provider decision-making and confidence in the actual work place environment.

Critical care based simulation training can take place in the traditional simulation center setting, or in the "in-situ" setting, in which the training is carried out in the actual department. Established simulation centers often have the advantage of high fidelity equipment, the capability to run multiple simultaneous scenarios, and the flexibility to adapt the surroundings to the needs of the scenario (battle field, pre-hospital, emergency department, ICU, etc.). This may be more difficult with in-situ simulation, which can be constrained by the space of the department in which it occurs. The availability of a bed as well as personnel to participate in the simulation experience may be superseded by the needs of ongoing patient care in the area. However, the obvious advantage in-situ simulation holds over simulation center based instruction is that the training can be held in the actual clinical setting with team members and equipment participants use daily.

Critical care scenarios also benefit from the ability to simultaneously focus on multiple aspects of critical care medicine or isolate key components of management of the critically ill patient to enhance both individual and team performance. Multiple studies have found simulation to be an effective teaching strategy for learning early recognition of shock, basic resuscitation, and procedural skills [1–6]. In addition, groups have used simulation training in the critical care setting to uncover and improve patient safety and systems issues within their units and departments [7, 8].

Best Practices

A wide array of research has been undertaken to determine the effectiveness of simulation training, an essential core of this research has focused specifically on critical care. While there is no consensus on a specific system or curriculum, what has been demonstrated is that repeated simulation training improves participant knowledge and skills when compared with non-simulation groups [1–6].

In addition to learning and practicing the treatment of specific diseases, simulation has also become an effective means for learning and maintaining procedural critical care skills. Current high-fidelity simulation systems allow for intubation, cricothyroidotomy, thoracostomy, intraosseous and vascular access, and cardiac pacing to be performed just as they would in the actual clinical environment. Critical care simulation can also monitor device placement and mimic clinical improvement or a decompensating patient accordingly. As with other forms of simulation training, learning can be further enhanced with the incorporation of a hybrid simulation. One example of hybrid simulation is illustrated when live actors serve as interactive patients that then transition the patient role to a high fidelity mannequin once procedural intervention is required and/or physiologic deterioration occurs requiring active resuscitation. Task trainers can further be utilized with hybrid simulations to allow for brief suspension of the active interaction with the actor to perform a specific procedure and then return the attention of the learners to the live actor or high-fidelity mannequin. In addition, hybrid simulation may utilize moulage and simulation trainers that attach to the actor to create a higher degree of fidelity (e.g. a severely injured and actively bleeding limb attachment used to model a devastating bomb blast injury in a live actor). When compared to didactic or low fidelity train-

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ing alone, current available data provides support for these practices [9, 10]. These techniques highlight the advantage of simulation training by allowing the performance of care within a high-risk, error prone management in complex scenarios without the risk to an actual patient. As a result, educators in fast paced high acuity environments frequently find simulation training an ideal means for mastering new or rarely performed procedures coupled with the ability to reproduce communication challenges encountered in these patient encounters [1–6]. In addition, there is compelling evidence that patient outcomes are improved due to lower procedural infection and complication rates after simulation training [11, 12].

An area of simulation that is gaining ground in critical care is in-situ simulation, in which the training takes place within the actual ICU setting and utilizes members of the ICU team [1, 7, 8, 13, 14]. The aim of this style of simulation is to mimic the critical care environment and to allow the ICU team to practice cases together as interdisciplinary teams in both a familiar and educationally convenient environment. Many groups have utilized this method to orient students and residents to the ICU, and it is also being used to help uncover operational deficiencies within departments [7, 8].

Sample Curriculum

Medical Student Curriculum

1. Recognition of shock
   (a) Hypovolemic (hemorrhage)
   (b) Cardiogenic (STEMI)
   (c) Distributive (Septic)
   (d) Obstructive (PE, tamponade)
2. Basic Resuscitation
   (a) Advanced Cardiac Life Support
   (b) Pediatric Advanced Life Support
   (c) Advanced Trauma Life Support
3. Basic Critical Care Procedures
   (a) Sterile technique
   (b) Central line placement (Femoral, subclavian, IJ)
   (c) Thoracostomy tube placement
4. Basic Critical Care Ultrasound
   (a) Central line placement
   (b) RUSH exam

Resident Curriculum

1. Management of shock
   (a) Recognition
   (b) Fluid resuscitation
   (c) Pressors
   (d) Cardiac pacing
   (e) Thrombolysis
2. Advanced Critical Care Procedures
   (a) Difficult airway
   (b) Hemodynamic monitoring
3. Advanced Critical Care Ultrasound
   (a) IVC for IV fluid response
   (b) Echocardiogram
4. "Breaking bad news"

Multi-disciplinary Curriculum

1. Patient safety training
   (a) Informed consent
   (b) Wrong patient chart
   (c) Disruptive family
2. Resuscitation team skills
   (a) Close loop communication
   (b) Team member feedback
   (c) Leadership
3. Quality assurance
   (a) Recreating case with known errors to detect systems issues
   (b) Bundled process for placement of central lines

Integrating into Existing Education

Critical care simulation should not be limited only to experienced providers as it can play an important role in medical education from the very beginning. In 2010, a survey by the Association of American Medical Colleges found that, at that time, 90 out of 133 medical schools were utilizing either live or simulated patients [15]. These experiences are often focused on developing basic history and physical exam skills. As students prepare for their various rotations, it may be useful to provide more complex and specialized training in critical care that often crosses multiple specialty boundaries. Specifically, with training in the early recognition of shock, respiratory distress and other life-threatening conditions, students are more prepared with a higher degree of clinical awareness that can improve patient safety and care on the different wards. In addition, confidence gained with exposure to procedural skills that are often only encountered on a critical care rotation provides an additional foundation toward mastery of those core skills. By focusing on these basic components of critical care, students can be more prepared to perform an active role in the team. In addition, by participating in these simulations, students can gain insight into the often stressful and emotionally taxing environment of critical care; thus setting expectations and learning coping techniques prior to the actual clinical experience. By desensitizing students, to some degree, to the higher stress, they potentially can then focus more on the clinical information being provided than the intensity of the moment.

With the transition from medical school to residency, a training physician is expected to continue to improve his or her understanding of specific disease processes and to continue to gain confidence in the clinical setting. This evolution includes the progression as a functional member of the resuscitation and critical care team into the role of the team leader. In this new role, the resident is expected to absorb a large amount of clinical information, determine the acuity and severity of illness, maintain situational monitoring and awareness, allocate resources, and delegate tasks. This is often a challenge for a young resident as it signifies an exponential growth in responsibility from the passive or less-active learner to a responsible decision-maker and caregiver. Simulation is ideally suited to offer a safe and controlled environment to nurture and monitor this growth. Cases designed to test leadership skills and fast-paced critical thinking can be used longitudinally in a residency curriculum to acquire competency and ultimately mastery of these skills, while providing the training program a standardized means for evaluating both the clinical knowledge and these often difficult to measure behaviors.

Another important role for simulation in medical education is in the training of multi-disciplinary teams. In the hospital setting, the success of resuscitation, code, and ICU teams relies on effective interactions between physicians, nurses, technicians, and other ancillary staff. By simulating scenarios encountered in the ICU management of patients, teams can not only practice together to build confidence and cohesion, but they can also uncover factors within the team or the system which may hinder efficiency and effectiveness. As teams prepare and work together, they learn each other's tendencies as well as begin to appreciate non-verbal cues that enhance their ability to communicate more efficiently.

Patient safety training can also be implemented as part of these team-based exercises. ICU-based scenarios that include multiple patient safety concerns (e.g. informed consent for an intubated patient, wrong medication administration with adverse outcome, breach of sterile technique, error disclosure) can include performance of critical actions that incorporate all team members. In the hospital setting, multi-disciplinary teams often respond to cardiac arrests and critical cases, bringing together members from multiple departments who may have limited regular interactions with each other. Simulation training can help these teams to establish and practice basic resuscitation protocols in a controlled learning environment. It can also help establish roles for each member to follow and establish team member performance expectations. Finally, simulation can be used to bring together multi-disciplinary learners and instructors to re-enact and actually debrief difficult patient encounters. When an error or near miss has been identified, events can be reconstructed within the safety of a simulation exercise. Clinical teams can discuss and document the system challenges that preceded the event. They can then work together to implement system-based plans for improvement to provide further system resources, education and administrative support to impact change that avoids future similar events. These team debriefings also provide an opportunity for both team members and leadership to demonstrate understanding and, when necessary, emotional comfort to the team members most impacted by the inciting occurrence.

Challenges and Solutions

A challenge often faced in simulation is recreating an accurate, realistic clinical environment. This desired fidelity might be especially difficult in critical care where, by its own nature of the acuity and severity of disease, a heightened stress response is produced in most providers. To help mimic this, some institutions have performed unannounced in-situ simulation training [13]. In addition, the use of high fidelity simulation systems has helped to provide a more accurate representation of the patient encounter. By allowing participants to not only intervene with the medical decision-making in the training event but also perform critical procedures (intubation, CPR, vascular access, cardiac pacing, etc.) on life-like mannequins that can mimic rapid physiologic and even anatomic changes, learners experience a more realistic encounter. Some units have set aside training rooms within the confines of the actual clinical unit to allow teams to take advantage of down-times or scheduled educational sessions to perform this multidisciplinary training. If dedicated additional space is not an option, simulators can easily be placed in open patient beds or gurneys within conference rooms.

One of the greatest challenges faced in simulation training is providing the time for training; this is clearly a barrier for multidisciplinary critical care training as well. Although educational time may be thought to be more available in the medical school and residency environment, it is generally already accounted for by the required curriculums. Therefore, educators frequently combine experiential simulation-based learning with didactic components to maximize available time and not displace other essentials for core learning. Time challenges after graduate and post-graduate training are often equal or even greater barriers to team and individual training. To ensure that all team members are trained, they frequently must participate on days off and therefore require additional reimbursement for their time. As previously noted, ICU in-situ training is a possible solution as it allows for simulation to take place during a shift and in the unit. Training exercises just prior to "shift change" are frequently utilized to incorporate the maximum number of personnel. Likewise, when the logistical barriers of competing patient care needs and space can be addressed, some institutions have been successful with focused learning with smaller teams for brief "just in time" learning exercises prior to them returning to their duties. As an added benefit, this training allows easier access to all staff, since it can take place over multiple days and during all shifts.

Interface with Regulatory Bodies

Aside from providing education and skills practice, simulation in critical care can also help hospitals, units, and individual staff members meet their regulatory needs. As previously mentioned, simulation can be a means for debriefing after a difficult case or a case in which a medical error occurred. Similarly, simulation can be used as an adjunct for root cause analysis investigations. In a rapidly moving and intense critical care environment, this can serve as formal quality assurance and quality improvement activities, in which members from the team discuss any important aspects of the case, any team or system factors which may have affected outcome, and plans for future improvements. By recreating a case and studying it step by step, it may be easier to tease out these details than if a team simply reconstructed the event with a table top exercise that avoids other critical factors such as ongoing phone call interruptions, patient care demand distractions and normal communication challenges in an often loud and busy environment.

For residencies in particular, there are requirements for weekly conference time. Simulation can help by providing high-quality, hands-on education on specific disease states, in which participants can actually witness classic presentations and observe the effects specific treatments have. In addition, residents are also required to perform and record specific numbers of procedures during their time in residency. By participating in simulation, residents can perform procedures which may be rare in the real clinical setting, repeating them multiple times to improve mastery, and experiencing the effects of mistakes without the potential for harm to actual patients.

Critical Care Simulation Cases (see "Appendix 1, Chap. 21 Supplemental Case Scenarios")

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Ultrasound

22

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Background

Over the past three decades, Clinical Ultrasound (CUS) systems have become increasingly compact, technologically advanced, and affordable. Now, over 21 medical specialties utilize CUS to improve daily patient care [1]. CUS is performed and interpreted by the practicing clinician at the bedside to help answer a focused clinical question, continually assess a patient's condition, and provide real-time direct visual guidance for traditionally blind landmark-based procedures. This differs significantly in purpose and scope from consultative and the more comprehensive ultrasound examinations commonly performed by specialties such as radiology, cardiology, and obstetrics.

The American College of Emergency Physicians (ACEP) first published a position statement on the performance of ultrasound by appropriately trained physicians in 1990. Four years later, Mateer and colleagues published the first emergency ultrasound curriculum [2]. In 1999, the American Medical Association House of Delegates released a landmark resolution, declaring that ultrasound may be used by any specialty, and furthermore deemed that each specialty would determine how to train and credential their clinicians [3]. In 2001 the Agency for Healthcare Research and Quality (AHRQ) endorsed clinician performed ultrasound-guided central venous access as a best practice to improve the patient safety [4]. Also in 2001, ACEP released the Model of Clinical Practice in Emergency Medicine (EM), declaring CUS to be "a skill integral to the practice of emergency medicine". This resulted in the Accreditation Council for Graduate Medical Education (ACGME) mandating that all EM residents attain CUS competency upon completion of residency training [5, 6]. Since then, multiple organizations have provided guidelines regarding scope of practice and suggested training for CUS in emergency medicine, across specialties, and in medical education [7–13].

Competency in CUS requires the development of adequate knowledge and skills within four inter-related learning objectives.

1. Recognition of the clinical indications and contraindications for a continually increasing number of CUS applications.
2. Acquiring adequate CUS images. This begins with an understanding of the basic ultrasound physics needed for machine operation, followed by the development of the required psychomotor skills across CUS applications and patient populations.
3. Recognize normal and abnormal findings. Normal findings vary by patient. Abnormal findings may represent artifact, normal variants, or pathology. Although many life-threatening CUS diagnoses are fortunately relatively uncommon, trainees must be able to recognize even subtle early pathologic findings. For example, early recognition of the blood accumulating in the pericardial sac after penetrating cardiac trauma must prompt operative intervention prior to cardiac arrest.
4. Integration of CUS practice and findings into an individual patient's management, overall ED operations, as well as any potential disaster response. This begins with an understanding of test characteristics and clinical utility of CUS findings for each application. Furthermore, clinicians performing CUS need to be able to properly record, store, and document images within the medical record systems to ensure optimal patient care and proper reimbursement. Compliance with documentation and billing requirements are essential to maintaining a CUS program.

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As a portable diagnostic imaging and procedural solution, CUS plays a vital role in the initial triage of disaster victims, as well as more long-term relief efforts.

Providing adequate training to achieve acceptable CUS remains a significant challenge for medical schools, residencies, continuing medical education programs, as well as military and disaster relief programs. The American College of Emergency Physicians (ACEP) CUS guidelines currently serve as a benchmark for training programs just beginning to utilize CUS [9]. These guidelines recommend participation in a 2 day didactic and hands-on course, the performance of 150–250 overall exams with 25–50 exams in each specific CUS application, and ongoing quality assurance of CUS exams [9]. Such traditional training requires significant economic expense with respect to faculty time, CUS systems, and the recruitment of both healthy and pathologic models. Fortunately, the rapid advancement in CUS technology has been paralleled by the development of likewise affordable and portable ultrasound simulators. Simulation now provides a viable educational tool for training and assessing competency in CUS.

Ultrasound simulators exist in two general forms: ultrasound simulation machines, which mimic real life ultrasound using computer technology, and phantoms or other models, which mimic ultrasound examinations, but require the use of a real ultrasound machine. Ultrasound simulator machines began as expensive, bulky, and low fidelity training solutions. Today, ultrasound simulators are considerably less costly, and more compact, while providing an increasing number of capabilities. For example, laptop simulators provide platforms for online or narrated didactics. Ultrasound simulators may now be as simple as connecting a simulator mock US probe into the USB port of the trainee's computer. Educational software can be accessed online and scanning performed on a model patient, mannequin, or any other surface. Gyrometer-equipped simulator probes change the US simulator screen depending upon subtle changes in trainee probe positioning and can even compare trainee hand movements to those of an expert in order to shorten the learning curve. Ultrasound loops from actual patients or realistic computer-generated images can provide exposure to an abundant number of artifacts, common and rare variants, and pathologic patient images. Simulator libraries provide opportunities for deliberate practice with a high number of pathologic cases not encountered in typical patient-only scanning [6]. Likewise, simulator assessment tools measure trainee progress towards and maintenance of competency across the four inter-related CUS learning objectives. Ultrasound phantoms are different training models designed to mimic real life findings or procedures. These may vary from simple homemade models using gelatin and food coloring to more complex, factory-designed models. These models are most commonly used when practicing ultrasound-guided procedures, such as vascular access and nerve blocks.

Best Practices

Due to the rapid development of CUS and ultrasound simulation technology, best practices have yet to be established. However, numerous studies have demonstrated that ultrasound simulators are an effective CUS learning modality [14–20]. For example, multiple studies have demonstrated that ultrasound simulation trainers can improve central venous access skills [14, 15]. Additionally, Girzadas and colleagues demonstrated that the addition of an endovaginal ultrasound simulator enhanced resident educational experience, as well as the faculty's ability to evaluate resident's ultrasound skills [16].

Within undergraduate medical education today, CUS plays an increasingly important role in providing the vital clinical context for learning fundamental pre-clinical concepts. Ultrasound is increasingly used as an adjunct to traditional didactic learning in anatomy, pathophysiology, and physical exam courses. Recent work demonstrate that medical students enjoy utilizing this new technology, and that incorporation of ultrasound increases medical students understanding of pre-clinical concepts [21]. The ready availability of ultrasound simulator machines provides additional opportunities for independent learning and skill development. Ultrasound simulator procedure task trainers foster the early development of psychomotor skills, provide an opportunity for deliberate practice of less common tasks, and can serve as an assessment tool to document ongoing procedural competency [22, 23].

Sample Curriculum

Curricula specifically detailing the use of simulation in CUS training have yet to be published. However, multiple organizations have suggested the utilization of simulation as both a learning modality and assessment tool [9, 24]. For example, ACEP suggests the incorporation of simulation into the training via simulator machines, ultrasound phantoms, and even patients (e.g. ascites could mimic a positive FAST exam) [9]. Many of today's simulators incorporate mixed method knowledge learning that includes narrated screencasts, multiple choice questions, and skills instruction. Likewise, simulators often provide baseline assessments of pre-curriculum knowledge and skills, as well as ongoing progress, and lastly a final assessment of post curriculum competency across the four inter-related CUS learning objectives [23].

Integrating into Existing Education

Many academic centers today have already implemented vertical curriculum in ultrasound spanning all 4 years of undergraduate, then continuing in the post graduate years of medical training.

Two studies have incorporated ultrasound into physical examination courses for first year medical students, demonstrating improved outcomes in both ultrasound and non-ultrasound skills. [25, 26] Another study demonstrated that incorporation of ultrasonography into a cardiac anatomy and physiology course for second year medical students was well-received and improved their cardiology knowledge [27].

The incorporation of simulation in ultrasound training reduces the number of instructors, ultrasound systems, and models needed for traditional training courses and CUS rotations. Trainees typically learn CUS knowledge through local expert-provided didactics and high-quality websites. While expert hands-on instruction remains an essential component of CUS training, simulation adds a worthwhile, complimentary, multi-modal approach. Deliberate practice with an ultrasound simulator may shorten the individual trainee's time to develop competency in image acquisition and improve their ability to recognize more infrequent pathology. As an example, the utilization of simulation can interlace normal and abnormal cases with increased frequency than would be feasible with scanning only live, healthy patients, allowing providers to gain more experience and become more facile with identifying pathology [24]. For example, the European Federation of Societies for Ultrasound in Medicine and Biology recommend that 10–20% of all ultrasound images be positive for pathology when undergoing training [24]. By increasing the potential for positive findings via simulators, instructors are able to give direct feedback when false negative findings are noted by trainees [24].

Additionally, ultrasound can be incorporated into current simulation training modules focusing on core concepts in Emergency Medicine. The utilization of CUS systems, images or simulators may improve the fidelity of the simulation learning experience, while encouraging the use of ultrasound in real-time clinical scenarios.

With the increasing sophistication and portability of ultrasound simulators, training can be performed almost anywhere. While larger, more complex echocardiography simulators are typically stored in an institution's simulation lab, smaller laptop-based simulators may be utilized "outside the classroom" by the individual student, or stored within the actual clinical environment for on-demand education.

Challenges and Solutions

One of the largest challenges to implementing either a simulation or CUS training program remains the initial monetary cost of equipment. Although ultrasound simulators have dropped dramatically in cost, a significant capital investment is still required to purchase both the simulator hardware, as well as software for different CUS applications. Additionally, older ultrasound simulators require routine maintenance to ensure optimal operation. A potential solution is for several groups of educators from different departments to purchase ultrasound task trainers and simulators together. There is a great deal of overlap in CUS applications across medical specialties. Joint purchasing reduces the individual department cost substantially. The ultrasound simulators may then be stored in a central simulation lab or shared between multiple training programs with allotted ownership times. This may also allow for one department to borrow the machine and perform in situ education or simulation sessions without requiring its own simulation center.

Additionally, incorporating simulation into CUS training requires significant faculty expertise and time. Faculty time is needed for the initial development of the program, as well as with each new trainee who begins the program. However, this initial monetary and faculty time investment in the long term has the potential to improve both trainee learning and patient care. Furthermore, long term direct faculty oversight and trainee clinical practice may be reduced. Portable simulation technology provides the opportunity for trainees to practice independently with real-time feedback. Ongoing deliberate practice with simulators may reduce the time needed for trainees to practice and maintain skills in the clinical environment.

Interface with Regulatory Bodies

With the increasing importance of CUS within multiple medical specialties, several regulatory agencies have begun to incorporate ultrasound into training recommendation. In 2012, the Accreditation Council for Graduate Medical Education (ACGME) and American Board of Emergency Medicine (ABEM) designated CUS as one of the 23 core milestone competencies for Emergency Medicine residency graduates [13]. Simulation may be utilized to complete a portion of training exams required while providing exposure to less commonly encountered clinical findings [9]. The reliability and reproducibility of simulation based CUS assessments provides the opportunity to rapidly measure and document initial and ongoing CUS competency [28].

In community institutions, simulation may assist with training and hospital credentialing for physicians who completed a residency program before CUS became an integral part of the core curriculum. At smaller institutions, needed CUS experts may simply not be available. Simulators then may provide an additional on demand learning and assessment modality. Ultrasound simulator procedural task trainers provide an opportunity for clinicians trained only in the traditional landmark based approach to quickly learn to perform a safer ultrasound guided approach to invasive procedures.

[See “Appendix 1, Chap. 22 Supplemental Case Scenario”]

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Disaster Medicine

23

Lisa Jacobson

In few places is simulation more relevant to training than in disaster preparedness. Because disasters are low frequency and high stakes events, they are the events for which providers are, almost by definition, most unprepared. Even with advanced warning technologies, disasters typically occur with little warning. However, the impact of these infrequent events is significant and as a result, disaster medicine has historically been a field focused on simulation in one form or another.

As described earlier in this text, simulation, can take many different forms. As early as the 1950s, there are published reviews of using scenarios augmented with movies to improve disaster training [1]. Simulation in this setting can come in all forms – tornado drills in elementary schools, formal immersive high fidelity training for students, chaotic scripted scenes testing paramedic skills, or even virtual reality gaming. All of these types of simulation are still employed in this field and will be described in the upcoming text.

How We Currently Employ Simulation in Disaster Medicine

One of the earliest variations of simulation used in disaster planning is the tabletop drill. Once a hospital system or a community develops a disaster plan, the next step is often to sit around the table with the representative players and to verbally walk through what would happen in the event of certain anticipated disasters, ex: large storms, chemical leaks or pandemics. This allows for the identification of pieces of a plan that may or may not function as perceived, or may not be clearly elucidated in a disaster plan. These often occur in boardrooms full of administrators, but have evolved. In advance of the 2010 FIFA World Cup, an atypical "tabletop" drill was performed to identify in what ways South Africa was already prepared and where there was need for improvement. This drill took place both over a long distance and a protracted period of time via email, but still operated similarly to a standard tabletop drill [2]. Though simulation as a field has advanced since some of this research, CH Chi et al. published study events from 1998–1999 suggesting that there were some components of disaster management for which tabletop drilling appeared to be a better tool in the eyes of the training emergency medical technicians [3]. They believe that demonstration of role flexibility is better facilitated with tabletop drilling.

More interactive simulations can range in scope from a simple fire drill to a fully immersive scene with live actors, manufactured noise and real equipment to use. It may be difficult to imagine that a school child's rehearsal of what to do in the event of a fire is truly a simulation, but it typifies features of classic simulation training. Practicing the response of a large group of people to an alarm provides an opportunity to both train the relevant players (in the case of a fire drill, for example, the students and teachers) and to test the protocol (do doors accidentally lock when an alarm is triggered, can the teacher with a cane successfully follow the path to the exit, etc.). More sophisticated examples of this include paramedic trainings, Wilderness First Responder Courses and military pre-deployment experiences. These more complex trainings are immersive, as in the case of the Wilderness First Responder Course where students are brought into austere environments and asked to respond to the medical needs of fully moulaged humans in, often, compromised situations.

In addition to the more typical role of simulation in training, an important extension of simulation in disaster medicine involves prediction and preparedness. As mathematics and engineering become more adept, computer modeling and virtual reality environments have become steady presences in disaster management. Computer modeling is not

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only used to predict when and where a disaster might strike but can also evaluate a system's capacity to handle abrupt changes in volume or increased need for a specific resources, such as a burn unit bed following a large fire [4]. Virtual environments are also becoming feasible training tools for mass casualty response training, having been positively reviewed in pilot studies thus far [5].

Disaster Medicine Education and Simulation – Current Status

As is discussed in this text, simulation is a useful tool for education. Purely didactic training is not enough preparation for an actual disaster. The cognitive dissonance induced by competing interests, background chaos or emotional stakes easily distracts from the basic algorithms, such as the START system for disaster triage. Educators should instead use either standard immersive simulation or virtual reality immersive simulation for training. One study saw improved triage skills in medical students trained with simulation exercises rather than solely didactic training [6]. Another suggests that virtual reality environments provide non-inferior training environments for triage training [7]. Immersive simulation allows for training in communication and collaboration, important skills in Emergency Medicine in general, and Crisis Management specifically, that cannot truly be taught with basic didactics. Immersive simulation also provides experience with cognitive dissonance, preparing providers for the chaos to come [7].

While medical students, residents and other physicians need training in mass casualty triage and disaster response, it is first responders who are most likely to be immersed in disaster events. A 2008 study highlights that despite extensive "traditional" training and years of field experience, first responders often share common failures. These include failing to adhere to strict protocols, decisions to over-treat based on triage level, inadequacies in communication and failure to recognize scene hazards [8]. This study points out that typical drills often lack individualized feedback, focusing instead on the disaster plan or the system and suggest that simulation allows for an integration of knowledge with psychomotor skills. They note, as do others, that immersive high fidelity simulation can be expensive and difficult to reboot to allow for deliberate practice, wherein there is likely a role for virtual environments.

In addition to the publications reviewed in this text, there are many well-respected, frequently used disaster preparedness programs in existence, especially in the military. One example is FEMA's Technical Emergency Response Training (TERT) for CBRNE (chemical, biological, radiological, nuclear or explosive) Incidents course. After teaching attendees how to recognize, respond to and remain safe in hazardous environments, the course culminates with an immersive simulation in a simulated toxic environment – the Chemical, Ordnance, Biological, and Radiological Training Facility (COBRATF) where students must display such skills as chemical dispersion, mass casualty triage, evacuation and decontamination. Taken one level further, the armed services training in CBRNE involves soldiers in full gear developing hot and cold zones, decontaminating, triaging, and transporting victims to medical providers who then continue the scenario by managing both transported patients and the potentially exposed walking wounded. Another example, the Combat Casualty Care Course, is required training for the Military Medical Corps from the Army, Navy and Air Force. It prepares providers for combat deployment or humanitarian aid encounters and includes basic ATLS (Advanced Trauma Life Support) as well as more intense immersive simulation, such as exposing the providers to irritants such as pepper spray.

Disaster Medicine Curricula

Depending upon the type of trainee, a model curriculum in disaster medicine could take many different forms. Descriptions of the individual course curricula can be found online based on course provider (American College of Surgeons, FEMA, USAMRIID etc). For an example of a more protracted disaster medicine curriculum, one can look to the International Disaster Medical Sciences Fellowship curriculum reviewed in the Western Journal of Emergency Medicine in 2009. The curriculum can be viewed in Table 23.1. It is difficult to find a component of the curriculum that could not be facilitated with simulation.

In the 2011 Model of the Clinical Practice of Emergency Medicine, as defined by the Council of Residency Directors of Emergency Medicine, it specifically notes that a physician should "prioritize and implement the evaluation and management of multiple patients in the emergency department, including handling interruptions and task switching, in order to provide optimal patient care" and should "coordinate, educate, or supervise members of the patient management team: utilize appropriate hospital resources: [and] have familiarity with disaster management." [10] These priorities allow for easy integration of disaster management simulation into existing emergency medicine resident education. A familiarity with disaster medicine is an essential component of basic Emergency Medicine training. Basic didactics on both triage mechanisms and complex pathophysiology, toxicology rotations, and EMS experiences have been the core of this training. Simulation can successfully augment these components and, importantly, also serve as an assessment tool. In one example of assessment, gaming simulation was used to evaluate a bioterrorism training program. Students

Table 23.1 ABEM/ECFMG International Disaster Medicine Sciences Fellowship Core Curriculum [9]

1.0 Conceptual Framework and Strategic Overview of Disasters
1.1 Disaster Nomenclature
1.2 Disaster Research and Epidemiology
1.3 Disaster Education and Training
1.4 Surge Capacity
1.4.1 Critical Thinking in a Resource Poor Environment
1.4.2 Alternate Care Sites
1.5 International Perspectives on Disaster Management
1.6 Ethical Issues in Disaster Medicine
1.7 Emerging Infectious Diseases
1.8 Disaster Mental and Behavioral Health
1.9 Special Populations
2.0 Operational Issues
2.1 Public Health and Emergency Management Systems
2.1.1 National Incident Management System
2.1.2 Incident Command System
2.1.3 Communications
2.1.4 Media
2.1.5 Phases of Emergency Management
2.1.6 All-Hazard Approach
2.1.7 Resource Management
2.1.8 Volunteer Management
2.1.9 National Disaster Medical System
2.1.10 Personal Preparedness
2.2 Legislative Authorities and Regulatory Issues
2.3 Syndromic Surveillance
2.4 Disaster Triage
2.5 Personal Protective Equipment
2.6 Decontamination
2.7 Quarantine
2.8 Mass Dispensing of Antibiotics and Vaccines
2.9 Management of Mass Gatherings
2.10 Transportation Disasters
2.11 Emergency Medical Services Scene Management
2.11.1 Recognition, Notification, Initiation
2.11.2 Scene Safety
2.11.3 Search and Rescue
2.11.4 Transportation
2.12 Health Care Facility Disaster Management
2.12.1 Hospital Incident Command System
2.12.2 Allocation of Scarce Resources
2.12.3 Evacuation
2.13 Mortuary Affairs
2.14 Crisis and Emergency Risk Communication
2.15 Telemedicine and Telehealth Role in Public Health Emergencies
2.16 Complex Public Health Emergencies
2.17 Patient Identification and Tracking
3.0 Clinical Management
3.1 Chemical-Biological-Radiological-Nuclear and Hazardous Materials
3.1.1 Traumatic and Explosive Events
3.1.2 Burn Patient Management
3.1.3 Clinical Aspects of Large-Scale Chemical Events
3.1.4 Biological Events
3.1.5 Nuclear and Radiological Events
3.1.6 Hazmat, Toxic and Industrial Events
3.2 Environmental Events
3.2.1 Floods
3.2.2 Hurricaines
3.2.3 Tornadoes
3.2.4 Earthquakes
3.2.5 Tsunamis
3.2.6 Winter Storms
3.2.7 Heat Waves
3.2.8 Volcanoes

who had completed the training were compared with students who had not completed the training but were experienced in working in bioterrorism and with students who had no experience and no training. The gaming simulation assessment was able to differentiate between the experienced and inexperienced providers in terms of performance [11].

It is important to acknowledge than in addition to the medical knowledge and teamwork/communication skills taught to providers, educators must also prepare providers for the stresses involved in disaster care. Most practiced thus far in the military, stress inoculation is an important component of training. Simulations such as the mock battlefields of CCCC training in the military or those occurring in the virtual reality realms described in this text can provide emotional stimuli to the trainee. Structured debriefing following these encounters may allow the providers to develop coping skills to manage both the physiologic responses to stress that may inhibit performance during a disaster and the residual responses to a trauma that may influence daily life in the future.

Challenges in Disaster Medicine

Because disasters are chaotic multifactorial events, studying them is difficult. It is these descriptors, however, that make it important to study disasters in order to improve our management and preparation. Integrating new data collection technology during simulated disasters may help with future plans as well as assessment of performance. Recently published results of a comparison of data collection during a simulated disaster via RFID technology versus manual recording showed improved data collection using the tags [12]. Technology that could assist in capturing everything that is occurring has the potential to improve future disaster management allowing for more thorough debriefing and analysis of the system and each individual component.

Perhaps one of the biggest challenges of disaster medicine is its unpredictability. This has led to the use of computer modeling to help with planning and projection. It is important, however, to recognize that disaster management revolves around interconnected complex decision-making cascades. At some point all models will fail in their ability to simulate the interdependencies of a complex system and the motivations of any single decision [13]. Simplistic or reductionist models are seen by researchers as inadequate and some suggest the use of more advanced complexity science to better study mass casualty incident response [14]. Like large economies, or the human body, there are multiple interconnected components within a disaster model that operate with individual motivations and constraints not easily modeled. Importantly, while computer models have value, disaster medicine will always be a science of humans. Resilience and creative decision-making cannot be entirely engineered [15].

A large challenge in disaster planning is the execution of drills. They are expensive, time consuming, rarely incorporate all players, and cannot usually be stopped and restarted, or done repetitively for the purpose of training. The choice between in-situ or non in-situ drills is sometimes the choice between the lesser of two evils. In-situ events are disruptive and often met with disdainful attitudes. Many times they have to be rescheduled so as to accommodate day-to-day disasters in the hospital system. It's difficult to tell a patient that they have to wait because there is a mock drill going on, though hopefully they will be more patient in the event of a real disaster. While some of the weaknesses of in-situ drills can be avoided with simulation center based programming, many of the same problems remain. They remain consumers of extensive time and resources and still cannot truly test the real system without completely recreating an identical patient care environment. The rapidly developing fields of virtual reality and serious gaming are an evolving solution to these problems. Gaming allows for character interactions and can be developed with easily manipulated variables including number of providers, number of victims, time allowed, skill level of responders or even the effect of interventions performed [16]. Games can be stopped and started or even reset and played again. It is also very easy to collect all of the data from an event.

Another challenge in disaster planning is determining to what degree you're evaluating the system and to what degree you're evaluating an individual. Many trainees voice concerns that their failures are not their own, but the result of the system. While this may at times be true, experienced debriefers will ideally facilitate a conversation that highlights the strengths and weaknesses of the individual and the system and produces actionable feedback to improve the performance of both. Virtual reality, because it can collect all available data and provide an opportunity for debriefing from an individual perspective as well as a system perspective may provide one solution to this problem.

An interesting finding in a case study by Schulz 2014, wherein providers were more likely to let simulators die than human actors leading them to inappropriately triage or inappropriately respond to a triage tag, suggests that exposure to simulators is necessary before incorporating high fidelity simulators into any disaster training or evaluation [17]. This is not entirely unexpected, but is a useful reminder to educators and researchers who plan to use high-fidelity human patient simulators in their disaster preparedness work.

Simulation as a Measure of Preparedness

One major role for simulation in disaster medicine is its utility in evaluating a disaster plan. Some have described this as exercise play. Simulated exercises can recognize the faults of a plan, including rate-limiting steps, missing or malfunctioning equipment or even undertraining/lack of education [15].

Determining the readiness of a public health system at any one point in time is an important component of disaster preparedness. Resources such as EMCAPS (Emergency Mass Casualty Planning Scenarios) exist to help disaster preparedness officers and other interested parties in evaluating their system. Developed by The National Center for the Study of Preparedness and Catastrophic Event Response, these are downloadable scenarios covering such topics as bus bombs, toxic spills or food contamination that can be used by any preparedness team to insert its own system's identifying characteristics into pre-programmed scenarios to analyze the impact of the event on the system, mainly by predicting casualties. Additionally, a system should be able to evaluate how policy decisions might influence their plans. In one published model, a tabletop drill is augmented with compelling video and computer simulation to evaluate gaps in resources and planning that could be reformed [18]. In this specific case, the policy makers were encouraged to sit around the table as well, to see the anticipated impact of their decisions.

While it appears inherently prudent to determine a community or hospital system's level of disaster preparedness and to find the time to test equipment, educate and refresh providers of all levels on skills and protocols and to test the strain of a disaster on a system, if prudence is not a convincing argument, healthcare regulatory agencies have mandated these behaviors. One such regulation comes from The Joint Commission of Accreditation of Healthcare Organizations (JCAHO), which mandates that community-wide tabletop exercises must be conducted to clarify roles and responsibilities of local first responders and the health care organization being accredited. JCAHO also mandates that any organization offering emergency services or serving as a "disaster receiving station" must perform a simulated exercise with an "influx of simulated patients." Per JCAHO, "for an 'influx' exercise to be acceptable, it must be an active process that is conducted throughout the facility, involve personnel from the organization and simulate the movement of patients. A tabletop exercise does not meet this requirement."

Simulation is a tool worth using in disaster medicine and disaster preparedness. It is an effect modality for learning and assessment of both systems and individuals and can be used with a wide range of student types in environments including boardrooms, VR labs and in the field.

[See "Appendix 1, Chapter 23 Supplemental Case Scenario"]

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Simulation in Defense and Combat Medicine

24

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Background

The United States (U.S.) military has long employed simulation training exercises for combat training, including medical responses on the battlefield [1, 2, 4, 5]. The execution of quality medical care in the operational environment is among the most challenging goals to achieve. Military medical training must take into account factors rarely encountered in civilian medical or trauma centers. While blunt trauma remains the overwhelming cause of civilian trauma center activation, trauma in the operational setting often includes high percentages of blast and penetrating injuries [1, 6, 7]. In addition to these unique types of injury patterns, the MMP must consider operational complexities such as austere and hostile conditions as well as unpredictable evacuation times [8–10]. The absence of such operational content and military care paradigm within the traditional, civilian medical training highlights the increasing importance of military simulation-based training for the military medical provider.

This chapter discusses how simulation training has improved military readiness and MMP for operational and battlefield medicine. We highlight examples of best practices from the Tactical Combat Casualty Course (TCCC), Combat Casualty Care Course (C4), and two successful advanced military simulation training programs at the Madigan Army Medical Center in Tacoma, WA and the Naval Medical Center in San Diego, CA. Also, we include sample training scenarios and "just in time training" procedure cards that address several of the most common causes of preventable battlefield deaths (Appendix 2c). We then conclude with a discussion on how simulation training is integrated at the military medical school, Uniformed Services University Health Sciences (USUHS), and few of the current challenges facing the military simulation community.

Military Medical Simulation Training Facilities

Medical units such as field hospitals, hospital ships, shipboard medical departments, and forward surgical teams (FST) conduct large-scale simulation training via field exercises in order to enhance operational efficiency in austere conditions [2, 3, 11]. Training includes learner evaluations and a strong emphasis on leadership, teamwork, communication, and operationally relevant procedural skills. The military mantra, "Fight like you train and train like you fight," is as relevant to simulation training as it is to combat training. However, due to limited resources and other challenges, pre-deployment training remained highly variable through the 1980s and 1990s [2, 7, 11]. As a result, immersive training, experiential learning and deliberate practice for the deploying

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MMP remained at the discretion of the individual military unit and their leaders [11].

Operation Desert Storm, which took place from 17 January 1991–28 February 1992, served as the initial impetus to modernize and standardize pre-deployment training in order to achieve a highly reliable and sustainable level of medical military personnel readiness. The conflicts following 11 September 2001, Operational Iraqi Freedom (OIF), and Operational Enduring Freedom (OEF), led the United States military to invest substantial resources to fund advanced medical simulation to improve clinical, operational, leadership, and communication skills training [1–3, 12].

The US Army Medical Research and Material Command help support various programs for front-line medics and corpsmen [3, 11, 13]. On the technology front, the Telemedicine and Advanced Technology Research Center (TATRC) located in Ft. Detrick, Maryland, leads integrated research teams from the Department of Defense, academia, medical communities, and commerical industries to fund and develop the next steps in military medical simulation [2, 3, 5]. The aim is to provide the military medical communities the best resources to conduct immersive training with robust assessment capabilities. TATRC promotes the rapid development of low and high-fidelity task trainers and virtual reality simulation equipment for dissemination throughout military training facilities [5].

Currently, the U.S. military operates over 25 Medical Simulation Training Centers (MSTCs) [8, 14]. Each MSTC is staffed by full-time simulation instructors and content experts and is equipped with a wide array of simulation equipment to meet the operational objectives. Using advanced virtual reality simulation technology and software, some of the MSTCs are now able to reproduce, in three dimensions, a level of realism only exceeded on the battlefield [15]. Using a computer graphic user interface with haptic device and animation, the instructor recreates sensory aspects of the simulation case to elicit the emotion, tension, fear, and chaos that combat brings [15–17]. Researchers are now using this information to determine the impact of process and equipment failures on individual performance and operational capabilities [15, 16, 18]. Tens of thousands of soldiers, sailors, and airmen have been trained in MSTCs for operational readiness training. This illustrates how simulation training can quickly and effectively transmit lessons learned from the battlefield to the medical training environment.

Based on the positive results of simulation training in the military community, in recent years, the Veterans Health Administration (VHA) has also invested heavily in establishing medical healthcare simulation programs throughout its medical facilities nationwide [19]. In 2009, the Under Secretary for Health for the VHA established the National Simulation Learning, Education, and Research Network (SimLEARN). The mission of SimLEARN is to promote excellence in healthcare provided to America's Veterans through the use of simulation technologies for process modeling, training, education, and research [20].

Best Practices

"Just in time" hands-on training needs of the deploying MMP differ considerably depending on their area of specialization, mission objective, scope of the medical operation, and the level of care they provide. To provide the best combat medical practices, service-specific training centers and specialized military commands have been established to provide high-value training for all levels of MMP. These individuals include combat medics, transport specialists, nurses, general medical providers (i.e., internists, pediatricians, psychiatrists), surgical subspecialists and trauma surgeons. Two simulation-based training courses, Tactical Combat Casualty Care (TCCC) and Combat Casualty Care Course (C4), respectively address the learning objectives of combat medics and junior resident physicians from all military training programs.

Tactical Combat Casualty Care (TCCC)

In the late 1990's, the Naval Special Warfare Group developed guidelines for the management of combat trauma based on lessons learned from the battlefield [13]. As most deaths occur before the wounded ever reach the MTF, the emphasis of this course is directed towards the medic who provides life-saving care on the battlefield [10, 21]. The focus of the training involves recognition and management of the top three reversible causes of death noted on the battlefield: hemorrhage (91%), tension pneumothorax (8%) and airway obstruction (1%) [10, 22, 23]. In the TCCC paradigm, management of the injured soldier is broken down into three distinct phases: Care Under Fire, Tactical Field Care, and Tactical Evacuation Care. In each phase, tactical considerations dictate the care and interventions to be given. For example, in Care Under Fire, the only indicated medical procedure is to rapidly arrest the massive hemorrhage while returning fire and seeking cover [6, 24].

By giving each phase a unique priority within the overall mission framework, TCCC enables learners to understand the overall mission in smaller, more manageable "frames" with practical battlefield application. Courses are designed to enable learners to visualize specific objectives within each frame, engage in deliberate practice using partial task trainers, receive formal feedback and repeat the training until they can demonstrate mastery of the objective. These courses reinforce the fundamental principles of simulation training: clear objectives, appropriate level of fidelity or realism (i.e., setting, condition, resources, etc.), emphasis on communication, teamwork, and formal debriefing. As a direct result of this type of focused simulation-based training, the survival rate among injured soldiers in combat has been at the highest in recorded military history [9, 10].

Combat Casualty Care Course (C4)

The Combat Casualty Care Course (C4) is an 8-day immersion course intended for first-year resident physicians at all military MTFs. Using lessons learned from previous medical operations, the team-based training focuses on situational awareness, communication, and procedural skills needed under operational conditions in tents and makeshift facilities with limited resources.

Areas of instruction and practical evaluation are varied and complex, including the TCCC concepts with emphasis on the use of a proper chain of communication. Learners are also exposed to various environments including an animal skills laboratory for procedural training and an advanced simulation center equipped with task-trainers and high-fidelity simulators for team-based and communication training. Subjects matter experts provide formative and summative feedback to all of the trainees during and after each training exercise, respectively. The training course culminates in an all-night, high-intensity immersive battlefield training with professionally moulaged standardized patients (SPs). This type of early exposure to combat medicine remains instrumental in shaping and preparing military physicians for the operational responsibilities many assume upon completion of their internship or residency training.

Army Medical Center-Hybrid Simulation and Live Tissue Training

The training curriculum developed at the Madigan Army Medical Center in Tacoma, Washington, integrates high-fidelity simulation training with live tissue training [1, 5]. This four-day program focuses on improving the trainee's ability to perform primary and secondary trauma surveys. It also includes training on life or limb saving high stakes battlefield procedures such as cricothyrotomy, chest tube thoracostomy, venous cutdowns, intra-osseous placement, and tourniquet application. (See Appendix 2c, parts 4a, 5a, and 6a) Professionally trained SPs employ moulage and human worn partial task surgical simulator (a.k.a. "Cut Suit") to heighten the emotional realism of chaotic battlefield scenes. Unique to this training experience, the learners are required to verbalize their assessment of the primary and secondary surveys and are expected to perform in real-time the appropriate lifesaving intervention on an SP as the situation dictates. This training format reinforces the important link between two equally critical skills for effective combat care: critical decision-making and decisive actions. Essential to this form of training is a blame and risk-free environment where the learner is allowed to make mistakes during the simulation. The formal debriefing period after the simulation subsequently allows the learner to engage in self-reflection about the events and what, if anything, could be done differently in the future.

Bioskills and Simulation Training Center (BSTC), Naval Medical Center San Diego

The United States Navy is often required to overcome diverse operational medical care challenges throughout the world. In recent years, Navy medicine has been called to provide combat and humanitarian care on land, sea, and air. As the medical support element of the United States Marine Corps (USMC), Navy physicians staff the Shock Trauma Platoons (STP) and Forward Resuscitative Surgical Suites (FRSS) on the battlefield, field hospitals behind the front lines, shipboard medical departments throughout the Naval Fleet, and the USNS Hospital Ships, Mercy and Comfort [5, 11, 18]. The Naval Medical Centers in San Diego (NMCSD) and Portsmouth (NMCP) serve as the primary medical treatment facilities where military trainees gain extensive simulation exposure and training through the simulation center.

At NMCSD, critical war surgery concepts are reinforced to the deploying surgeons through the Emergency War Surgery course and the Advanced Surgical Skills for Exposure in Trauma course [4, 18]. In collaboration with the 1st Marine Division, the Bioskills and Simulation Training Center (BSTC) in San Diego developed a weeklong curriculum for STP and FRSS personnel emphasizing operational process improvement and team dynamics training. Teams of physicians, nurses, and corpsmen train in individual procedural skills and participate in team casualty events in order to solidify principles of combat medicine. During the last two days of the event, learners are fully immersed in the field environment while actively receiving, managing, and evacuating casualties.

Sample Curriculum

Appendix 2c (Parts 1a, 2a, and 3a) provides three training scenarios that address the most common causes of preventable battlefield deaths. Appendix 2c (parts 4a, 5a, 6a) provides three procedure cards used by the military medics that highlight the utility of high impact, high yield "just in time" training reminders. These examples are written with front-line medics in mind, however, the template can be modified for use with other target audiences.

Integration into Existing Education

Simulation-based training has the potential to revolutionize health care in the military, just as it does in civilian care. For the learner, integration of simulation training into the existing preclinical or clinical education is essential to achieving high-quality medical education as well as emphasizing the importance of patient safety [25–27]. Numerous published surveys involving medical students and resident physicians show overwhelming support for simulation integration into the existing educational curriculum [25, 26, 28, 29]. Given the body of evidence supporting its efficacy in medical training, some researchers have argued that simulation training is not just an option, but rather "a moral imperative" to be included in medical education and residency training [30].

The use of simulation training in military medicine has dramatically changed the way MMP train and prepare for operational and combat medicine. At the Uniformed Services University of Health Sciences (USUHS), the pre-eminent center for the study of military medicine, tropical diseases, disaster medicine, and adaptation to extreme environments, simulation science is integrated throughout all four years of the medical school curriculum. In the preclinical years, the simulation curriculum includes using a wide variety of high-fidelity computerized mannequins for advanced physiology, cardiopulmonary, and pharmacodynamics training [31]. As the learners advance, SPs are increasingly incorporated into the simulation training to improve assessment of the learner's specific knowledge, skills, communication, and attitudes.

Procedural competency and proficiency training that commence in the simulated surgical suites with partial task trainers and virtual reality part-task trainers culminate in two capstone courses offered to all 4th-year students, the Military Contingency Medicine (MCM) and Operation Bushmaster (OB) [32] These courses provide the graduating student practical tactical-level experience, as well as, formal assessment and evaluation of their medical knowledge and leadership abilities in a simulated, resource-constrained, far forward tactical field setting. Students are expected to demonstrate competence in a leadership role in a joint battalion aid station where they are presented with operationally current, reality-based missions and operational problems for which they must plan and execute while simultaneously managing the medical care of simulated Disease and Non-Battle Injury (DNBI) patients, combat stress casualties, and combat trauma casualties [31, 33].

In addition to live field training, USUHS students have access to an 8000 square-foot wide-area virtual environment (WAVE) for virtual reality training. The WAVE is composed of two pods surrounded by circumferential 9 × 12-foot movie screens and a high-fidelity directional sound system that allows for virtual reality training capable of recreating operational and battlefield medical conditions the learner may encounter during their deployment [15] Figs. 24.1, 24.2, and 24.3.

Challenges and Solutions

One area of high interest within the operational military medicine community involves the domain of competency assessment. Referring specifically to the surgical community, Colonel Edwards of the US Army wrote the following statement in her recent article titled, *Saving the Military Surgeon: Maintaining Critical Clinical Skills in a Changing Military and Medical Environment*. "The core surgical competence is the foundation on which all deployment skills are built…but wartime surgery requires specific skills that *cannot* be completely obtained with practice at modern civilian trauma centers alone." [34] Surgical competence for operating in combat zones remain challenging to measure and evaluate before deployment. This issue is further complicated by the wide variation in surgical practice and skill sets among the surgical subspecialists deployed to the combat zone [16]. Presently, significant resources are being deployed to address these issues, and to study the efficacy and impact of "just in time" simulation training and high-intensity simulation training refresher courses for the community of surgical specialists.

In like manner, medical providers outside of the surgical realm also wrestle with the issue of clinical and procedural competency assessment [26]. Medical planners and field commanders are responsible for assuring the readiness of all medical elements, including providers, equipment, and supplies. To accomplish this task, they have successfully employed realistically staged field exercises like the military assessment training exercise (MATEX) at Camp Pendleton, CA, to observe and assess the readiness of the medical support team. Using this type of live simulation training exercise, general practitioners unfamiliar with managing combat-related injuries can improve their skills to manage and to evacuate the injured soldier from their facility a higher level of care [4, 29].

Another challenge facing the military simulation community involves issues concerning the ethical treatment of ani-

Fig. 24.1 SIM WAVE 2013–18

mals and the fiscal responsibility of overall training costs [5, 35–37]. These issues are similar to those experienced in civilian training environments. First, the rising cost associated with training large numbers of combat medics and other military providers for deployment using live animals, has led the military to seek viable alternatives for procedural skills training. Second, many have felt that the current simulation task trainers can adequately replace the use of live animals for skills training without sacrificing performance [17, 38, 39].

To address the need for a realistic live tissue substitute, the military has funded several initiatives aimed at providing viable large scale substitutes that mimic the feel, pliability, bleeding quality and anatomy of live animals for the military trainees [40–42]. Currently, various research, innovation, and technology command centers are actively pursuing a solution to this problem. At the time of this writing, this effort has yielded several promising prototypes but nothing commercially available.

Other Implications for Civilian Practice

The War on Terror has alerted the nation's civilian medical communities to the growing need to prepare and train for mass casualty events. These events often involve injury patterns commonly seen in combat zones. According to the National Consortium for the Study of Terrorism and Responses to Terrorism, between the years 2001 and 2011, a total of 207 terrorist attacks were carried out in the United States [43]. Of note, 73% of the 207 attacks involved the use of explosives or incendiary devices. Since 2011 another 38 terror attacks have occurred in the US [44]. Unfortunately, traditional pre-hospital and hospital-based training often preclude training for first responders and medical providers in response to large scale terrorist-related attacks.

Several high-profile events in recent years highlight the need to expand civilian medical mass casualty training programs. In the bombing during the April 2013 Boston

Fig. 24.2 SIMCTR WAVE Open House

Fig. 24.3 WAVE – Airman Magazine. Val G. Hemming Simulation Center, Uniformed Services University

Marathon, 3 people were killed and 264 were injured when two homemade explosive devices detonated. In the Orlando Nightclub shooting that occurred in June 2016, 50 people were killed and 53 injured due to the use of a military-grade semi-automatic weapon [44]. These recent events suggest the lessons learned from years of battlefield medicine may be of relevance to the civilian medical community. Continued tactical simulation training for the civilian medical community, using core concepts like those taught in TCCC, will be imperative.

Conclusion

This chapter described how the military employs simulation training to address its unique training needs of deploying military medical providers. The positive impact of widespread adoption of advanced simulation training has been to improve our medical providers' preparedness which has directly translated into lives saved on the battlefield [7]. As technology and material science continue to advance at a rapid pace, the future of simulation training in the military will most certainly involve greater use of virtual reality simulation for team training, life tissue substitutes for procedural training, and immersive field exercises that continues to the limits of the individual, as well as, the team.

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Part V

Conclusion

25 The History, Present and Future of Healthcare Simulation

Nelson Wong and Yasuharu Okuda

In 2004, David Gaba, citing experiences from the first 20 years of healthcare simulation, laid out two possible visions for 2025 [1, 2]. The first envisioned simulation woven into the fabric of healthcare training and interprofessional practice based on face validity, evidence and demands for quality and safe patient care. Having found champions in professional societies, administrators as well as risk management, simulation will have been validated as a tool for improving healthcare. In the alternative scenario, simulation will fall to the wayside as a costly, unproven and misunderstood technology. In his conclusion, Dr. Gaba theorized:

> *The fate of simulation as a means to a revolutionary change in healthcare is approaching a "tipping point" that will resolve itself strongly in the direction of one of these alternate histories over the next 10 years...*

Now, just over a decade later, do we know on which road we are headed? Hopefully your own experiences and the information contained in this text lend themselves to the conclusion we have tipped towards the more optimistic path. Simulation use and training in healthcare has grown tremendously [3, 4]. Chapter 1 outlines the history of simulation within the field of Emergency Medicine – a natural marriage of a complex specialty with diverse needs and tool that continues to redefine its boundaries and applications (Chaps. 9, 10, 11, 12, and 13). At its foundation, healthcare simulation is an arguably revolutionary technique based on successful applications in parallel fields (Chap. 1), learning theory (Chap. 2) involving practice within simulated clinical experiences (Chap. 3) and the essential characteristic of catalytic reflection in the debriefing (Chap. 4). Beginning from roots in medical education (Chaps. 14, 15, 16, and 17) and procedural training to evolving applications such as team training (Chap. 6) and as a driver of patient safety (Chap. 8) simulation has created more direct connections to higher level Kirkpatrick outcomes (Chap. 7). Simulation as a tool has permeated throughout the geography of Emergency Medicine (Chaps. 17, 18, 19, 20, 21, 22, 23, and 24). Driving this surge is a body of evidence supporting the use of simulation training in improving educational and patient outcomes as well as the formation of a community of practice [3–13]. Healthcare professionals are also demanding safer and more effective training [14–16].

Reading through this text, we see that while barriers and room for growth still exist, simulation in Emergency Medicine has seen rapid expansion over the past decade. Traditional training has been focused on the use of high-fidelity mannequins and task trainers occurring mainly in simulation centers with a shift towards in situ, in our Emergency Departments. Curriculum has been focused on low event/high acuity events and strong research evidence now exists in areas such as code team training, airway management and procedural training. The literature describes curricula targeted towards trainees rather than practicing professionals [3, 17–19].

As an illustration of harmony between form and function, the original high-fidelity mannequins and trainers were married to their logical purposes of rapidly evolving clinical scenarios involving teamwork and/or individual procedural skills. The natural habitat and champions for these trainings lay predominantly in schools with academic faculty and trainees with protected non-clinical time and an easily understood moral imperative to "learn" and "practice". With learning theory providing grounding for simulation practice, adaptation into early clinical training has proven to be impactful as a means of providing holistically engaging

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experiences, effectively winning over the "hearts" of generations of healthcare practitioners.

After this initial period of growth we are now moving towards maturation. Attention for faculty development has become prevalent in the literature. [20–24] Calls for standardization in other arenas such as simulation center designation, fellowship training and assessment of programs also continue. The use of simulation in healthcare has begun to shift in response to the value proposition –increasing the focus on the roots of simulation in patient safety and quality as well as adding to the attention given to higher level Kirkpatrick assessments. These factors, alongside the development of emerging technologies as both a means of training as well as access and connection represent the next phase in simulation.

As generations of simulation educators are "growing up", and their numbers reaching critical mass, the call from the academic world is now for quality control of the "minds" behind simulation. Information on best practices, research guidelines, faculty standards, simulation center accreditation and evidence of benefit offer a clearer understanding of the skills and resources necessary to wield simulation responsibly (both educationally and fiscally). While training organizations and risk management groups have begun to actively promote simulation, professional organizations such as specialty boards have been more hesitant, likely requiring more robust evidence of value before "changing their minds".

Overall, simulation is closer to the optimistic view Dr. Gaba set out. Simulation use has been rapidly expanding. Initially focused on the education of trainees and practitioners with physical simulators and spaces, there is a shift towards developing standards and resources, particularly faculty. The more distant future holds promise of increasing virtual and connective technologies as well as a push for additional evidence of the value of simulation:

A Vision of the Future of Simulation

By 2025, with continued organizational support and building upon foundational principles developed over the first half century of healthcare simulation, new technologies and clinical needs will be seamlessly integrated into nationally developed and shared curriculum. Some of this education and training for new technologies and techniques will happen "just in time" via virtual and augmented reality simulation integrated within the clinical technology used at the bedside. Otherwise, the majority of training is delivered via skilled facilitators using learner targeted modalities with opportunities for deliberate practice. Artificial intelligence and data science (analysis of "big data") are also beginning to contribute to gap analysis based on clinical charting and practice patterns as well as the curation of individualized and stepwise asynchronous curriculum.

These needs and new technologies are driven by an unwavering awareness of the priorities set forth by the care of patients. Telehealth has expanded to provide timely and quality care. New technologies in clinical care, both diagnostic tools as well as therapeutic have been developed. Prior to initiating these spaces, processes and technologies, rigorous testing is conducted by teams expert in administration, resilience engineering, human factors, patient safety, and simulation. Development teams are not only able to meet in person mirroring the proposed spaces replete with 3D printed models but also in virtual worlds where representative avatars interact with digital models. Also present in these virtual worlds are patients, practitioners and learners. All participants have 24/7 access to projects, literature, games for both training and therapeutic purposes, as well as each other. Technology has mitigated many barriers to education and simulation-based resources have become even more accessible than "a book on a bookshelf" [25].

The community of simulation practitioners has flourished based on two driving forces: 1) a culture of purposeful practice and open communication and 2) the leveraging of telecommunications to create a more connected world. Nationally accepted criteria for a tiered approach to faculty development as well as a system of continuous feedback have been developed. Virtual debriefing worlds have been created for additional practice and feedback using standardized tools with evidence of validity. Best practices and other tacit knowledge are being shared via online forums and scheduled web meetings.

This culture of simulation has also spread to the larger clinical community and has been attributed to improved teamwork and decreased rates of medical errors as well as improved patient care at lower cost. While smaller datasets may not have been able to demonstrate this change, national systems of data collection are analyzed in collaboration. Based on these findings, and the wave of public support that followed, nearly all professional societies and hospitals will have integrated simulation training into not only mandatory signposts such as credentialing but also regular team training and systems checks.

This vision for the future builds upon Gaba's vision of what would be possible for simulation in healthcare. Lessons learned in the past 30 years will provide the basis for future training. Paramount to the effective use of simulation are faculty grounded in educational and simulation theories as well as a vigilant mindfulness of organizational priorities and emerging patient needs. People trained not only in the use of technology but with the skills to adapt them to learning opportunities will be the bridge to the next 30 years. Leveraging technologies to mitigate barriers of space and time, asynchronous and virtual training spaces will take their place next to simulation center and in situ trainings. As described, the world is moving towards seamless integration of simulation into nearly all aspects of healthcare training and systems - the vision described by David Gaba over a decade and a half ago.

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Appendix 1: Supplemental Case Scenarios and Content

How to use this Appendix:

This Appendix includes supplemental case scenarios that correspond to each chapter of the book. They are provided as examples of simulation cases of the topics covered in the corresponding chapter, and are listed in the table of contents below in the order which they appear in the book. Some chapters do not have a corresponding supplemental case scenario and therefore are not included in this Appendix.

They may also be used independently as a library of case scenarios. Included is a list of the supplemental case scenarios organized by topic for easy referencing.

Appendix 2 includes case templates as well as curriculum that are referenced in several of the book chapters.

Supplemental Case Scenarios and Content

Supplemental Case Scenarios and Content Organized by Topic

C. Strother et al. (eds.), *Comprehensive Healthcare Simulation: Emergency Medicine*, Comprehensive Healthcare Simulation,
https://doi.org/10.1007/978-3-030-57367-6

Chapter 2: Education and Learning Theory

Supplemental Case Scenario: Penetrating Trauma

Scenario Overview

26-year-old-male, BIBA, stab wound to right neck and thorax. Patient states that he was "minding his own business". States assailant and weapon were unknown. Denies any other injury or medical issues. Patient is agitated and uncooperative screaming about his right chest hurting.

Teaching Objectives

- Clinical and Medical Management
  - Recognition and management of penetrating neck and thoracic injury
  - Recognition and management of trauma including primary and secondary survey
  - Recognition and management of difficult trauma airway
  - Recognition and management of hemopneumothorax
- Communication and Teamwork
  - Identify team roles and leader
  - Proper communication and demonstration of crisis resource management techniques
  - Management of agitated family members

Target Audience

- Resident (PGY1, PGY2, PGY3, PGY4)
- Fellow
- Attending Physician
- Nurse
- EMT
- Physician Assistant

ACGME Core Competency

- Patient Care
- Medical Knowledge
- Systems Based Practice
- Professionalism
- Interpersonal Skills and Communication

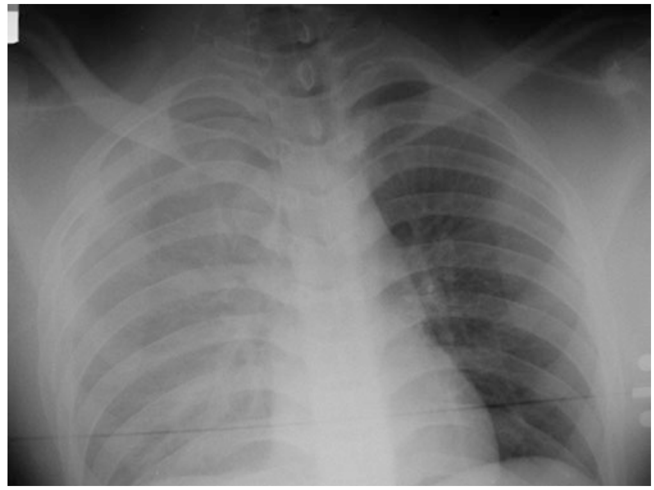

Fig. A1.1 CXR – trauma case

Supplies & Moulage

- Expanding neck hematoma
- Right thoracic injury
- Cricothyrotomy kit
- Chest tube set up

Images

- CXR – Hemopneumothorax on right side (Fig. A1.1)
- EKG – Sinus Tachycardia (Fig. A1.2)
- EFAST – Significant right hemopneumothorax. Rest of EFAST is negative (Fig. A1.3)

Actors and roles

- EMS: EMS states, they found patient bleeding but otherwise stable with a friend nearby. Patient was AxOx2, uncooperative and cursing. Moving all extremities symmetrically.
- Patient: Denying any issues but progressively becomes more hemodynamically unstable and airway becomes compromised.
- Family member: Enters after case has become more stable and is agitated because he/she is concerned about their family member.
- Nurse: Provides all requested assistance, helps with managing family member as needed
- Trauma Surgeon: Makes recommendations regarding airway management, chest tube, trauma resuscitation and finally states patient to go to CT and then either OR or ICU depending on results.

Case Flow/Timeline

- **TIME 0** NOTIFICATION: 26-year-old male. Stab wound to right neck and thorax. BP 185/110 HR 145 RR 22 Sat 100% on NRB
  - What does the pt. look like?

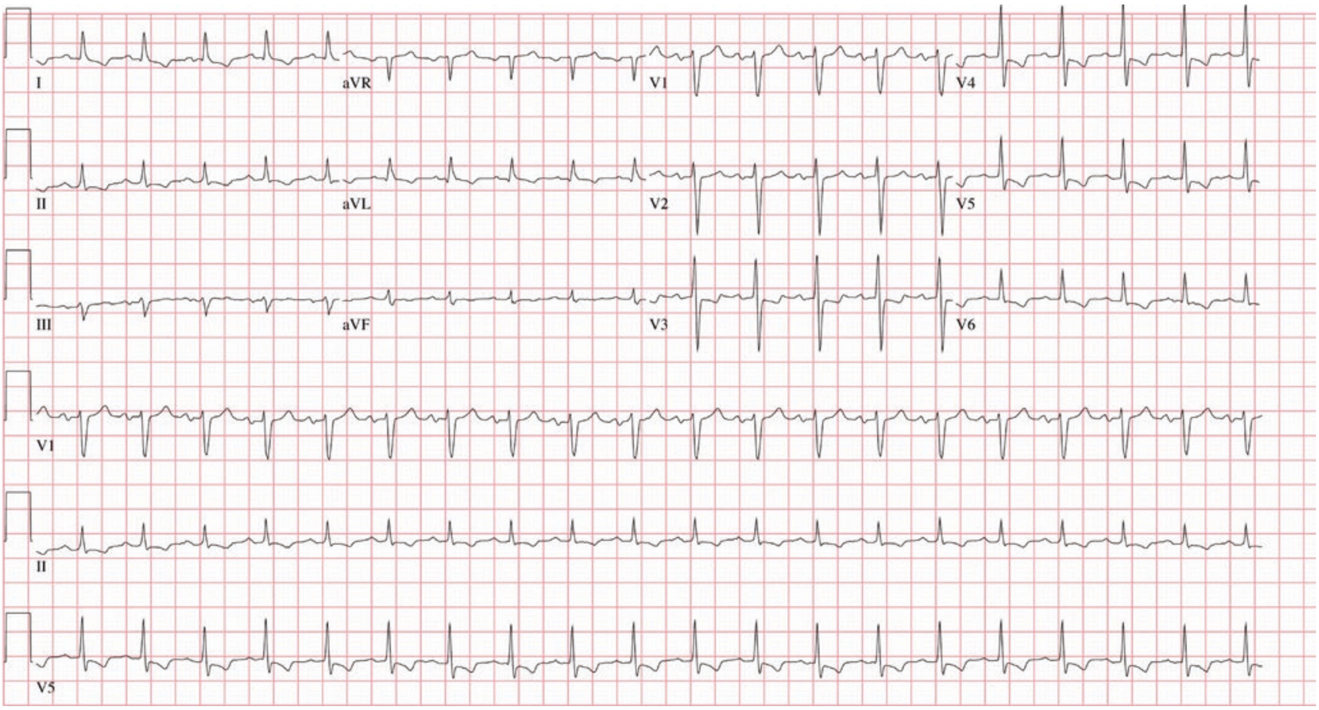

Fig. A1.2 EKG – trauma case

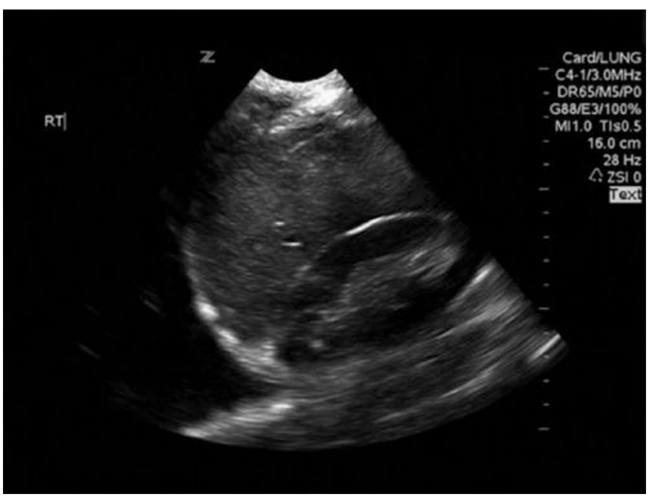

Fig. A1.3 FAST – trauma case

- Pt is agitated but consolable, blood on right neck and thorax
- Vitals:
- BP 90/50 P 124 RR 24 T 98.9 F Sat 97% on NRB FS 115
- IV: none
- Monitor: ST at 124
- Physical exam:
- Gen: AxOx2 (person, place, 2004 July), agitated and diaphoretic
- HEENT: 6 mm and reactive
- Neck: Right neck hematoma – slowly enlarging; patient develops stridor
- Chest: Decreased BS on right, + crepitus, normal BS on left
- Heart: Tachy rate without M/R/G
- Abdomen: NT, ND, no R/G/R, hyperactive bowel sounds
- Rectal: guaiac/gross blood negative if done, normal tone
- Skin: sweaty
- Ext: no C/C/E
- Neuro: AxOx2, moving all extremities symmetrically, CN2–12 grossly intact
- FAST: Normal if done
- EFAST: Hemopneumothorax on right with significant amount of pleural fluid

- **TIME 1MIN-2 MIN** (Initial State – Hemopneumothorax & Right neck hematoma)
  - Vitals - BP 95/45 P 134 RR 24 Sat 95% on NRB
  - Expanding hematoma on right neck - > If intubation attempted, unable to pass ETT given significant swelling, will need Cricothyrotomy
  - If airway not managed, patient will begin to have stridor and airway compromise
- **TIME 2 MIN- 4 MIN** (Trauma management)
  - Trauma management
  - Two large bore IV

  - Disability
  - Exposure – no other injuries noted
  - Labs (type and cross)
  - EFAST
  - CXR
  - Exam
- **TIME 4–5 MIN** (Hemorrhagic shock)
  - Patient becomes more hypotensive, more extreme if not autotransfused
  - VS BP 78/35 HR 145 RR 25 (or at vent rate) Sat 100% if chest tube placed, 87% if not placed.
  - Blood products available and starting if called for. If IV fluids started, BP will get marginally better than worsen.
  - Labs:
  - None available during case
  - Hemopneumothorax - > if no chest tube will de-saturate to 85% rapidly- > If chest tube placed 800 cc of blood return - > If autotransfuser used, can replace blood volume and BP improves
- **TIME 6–7 MIN** (Continue trauma resuscitation)
  - Trauma resuscitation
  - Trauma surgeon arrives and asks for update (recommends PRBCs if not given).
  - Family member arrives and is agitated and concerned
  - Analgesia and sedation drips started
  - Patient vitals stabilize if blood products given
  - Consider TXA
  - Dispo: After conversation with trauma surgeon, patient heads off to CT and from there either to OR or ICU depending on results

Key Action Items

- Actions for Trauma
  - (1 Min) ABC – recognition of expanding neck hematoma
  - (2–4 Min) ATLS, EFAST
  - (5–6 Min) Chest tube +/− auto transfusion, Blood product administration
  - Discussion with Trauma Surgery
  - Control environment – Get agitated family member away from trauma room
- Actions for Airway Management
  - Attempt at RSI - unsuccessful
  - Cricothyrotomy
- Actions for Cocaine overdose
  - Sedation with benzos
  - R/O other overdose
  - EKG
  - CT head
- Final Actions:
  - Discussion with Trauma surgery
  - Resuscitation with stabilization
  - CT angiography of the neck and chest

Critical Actions

- Cricothyrotomy
- Chest tube placement
- ATLS
- Trauma resuscitation
- Control environment, i.e. family

Chapter 3: Simulation Scenario Development and Design

Supplemental Case Scenario: Trauma and Sympathomimetic Toxicity

Scenario Overview

36-year-old-male, BIBA, s/p jumping off of a 3-story fire escape to get away from DEA. As per DEA, they were notified about drug activity in a building. When they responded and broke down the door, they found the patient swallowing something wrapped in a clear bag. They chased the patient onto the fire escape when the patient jumped off from the third floor onto the concrete sidewalk. Witnesses saw the patient hit his head. Patient is agitated and uncooperative screaming about his right chest that hurts.

Teaching Objectives

- Clinical and Medical Management
  - Recognition and management of Traumatic Brain Injury
  - Recognition of and management of sympathomimetic overdose – stuffer
  - Proper sedation in an agitated patient
  - Recognition and management of pneumothorax
- Communication and Teamwork
  - Identify team roles and leader
  - Conflict resolution with police

Target Audience

- Resident (PGY1, PGY2, PGY3, PGY4)
- Fellow
- Attending Physician
- Nurse
- EMT
- Physician Assistant

ACGME Core Competency

- Patient Care
- Medical Knowledge
- Systems Based Practice
- Professionalism
- Interpersonal Skills and Communication

Supplies & Moulage

- Handcuffs
- Simulator clothes
- C collar
- Head injury with blood and gauze

Images

- CXR – Pneumothorax
- EKG – Sinus Tachycardia
- CT head – Normal CT

Actors and roles

- DEA/Police: Police is in the trauma bay trying to get information from the patient. They are being obstructive to care. Refusing to leave. (States patient has had multiple priors and "I'm gotta find out who his dealer is!!!")
- EMS: EMS states, they found patient in handcuffs with police. Patient was AxOx2, uncooperative and cursing. + Head trauma. Moving all extremities symmetrically. Trying to get out of the cuffs.
- Patient: Agitated, swearing, refuses to cooperate with EMS and police.
- ER Tech: Facilitates management of case with key exam findings and physical exam items not reproducible on simulator.

Case Flow/Timeline

- **TIME 0** NOTIFICATION: 36-year-old male. Suffered a fall from 2–3 stories. BP 185/110 HR 145 RR 22 Sat 100% on NRB
  - What does the pt. look like?
  - Pt is agitated and uncooperative, blood on occiput
  - Vitals:
  - BP 185/110 P 155 RR 24 T 100.1 F Sat 100% on NRB
  - IV: none
  - Monitor: ST at 145
  - Physical exam:
  - Gen: AxOx2 (person, place, 2004 July), agitated and uncooperative, swearing
  - HEENT: 6 mm and reactive
  - Neck: Collar – no step-offs
  - Chest: Decreased BS on right, + crepitus, normal BS on left
  - Heart: Tachy rate without M/R/G
  - Abdomen: NT, ND, no R/G/R, hyperactive bowel sounds
  - Rectal: guaiac neg if done, normal tone
  - Skin: sweaty
  - Ext: no C/C/E
  - Neuro: AxOx2, moving all extremities symmetrically, CN2–12 grossly intact
  - FAST: Normal if done
- **TIME 1MIN-2 MIN** (Initial State – Pneumothorax & Agitation & Police)
  - Vitals - BP 185/110 P 155 RR 24 T 100.1 F Sat 100% on NRB
  - Pneumothorax - > if no chest tube will de-saturate to 85% rapidly - > if intubated without chest tube will de-saturate rapidly
  - Right sided chest tube
  - Pain medicine (rib fracture) - > no pain meds, unable to get chest tube
  - Agitation - > if not sedation, more agitated, unable to do exam
  - Ativan for sedation (2-4 mg)
  - Scene control (Police) - > cannot proceed until police removed from bedside
  - Remove Police from the bedside
- **TIME 2 MIN- 4 MIN** (Trauma management)
  - Trauma management
  - Two large bore IV
  - Disability
  - Exposure
  - Labs (type and cross)
  - Trauma team – Wants to wait till he drinks contrast
  - CXR, Pelvis, C spine
  - CT head/Chest/Abd/Pelvis
  - Exam
- **TIME 4–5 MIN** (Herniation and Intubation)
  - Patient becomes increasingly lethargic unresponsive
  - Starts to brady down with irregular breathing pattern
  - VS BP 205/120 HR 55 RR 6–12 Sat 93% on NRB
  - Intubation with RSI and brain protection
  - BP management
  - Labs:
  - Chemistry 7 (normal),
  - CBC (normal),
  - PT/PTT/INR (normal),
  - EtOH level 140
  - Other tox negative
  - CT results:
  - Head CT (+ epidural and subdural bleed);
  - C-Spine: normal
  - CT – chest/abd/pelvis - negative
- **TIME 6–7 MIN** (Head bleed)
  - Elevated ICP management
  - Neurosurgery
  - ICP monitoring
  - Elevate head
  - Hyperventilate
  - Mannitol
  - Maintain BP and Sat
  - Sedation/Ativan

Key Action Items

- Actions for Trauma
  - (1 Min) ABC – recognition of pneumothorax
  - (2–4 Min) ATLS
  - (5–6 Min) CT of Head and C-spine; give results
  - Trauma Surgery consult
  - Control environment – Get police away from patient
- Actions for Airway Management
  - Chest tube
  - RSI with in-line stabilization
- Actions for increased ICP/Bleed
  - Maintain MAP
  - Elevate head
  - Sedation
  - Hyperventilate
  - Mannitol
  - Surgery
  - ICP monitoring
- Actions for Cocaine overdose
  - Sedation with benzos
  - R/O other overdose
  - EKG
  - CT head
- Final Actions:
  - Neurosurgery
  - NSICU
  - Ventriculostomy

Critical Actions

- CT head
- Chest tube placement
- Control environment, i.e. police
- Intubation
- Benzodiazepine

Chapter 9: Standardized Participants

Supplemental Case Scenario: SIDS with Family Witnessed Resuscitation

Scenario Overview

A 2-month-old male baby is rushed in through walk in triage, accompanied by his parents who are both distraught, as well as the triage nurse, who also appears flustered. Per the limited history obtained by the nurse, the baby boy was found to be lying in his crib, apneic by his parents 45 minutes ago. The father had been last to see the baby breathing, when he arose to check in on the child 3 hours earlier. Prior to this the baby had been in his usual state of health. The baby was born prematurely at 34 weeks, and had a brief stay in the NICU prior to discharge from the hospital. The child's vaccinations are up to date, and he has no known allergies or medical problems.

Teaching Objectives

- Clinical and Medical Management
  - Recognition and management of asystolic arrest
  - Placement of IO line (optional)
  - Placement and confirmation of an advanced airway
  - Performance of bedside US to evaluate for cardiac wall motion (optional)
- Communication and Teamwork
  - Identify team leader and roles
  - Calm parents and offer opportunity for family witnessed resuscitation
  - Perform death notification

Target Audience

- Resident (PGY1, PGY2, PGY3, PGY4)
- Fellow
- Attending Physician
- Nurse
- EMT
- Physician Assistant, Nurse Practitioner
- Medical Student (MS4)

ACGME Core Competency

- Patient Care
- Medical Knowledge
- Systems Based Practice
- Professionalism
- Interpersonal Skills and Communication

Supplies & Moulage

- Infant clothes

Images

- Pericardial view Ultrasound movie – no wall motion noted (optional)

Labs

- Point of Care fingerstick glucose - 85

Actors and their roles

- Mother: distraught; crying; pleading with healthcare team to save her son; temporarily consolable; does not obstruct care unless her questions/concerns are ignored by team; if ignored, her behavior will escalate, and she will reach out to hold her son
- Father: distraught; quiet; does not obstruct care unless his wife's concerns are unaddressed by team; in this case he will become angry and start shouting ("do something! You're letting our child die!")
- Nurse: initially flustered as she has been presented with 2 distraught parents and a dead child in walk-in triage; after

this, efficient, will perform assigned tasks as expect with good closed loop communication (alternately, can "forget" to do things if closed loop communication and strong team leadership are being emphasized)

- SimBaby mannequin: cyanotic; remains in asystolic with no vital signs throughout the course of the simulation

Case Flow/Timeline

- **TIME 0** NOTIFICATION BY NURSE**:** 2-month-old male. Found apneic by parents 15 minutes ago. No chest rise noted in triage (vitals not measured, nurse rushed patient back)
  - Vital Signs: BP 0/0, HR 0, RR 0, Pulse ox: unmeasurable
  - 2-month-old male baby – cyanotic; unresponsive
  - IV: none
  - Physical Exam:
  - Gen: Unresponsive, apneic, cyanotic infant, lying still
  - HEENT: normocephalic, atraumatic; fontanelle soft; pupils fixed; trachea midline
  - Neck: no step-off
  - Chest: No breath sounds or chest rise noted;
  - Heart: No heart sounds auscultated
  - Abdomen: soft
  - Rectal: guaiac negative if done; rectal temp 34 C if checked
  - Skin: cyanotic/grey
  - Ext: no c/c/e
  - Neuro: unresponsive;
  - FAST: absence of heart wall motion, if checked
- **TIME 1–2 MIN** (Initial State – Setup, ID of cardiac arrest, begin PALS protocol)
  - Vital Signs – BP 0/0 HR 0 RR 0 T 33.4 axillary sat unmeasurable

    1 provider identifies themselves as team leader, and assigns roles to members

    Team leader specifically assigns someone to speak to parents/obtain collateral history

    Parents are distraught, repeatedly asking for someone to save their child, are standing right next to the bed; if not addressed by a specific team member, their behavior escalates to crying and yelling, disrupting the resuscitation effort

    Team identifies apnea and pulselessness, initiated PALS treatment of cardiac arrest

    Team places pads, identifies asystole rhythm

    Nurse places IV; alternately, if procedural practice is desired, nurse can state they cannot obtain IV; in this case team leader should request IO and team member should place it rapidly
- **TIME 4 MIN** (Family Witnessed Resuscitation, placement of advanced airway)
  - Vital Signs – BP 0/0 HR 0 RR 0 T 33.4 axillary sat unmeasurable

    Team continues resuscitation effort for asystolic arrest

    Blood sugar if checked, is within normal limits

    Advanced airway is placed

    FAST exam, if done, reveals no cardiac wall motion

    A team member continually updates the parents about their child's status; strong preference for stating the child is dead, and the team is doing their best to revive him; reassurance to be provided that the parents have done nothing wrong; If parents are not addressed, their behavior escalates; if ignored, the nurse standardized participant asks team leader to address them, or call security

    Team member should do their best to involve parents in the resuscitation, while ensuring the team's efforts are not disrupted; this can include having the parents hold the child's foot/hand

    If team requests chaplain/social worker, they are notified they are on their way
- **TIME 8 MIN** (Death notification)
  - Vital Signs – BP 0/0 HR 0 RR 0 T 33.4 axillary sat unmeasurable

    Team goes through Hs/Ts

    Team leader breaks off to debrief parents of child's status; if the parents have been properly addressed, they are sad, but calm;

    Team leader pronounces time of death

    Team leader informs parents explicitly of child's death; team leader is to use the word "dead", not "passed on" or any other euphemisms

    Team leader offers to allow parents to remain at child's side for as long as they need to; case ends

Key Action Items

- Actions for Cardiac Arrest Management
  - (1 Min) Recognition of cardiac arrest
  - (1–2 Min) Placement of chest pads
  - (1–2 Min) IO placement (optional)
  - (1st rhythm check) identification of asystole rhythm
  - Administration of epinephrine 0.01 mg/kg q3–5 mins
  - CPR 100–120 compressions/minute, with depth > 1/3 A-P diameter of chest per compression
  - (4–8 Min) Analysis of Hs/Ts for potentially reversible causes of arrest
- Actions for airway management
  - (1 Min) BVM management of patient @ ratio of 15 compressions:2 breaths
  - (4 Min) Placement of advanced airway (likely 3.5 cuffed ETT); then ventilation at 8–10 breaths/min
  - ETCO2 to confirm adequacy of compressions/placement

- Actions for Family Witnessed Resuscitation
  - (1 Min) Assign team member to address parental concerns and get collateral history
  - Team member to continually update parents on patient's status
  - (8 Min) Team leader to update parents on unsuccessful resuscitation attempts
  - (8 Min) Team leader to perform death notification and stopping resuscitation efforts

Critical Actions
- Identification of asystolic arrest with management with epinephrine
- Administration of adequate CPR
- Hypoglycemia check
- Family witnessed resuscitation - assigning team member to address/comfort parents
- Death Notification using the word "death"

Chapter 15: Simulation in Undergraduate Medical Education

Supplemental Case Scenario: Blunt Trauma from MVC

Scenario Overview
45-year-old-male, brought in by ambulance after being involved in a motor vehicle collision. Awake, alert and oriented, can verbalize how the accident happened including that he doesn't remember anything from impact to when EMS was removing him from the car. His chief complaint is difficulty breathing and abdominal pain.

Teaching Objectives
- Clinical and Medical Management
  - Initial management of trauma
  - Recognition and management of pneumothorax
  - Recognition of and management of splenic laceration
  - Proper management of pain
  - Proper use of consultants
- Communication and Teamwork
  - Appropriate communication with nursing
  - Appropriate communication with consultants
  - Proper communication with patient

Target Audience
- Medical student (MS4)

Supplies & Moulage
- Non-rebreather mask
- Simulator clothes
- C collar
- Head injury with blood and gauze

Images
- CXR – Pneumothorax
- EKG – Sinus Tachycardia
- CT head/C-spine – Normal
- US FAST results – positive LUQ
- Chemistry results – normal
- CBC results – normal
- Type and Screen or crossmatch
- Alcohol level

Actors and roles
- EMS: EMS states that they arrived on scene of motor vehicle collision. Mid-size sedan struck telephone pole with extensive damage to front of car. Patient confused upon our arrival. The patient was belted in driver's seat. Airbag had deployed. Complaining of difficulty breathing and abdominal pain. Patient says he swerved to avoid oncoming car, lost consciousness and does not remember accident. Mental status improved during transport.
- Patient: Awake, alert and oriented, can verbalize how the accident happened including that he doesn't remember anything from impact to when EMS was removing him from the car. The patient is extremely concerned about how serious his injuries are, getting his wife to the hospital, and whether he has any permanent damages.
  - Involved in serious, high speed motor vehicle collision.
  - Was driver & only occupant. Was wearing seatbelt.
  - Traveling on a two-lane road and an oncoming car skidded into your lane. You swerved to avoid a direct collision but your car struck a utility pole at high speed.
  - The airbag deployed but you lost consciousness on impact.
  - You awoke, somewhat confused, to EMS personnel trying to pull you out of the car.
  - In the ambulance you began to remember what had happened. You can verbalize what happened up to the point of impact and since EMS pulled you out of the car.
  - Pain in right side of chest (5/10) and it hurts to breathe.
  - Pain in left upper side of abdomen and some nausea.
  - Strapped to a backboard with a collar around your neck, both of which are quite uncomfortable. You are brought into the Emergency Department and placed in the trauma bay. You were taken off the backboard but the collar is still in place.
  - When student enters, you are awake, alert and oriented to person, place and time (you know your name, where you are and what day it is). GCS = 15.
  - You are breathing quickly (about 28 times a minute) because you have a lung injury.

Case Flow/Timeline

- **TIME 0** NOTIFICATION: 45-year-old-male. Involved in MVC. BP: 95/60 HR 130 RR 30 Sat 90% on RA
  - What does the patient look like?
  - Patient is awake and alert, appears to have difficulty breathing but still able to provide a history. Taken off backboard.
  - Vitals:
  - BP: 95/60 HR 130 RR 30 Sat 96% on non-rebreather
  - IV: 18 gauge right AC, NS running at 150 cc/hr
  - Monitor: Sinus tachycardia 135
  - Physical Exam:
  - Physical exam:
  - Gen: AxOx3, on backboard, complaining of pain/difficulty breathing and abdominal pain
  - HEENT: 5 mm and reactive to light bilaterally
  - Neck: Collar – no step-offs
  - Chest: Tachypneic, decreased BS on right, normal BS on left
  - Heart: Tachycardic rate without M/R/G
  - Abdomen: LUQ abdominal tenderness, no distension, no guarding or rebound, +BS
  - Rectal: guaiac neg, normal tone
  - Skin: broken glass on the arms, abrasions on bilateral knees
  - Ext: no C/C/E
  - Neuro: GCS 15, moving all extremities symmetrically, CN2–12 grossly intact
  - FAST: Positive LUQ
- **TIME 1MIN-2MIN** (Placement of chest tube)
  - Vitals-95/60 HR 130 RR 30 Sat 96% on non-rebreather
  - 2 L IVF bolus continued after 18 gauge placed in left AC
  - Pneumothorax, right sided chest tube placed. If not placed, patient's HR increases to 160's and tachypneic to 40.
  - IV pain medication
- **TIME 2MIN-4MIN** (Trauma management)
  - Trauma management-Disability, Exposure
  - Trauma labs drawn-Chemistry, CBC, T&S, Alcohol level
  - Imaging performed-CXR, XR Pelvis, CT head, c-spine, chest, abdomen, pelvis
  - Trauma team consulted, but are unavailable
- **TIME 4MIN-5MIN** (Case conclusion)
  - Vitals-105/65 HR 110 RR 20 Sat 98% on non-rebreather
  - XR results:
  - CXR pneumothorax resolved, chest tube in place
  - XR pelvis, normal
  - CT results:
  - CT head/C-spine, normal
  - CT chest/abdomen/pelvis, grade 2 splenic laceration
  - Trauma team arrives at the bedside, takes patient to ICU for conservative management of pneumothorax and splenic laceration

Key Action Items

- Actions for Trauma
  - ABC'S
  - Recognition of pneumothorax
  - Chest tube placement
  - FAST exam
  - Trauma consultation for +FAST exam
  - Order CT imaging
  - Pain control

Chapter 16: Graduate Medical Education

Supplemental Case Scenario (a): Dyspnea Secondary to Sub-massive Pulmonary Embolism

Scenario overview

An 84-year-old male with a history of chronic obstructive pulmonary disease (COPD) and limited mobility due to osteoarthritis who presents with 2 days of worsening dyspnea. He requires prompt respiratory support and is found to have a COPD exacerbation secondary to a sub-massive pulmonary embolism (PE). The patient has had 2 days of worsening shortness of breath with some mild chest tightness. The chest pain is slightly worse with inspiration. He has not had any change in sputum, cough, fever, or preceding illness but has severe arthritis and has very limited mobility.

Teaching Objectives

- Clinical and Medical Management
- At the conclusion of the debriefing the participant should be able to:
  - Identify PE as an underlying cause of a COPD exacerbation
  - Demonstrate effective management of COPD exacerbation including non-invasive positive pressure ventilation
  - Correctly interpret diagnostic laboratory and imaging studies
- Communication and Teamwork
  - Demonstrate excellent leadership via role allocation, directing events and periodic summarization of the clinical picture
  - Practice clear and concise closed loop communication between all team members
  - Encourage all team members to share ideas and input

Target Audience
- Residents (Mixed PGY 1–4, PGY4 residents can play a supervisory role)

ACGME Core Competency
- Patient Care
- Medical Knowledge
- Systems Based Practice
- Professionalism
- Interpersonal Skills and Communication

Supplies & Moulage
- High fidelity simulator
- Oxygen mask
- BiPAP machine
- Cardiac Monitor

Images
- EKG: Sinus tachycardia with non-specific ST changes
- Chest x-ray: Hyperinflated lungs, no consolidation
- Bedside Ultrasound: no b lines in lung fields, normal lung sliding, heart with mild RV dilation, and non-compressible right lower extremity deep veins (if requested)
- Chest CT: Saddle pulmonary embolus

Labs
Normal except for:
- ABG: 7.31/46/59
- Troponin T: 0.05
- BNP: 3000

Actors and roles
- Pre-hospital report provided verbally by faculty

Case Flow/Timeline
- **TIME 0** NOTIFICATION:
  - Vital Signs: T36.5 HR 110 BP 127/68 RR 24 SpO2 78% on room air
  - What does the patient look like?
  - The patient is speaking in short sentences with obvious respiratory distress
  - Vitals:
  - HR 110 BP 127/68 RR 24 T36.5 SpO2 78% on room air
  - IV: None
  - Monitor: Not attached
  - Physical Exam:
  - Gen: A&Ox3
  - HEENT: PERRL
  - Neck: Normal
  - Chest: Tachypnea, bilateral wheezing throughout
  - Heart: Tachycardic without M/R/G
  - Abdomen: Soft NT,ND
  - Skin: Cyanosis
  - Ext: Right lower extremity edema (if requested)
  - Neuro: Moving all extremities symmetrically, CN2–12 grossly intact
- **TIME 1–2 MIN** (Initial State)
  - Vital Signs
  - Patient is placed on the monitor and IV is established
  - Supplemental oxygen is provided
  - Team roles are established
  - History is obtained and examination is performed
  - EKG requested
  - Labs sent
  - Imaging requested
- **TIME 4 MIN** (Management of respiratory distress)
  - If no oxygen placed, oxygen saturations fall to 70%
  - If non-rebreather placed or nebulizers started, oxygen level improved to 87%
  - Decision made to initiate non-invasive positive pressure ventilation (CPAP or BiPAP)
  - EKG results, lab results, and chest x-ray provided
  - Bedside ultrasound results provided (if requested)
- **TIME 6 MIN** (Additional treatment)
  - Oxygen saturations improve to 90% on CPAP or BiPAP, HR remains 112, BP drops to 110/66, RR 20
  - Additional treatment initiated for COPD (steroids, antibiotics)
  - Consider underlying etiology including PE
- **TIME 8–10 MIN** (Final Actions)
  - Oxygen Saturation 90% on CPAP or BiPAP, HR 112, BP 110/66, RR 20
  - Consider chest CT or anticoagulation
  - Admit the patient to the ICU

Critical actions
- Recognize respiratory distress and provide supplemental oxygen
- Initiate non-invasive positive pressure ventilation
- Initiate medical therapy for COPD exacerbation
- Consider possible causes of COPD exacerbation
- Admit the patient to the ICU

Chapter 16: Graduate Medical Education

Supplemental Case Scenario (b): Sepsis Secondary to Pneumonia with ARDS

Scenario overview
A 66-year-old obese female who presents with pneumonia, sepsis, and hypoxia who develops ARDS. The patient arrives via EMS with confusion, fever, respiratory distress, and hypoxia despite non-rebreather supplemental oxygen. Participants will need to perform a difficult airway assessment and plan accordingly in order to have a successful intu-

bation. Once intubated, the patient will have imaging, labs, and hemodynamic parameters consistent with ARDS.

Teaching Objectives
- Clinical and Medical Management
- At the conclusion of the debriefing the participant should be able to:
  - Identify the need for intubation and perform difficult airway assessment
  - Adjust the intubation plan to include preoxygenation, fluids, and pressors
  - Diagnose ARDS and provide appropriate mechanical ventilation
- Communication and Teamwork
  - Demonstrate excellent leadership via role allocation, directing events and periodic summarization of the clinical picture
  - Practice clear and concise closed loop communication between all team members
  - Encourage all team members to share ideas and input

Target Audience
- Residents (Mixed PGY 1–4, PGY4 residents can play a supervisory role)

ACGME Core Competency
- Patient Care
- Medical Knowledge
- Systems Based Practice
- Professionalism
- Interpersonal Skills and Communication

Supplies & Moulage
- High fidelity simulator (can be obese)
- Oxygen mask
- Intubation equipment
- Cardiac Monitor

Images
- EKG: Sinus tachycardia with no ST-T wave changes
- Chest x-ray: Bilateral infiltrates
- Bedside Ultrasound: Hyperdynamic heart. IVC collapsing. Lungs with diffuse B lines

Labs
- ABG on 100% FIO2: 7.2/55/60

Actors and roles
- None. Pre-hospital report provided verbally by faculty

Case Flow/Timeline
- **TIME 0** NOTIFICATION:
  - Vital Signs: T101.8 HR 120 BP 92/60 RR 24 SpO2 84% on room air, 90% Nasal Cannula
  - What does the patient look like?
  - The patient is speaking in short sentences with obvious respiratory distress
  - IV: None
  - Monitor: Not attached
  - Physical Exam:
  - Gen: A&Ox2
  - HEENT: PERRL, normal
  - Neck: normal
  - Chest: Tachypnea, diffuse rhonchi
  - Abdomen: NT, ND, no R/G/R, hyperactive bowel sounds
  - Rectal: guaiac neg if done, normal tone
  - Skin: sweaty
  - Ext: no C/C/E
  - Neuro: AxOx2, moving all extremities symmetrically, CN2–12 grossly intact
  - FAST: Normal if done
- **TIME 1–2 MIN** (Initial State)
  - Vital Signs
  - Patient is placed on the monitor and IV is established
  - IV fluid bolus provided
  - Supplemental oxygen is provided
  - Team roles are established
  - History is obtained and examination is performed
  - EKG requested
  - Labs sent
  - Imaging requested
- **TIME 4 MIN** (Intubation)
  - If no oxygen placed, oxygen saturations fall to 70%.
  - If non-rebreather placed, sat rises to 95%. Rises to 99% with non-invasive PPV
  - Blood pressure falls to 80/50 if no fluids provided. Rises 10mmhg for each liter provided. Rises to 110/68 if vasopressors started
  - EKG results, lab results, and chest x-ray provided
  - Bedside ultrasound results provided (if requested)
  - Decision made to intubate
- **TIME 6 MIN** (Intubation and Ventilator Management)
  - If pt not preoxygenated before intubation, pt will have hypoxic (PEA) arrest with ROSC after 1 round of CPR
  - If full dose Etomidate given, drop BP to 77/45
  - If Ketamine or appropriate dose given, uneventful intubation
  - After intubation, inform that the patient is started on ventilation with setting of AC 600, RR 12, FIO2 1.0 and PEEP 0. Oxygen saturation 87%.
- **TIME 8–10 MIN** (Final Actions)
  - ABG provided and residents must adjust ventilator settings
  - Diagnose ARDS

 - Patient starts "bucking" vent if no sedation started. Start sedation
 - Patient become hypotensive if sedation started without pressors
 - Order antibiotics
 - Patient admitted to ICU

Critical actions

- Recognize and intervene in abnormal vital signs
- Recognize need for definitive airway
- Perform difficult airway assessment and identify difficult airway
- Prepare for difficult airway with preoxygenation, preparation and correct medication dosing
- Recognize ARDS and adjust ventilator settings

Chapter 18: Simulation in Emergency Medical Services

Supplemental Case Scenario (a): Esophageal Varices

Scenario overview

- The patient is a 54-year old man with a history of alcohol and hepatitis C related cirrhosis who complains of dark coffee-ground emesis since yesterday evening. He has been nauseous and vomiting intermittently, approximately 8 times in total and is actively vomiting bright red blood on scene. After your team arrives, he appears to experience an aspiration event and becomes acutely hypoxic to the 70s. The closest hospital with an emergency department is approximately 10 min from scene; the nearest trauma center is approximately 35 min from scene.
- This is a straightforward case of an upper GI bleed with an aspiration event. The case may be tailored to the level of the learner, and may be made more challenging by altering the vital signs or making the intubation progressively difficult.
  - VARIATION: The patient is hemodynamically unstable due to ongoing GI losses and hemorrhagic shock. The patient must be hemodynamically optimized with volume and vasopressors prior to airway management.
  - VARIATION: Airway management may be made progressively challenging by adding bloody vomitus (see below) to the airway simulator, obstructing the learners' view.

Teaching Objectives

- Clinical and Medical Management
  - Demonstrate appropriate management of an aspiration event
  - Recognize and appropriately manage patient unable to protect airway
  - Describe indications for intubation
  - Appropriately manage volume resuscitation in a patient with upper GI bleed
- Communication and Teamwork
  - Appropriately direct first-responders to ventilate patient with BVM
  - Appropriately utilize responders to orchestrate patient extrication
  - Communicate airway plan with team members

Target Audience

- EMT-Basic
- EMT-Paramedic
- Firefighter
- Resident (PGY 1–4 on EMS rotation)

ACGME Core Competency

- Patient Care
- Medical Knowledge
- Systems Based Practice
- Interpersonal Skills and Communication

Supplies & Moulage

- Medication bottle for nadolol (or other beta blocker)
- Empty beer cans/liquor bottles
- Basin with bright red emesis[1] with some emesis dabbed on patient's mouth, white makeup liberally applied to patient's face, light blue eye shadow under eyes to create sunken effect, sweat mixture (water + glycerin) sprayed to patient's face.

Images

- 12-lead ECG demonstrating sinus tachycardia

Labs

- POC glucose 92 mg/dl
- POC lactate 2.8 mmol/L

Actors and roles

- 2 fire-fighters on-scene trained to the *first-responder* level (cannot perform or assist with advanced airway management or venous access)
- Wife – will provide additional history on patient condition if asked

[1]Recipe: ¾ cup water, 1 Tbs instant oatmeal, 1 Tbs lubricating jelly, 2 Tbs brewed coffee, 1 tsp plain yogurt, 4 drops red food coloring. Mix all ingredients in a basin and allow to sit for ~5 min or until oatmeal has softened. Pretreat garments and patient as necessary.

Case Flow/Timeline

- **Time 0** NOTIFICATION: Dispatch- "Paramedic 2, stand by for Code 3 traffic. Please proceed to 1st and Rogers for 54-year-old male with lightheadedness and vomiting. Fire rescue is already on scene."
  - What does the patient look like?
  - Ill-appearing patient who vomits and appears to suffer an aspiration event immediately after the team arrives.
  - Initial interventions: Vital signs obtained by FF, patient placed on nasal cannula at 2 lpm by FF.
  - Vitals:
  - BP 110/75; HR 130; RR 28 (shallow); SpO2 72% RA; 37.1C
  - IV: none
  - Monitor: Sinus tachycardia
  - Physical Exam:

    Gen: Critically ill appearing, dusky face and extremities

    HEENT/Neck: Perioral cyanosis, copious frank blood in the oropharynx

    CV: Tachycardic, regular rhythm

    Resp: Acute respiratory distress, irregular shallow breathing pattern, gurgling respirations

    Abd: Distended, non-tender, +fluid wave

    Ext: 1+ pitting edema of the bilateral lower extremities

    Neuro: Obtunded, localizes to painful stimuli, spontaneous movement of all extremities
- **TIME 1 MIN-2 MIN** (Initial State)
  - Vitals: BP 108/77 HR 128 RR 15 (bagged) 90% BVM (improving)
  - Frank blood cleared from airway, cyanosis and respirations improve with 2-person BVM ventilation
  - If 1-person BVM ventilation is used, patient will not be successfully ventilated and will remain hypoxic
  - Labs available: POC glucose
  - Imaging available: Cardiac monitor showing sinus tachycardia
  - Patient's Wife – Will provide additional history if asked. Patient has not been feeling well for the past 2 days. He has had some general GI upset with loose stool, and today began vomiting. IF ASKED, stool was dark and tarry. IF ASKED, vomit was dark and looked like coffee grounds.
  - Students should consider advanced airway management given patient's decreased LOC and aspiration risk.
- **TIME 2 MIN-4 MIN** (Airway management)
  - Vitals: BP 110/74 HR 129 RR 12 95% BVM
  - Patient continues to decline. If respirations are not supported oxygen saturation will continue to decline.
  - Labs available: POC lactate
  - Imaging available: 12-lead ECG showing sinus tachycardia without evidence of ischemia
  - Additional FF or EMS – Ventilate patient, retrieve stretcher from ambulance
  - One team-member or standardized participant will need to leave the scenario for 2–3 minutes to retrieve the patient stretcher. Ventilation will continue to require 2-person technique.
  - Withhold IVF bolus
  - Decide on airway plan
  - Begin extrication to ambulance
  - Team may elect to secure airway at this point
- **TIME 3 MIN–10 MIN** (Intubation and extrication)
  - Vitals: BP 109/75 HR 124 RR 12 96% BVM
  - Airway secured via endotracheal intubation. Continuous capnography demonstrates good waveform with an end-tidal CO2 of 40 mm Hg with ventilation.
  - FF – ventilate patient through ETT
  - EMS/partner – assist with moving patient to stretcher, drive ambulance
  - Extrication and transport should be initiated shortly after the airway is secured.
- **TIME 10 MIN** (Final Actions)
  - Vitals: BP 108/72 HR 125 RR 12 99% ETT
  - If fluid bolus administered: BP 90/55, HR 138
  - Learners should deliver radio report to receiving hospital.

Key Action Items:

- Actions for Airway Management
  - Suction airway
  - Apply high-flow oxygen
  - Begin ventilations with BVM
  - Decide on airway plan
  - Secure airway via ETI

Critical actions

- Obtain initial vitals / Reassess frequently
- Perform focused history and physical exam
- Obtain large-bore IV access x2
- Do not give IVF
- BMV with good technique and/or intubation

Chapter 18: Simulation in Emergency Medical Services

Supplemental Case Scenario (b): STEMI

Scenario overview

The patient is a 56-year-old obese male complaining of severe substernal chest pain of 10 minutes duration. He just finished the Triple Bypass burger and a large beer when he had gradually worsening pain, which he describes as burning with radiation to the right shoulder. He is also complaining of an acid taste in his throat, nausea and has vomited x1. He has a history of reflux and takes omeprazole twice daily. The nearest community hospital is 3 minutes from scene; the nearest PCI-capable facility is 10 minutes from scene.

This is a case of an uncomplicated anterolateral STEMI. The case may be tailored to the level of the learner, and may be made more challenging by altering the vital signs or making the intubation progressively difficult.

- VARIATION: The patient is hemodynamically unstable due to compromised cardiac function following infarction. The patient will require careful preload optimization and consideration of an inotrope to restore adequate tissue perfusion. This may lead to a discussion of point-of-entry protocols for unstable patients with STEMI.
- VARIATION: The patient may suffer cardiac arrest and require full ACLS resuscitation. The patient will achieve ROSC if resuscitated appropriately, and necessary post-cardiac arrest care should be performed.
- VARIATION: The communication objectives can be made more challenging by changing the degree to which the patient's wife interferes with patient care. If not addressed promptly by learners, the wife will progress to agitation and require verbal de-escalation to enable appropriate patient care.

Teaching Objectives/Discussion Points

- Clinical and Medical Management
  - Understand the broad differential of chest pain, including potential cardiac, respiratory, gastrointestinal and musculoskeletal causes
  - Demonstrate appropriate management of a life-threatening cardiac presentation
- Communication and Teamwork
  - Demonstrate respectful and professional interaction with an anxious, disruptive family member
  - Utilize effective therapeutic communication to manage/calm an anxious patient and family member

Target Audience

- EMT-Basic
- EMT-Paramedic
- Firefighter
- Resident (PGY 1–4 on EMS rotation)

ACGME Core Competency

- Patient Care
- Medical Knowledge
- Systems Based Practice
- Interpersonal Skills and Communication

Supplies and Moulage

- Dining table with two place settings and remnants of an apparently large meal
- Sweat solution (glycerin + water) sprayed liberally over patient's face and neck

Images

- 12-lead ECG demonstrating prominent ST-segment elevations in V1 – V4

Labs

- POC glucose: 145 mg/dl
- POC lactate: 1.2 mmol/L

Actors and roles

- Embedded Participant 1 and 2: EMT-Basics (able to perform basic life support but unable to perform advanced airway management, establish venous access, or administer medications)
- Embedded Participant 3: Patient's wife, who is visibly upset and insists on immediate transport (even prior to any assessment or intervention by learners)

Case Flow/Timeline

- **TIME 0** NOTIFICATION: On arrival, standardized participant 3 (patient's wife) states "Oh, good, you're here. He needs to go to the hospital right away. Please hurry."
  - What does the patient look like?
  - Patient is anxious but in no respiratory distress.
  - Initial interventions: Vital signs obtained by standardized participant 1, patient placed on nasal cannula at 4 lpm by standardized participant 2.
  - Vitals:
  - BP 165/82; HR 89; RR 20 (unlabored); SpO2 99%RA; Temp 37.2C
  - IV: None
  - Monitor: Sinus rhythm w/ occasional unifocal PVCs
  - Physical exam:
  - Gen: Appears uncomfortable, diaphoretic
  - HEENT/Neck: Unremarkable
  - CV: Regular rate and rhythm, no murmurs
  - Resp: Clear to auscultation throughout
  - Abd: Obese, distended, non-tender throughout
  - Ext: Warm and well-perfused
  - Neuro: Alert and oriented, moving all extremities equally
- **TIME 1 MIN - 2 MIN** (Initial State)
  - Vitals: BP 164/85; HR 84; RR 20; SpO2 99%RA or 100% NC
  - If oxygen therapy continued patient will begin to complain about "these things in my nose" and ask why he needs it.

  - Labs available: POC glucose
  - Imaging available: Cardiac monitor showing sinus tachycardia
  - EMT Basic 1 – Obtain repeat vital signs
  - EMT Basic 2 – Attempting to obtain history from patient's wife
  - Patient's wife – Insists that the patient be taken to the hospital immediately and continually asks why the learners/providers are "not doing anything" and "wasting time"
  - Learners should recognize a high-risk cardiac presentation and consider implementing the ACS treatment algorithm (e.g. aspirin, nitroglycerin, pain management).
  - Learners should attempt to calm the patient's wife (standardized participant 3) and explain the need for their assessment and management prior to transporting the patient. Learners should exhibit effective communication techniques and consistently interact with the patient and patient's wife in a professional and respectful manner.
- **TIME 2 MIN - 5 MIN** (EKG and IV Access)
  - Vitals: No change
  - Physical exam remains unchanged.
  - Labs available: POC lactate
  - Imaging available: 12-lead ECG showing ST elevation in anterolateral leads with occasional ectopy
  - EMT Basic 1 – Repeat vital signs, retrieve stretcher from ambulance
  - EMT Basic 2 – Assists learner as directed
  - Patient's wife – Provides information as prompted by learner, occasionally interjecting "please hurry" or "can we go now?"
  - EMT Basic 1 will leave the scenario for 2–3 minutes to retrieve the patient stretcher.
  - Learners should ask the patient about any allergy to aspirin or evidence of recent bleeding; the patient will report neither. Learners should then administer a therapeutic dose of aspirin. If chewable tablets are used, the patient should be instructed to chew, then swallow the tablets.
  - If IV access is obtained, it will flow freely if secured properly
- **TIME 3 MIN – 8 MIN** (Extrication and Transport)
  - Vitals: BP 155/80; HR 95; RR 24; SpO2 99%RA
  - Patient becomes more anxious after aspirin administration, asking "What's wrong with me? Am I having a heart attack?"
  - Remainder of exam unchanged.
  - EMT Basic 1 – Returns with patient stretcher, assists learners in moving patient as directed, drive ambulance
  - EMT Basic 2 – assist with moving patient to stretcher, drive second ambulance
  - Patient's wife – Continues same behavior but can be redirected/calmed with appropriate communication from learners. Will accompany patient in same vehicle (and thus continue to be able to communicate with learners).
  - Extrication and transport should be initiated shortly after EMT Basic 1 returns with the patient stretcher. Learners should not delay transport to obtain venous access (if not already obtained).
  - Learners should continue to use effective therapeutic communication techniques with patient and the patient's wife. Learners should answer questions honestly and attempt to minimize patient discomfort and anxiety.
  - Learners should ask appropriate screening questions prior to administration of nitroglycerin. Patient will report recent (within last 24 hours) use of vardenafil if prompted. Learners should withhold nitroglycerin.
  - If nitroglycerin is administered, the patient will become hypotensive after 2 minutes; if unrecognized, the patient will become unresponsive after another 3 minutes.
  - Once transport is initiated, standardized participants 1 and 2 will no longer be available (as they will be driving both ambulances).
- **TIME 4 MIN– 10 MIN**
  - VS (no NTG): BP 148/77; HR 87; RR 22; SpO2 99%RA
  - VS (with NTG): BP 88/42; HR 122; RR 24; SpO2 99%RA
  - If NTG given, patient's mental status deteriorates over 3–5 min
  - Repeat 12-lead ECG demonstrates progression of ST changes with new extension into leads I, aVL.
  - EMT Basic 1 – Unavailable
  - EMT Basic 2 – Unavailable
  - Patient's wife – Physically removed from simulation, but intermittently interjects questions such as "how is he doing?" and "is he going to be okay?" and attempts to talk directly with patient.
  - If NTG given and the patient becomes hypotensive, he will respond well to a bolus of fluid with normalization of his vital signs and mental status
  - If pain management considered, either fentanyl or morphine is appropriate, and patient will report significant pain relief following an appropriate dose of either.
  - Learners can obtain second point of venous access.
  - Learners should continue to explain the situation and interventions to the patient and, as necessary, the

patient's wife. Effective communication will result in decreased anxiety in both; ineffective or absent communication will result in escalating anxiety in both, including tachycardia in the patient.
  - Learner should explicitly notify receiving facility of "STEMI alert"
  - Learner should obtain repeat EKG
  - Apply defibrillator pads to patient
- **Final Transition Point – 15 Minutes**
  - VS (no NTG): BP 138/74; HR 84; RR 16; SpO2 99%RA
  - Exam unchanged
  - Repeat 12-lead ECG unchanged.
  - Prior to arrival at the ED, learners should obtain a new set of vital signs and repeat 12-lead ECG.
  - Learners should provide ED staff with a transfer of care report that effectively summarizes the scenario and their interventions.

Key Action Items
- Action Items for STEMI:
  - Identify high-risk cardiac presentation and obtain 12 lead EKG
  - Discontinue oxygen therapy
  - Identify STEMI
  - Ask appropriate screening questions prior to aspirin administration

    Administer aspiring 325 mg (or 4 × 81 mg tablets)
  - Establish IV access
  - Extricate patient and begin transport to PCI-capable facility
  - Ask appropriate screening questions prior to nitroglycerin administration

    Withhold nitroglycerin based on recent PDE5 inhibitor use

Critical Actions
- Perform focused history and physical exam
- Obtain ECG and recognize STEMI
- Give full dose aspirin (325 mg, chewed)
- Transport patient to PCI-capable facility
- Utilize effective communication to help calm an upset/anxious family member

Chapter 19: Pediatric Emergency Medicine

Supplemental Case Scenario: Coarctation of the Aorta

Scenario overview

Nurse brings an infant into the trauma room and she is concerned with the way the baby looks, the color is very grey and mottled. Patient was driven in by parent and the parent is at the bedside.

Teaching Objectives
- Clinical and Medical Management.
  - Review differential related to lethargic 2-week-old
  - Recognize signs and symptoms of a ductal dependent lesion
  - Treat heart failure from a critical coarctation
  - Recognize and treat hypoglycemia in an infant
- Communication and Teamwork.
  - Identify team roles and leader
  - Organized team approach to resuscitation
  - Communication and management of family

Target Audience
- Residents (PGY1, PGY2, PGY3, PGY4)
- Fellows
- Attending Physicians
- Nurses

ACGME Core Competency
- Patient Care
- Medical Knowledge
- Practice Based Learning and Improvement
- Systems Based Practice
- Professionalism
- Interpersonal Skills and Communication

Supplies & Moulage
- Meds: RSI meds, prostaglandin E, Dextrose
- Equipment: Intraosseous access equipment, airway
- No specific moulage

Images
- EKG RVH (normal for age), upright t wave V1(abnormal after 3 days of life) (Fig. A1.4)
- CXR intubated infant with NG tube in place (Fig. A1.5)

Labs:

CBC		**Chem7/lactate**	
WBC (3.5–11.0) K/uL:	18	Na (135–145) MEQ/L:	134
HGB (11.0–15.0) G/DL:	16	K (3.6–5.1) MEQ/L:	4.8
HCT (32.0–45.0) %:	46	Cl (98–110) MEQ/L:	102
PLT (150–400) K/uL:	507	CO2 (20–30) MEQ/L:	8
SEG NEUT %:	43	BUN (6–24) MG/DL:	19
BAND NEUT %:	0	Creat (0.4–1.3) MG/DL:	0.8
LYMPH %:	47	Glue (67–109) mg/dl:	55
MONO %:	10		
		Lactic acid (0.2–2.2) MEQ/L:	Pending
Coagulation panel		**I-stat (drawn before dextrose given)**	
PT (11.0–13.2) SEC:	12	VBG	
PT INR:	1	pH	7.1

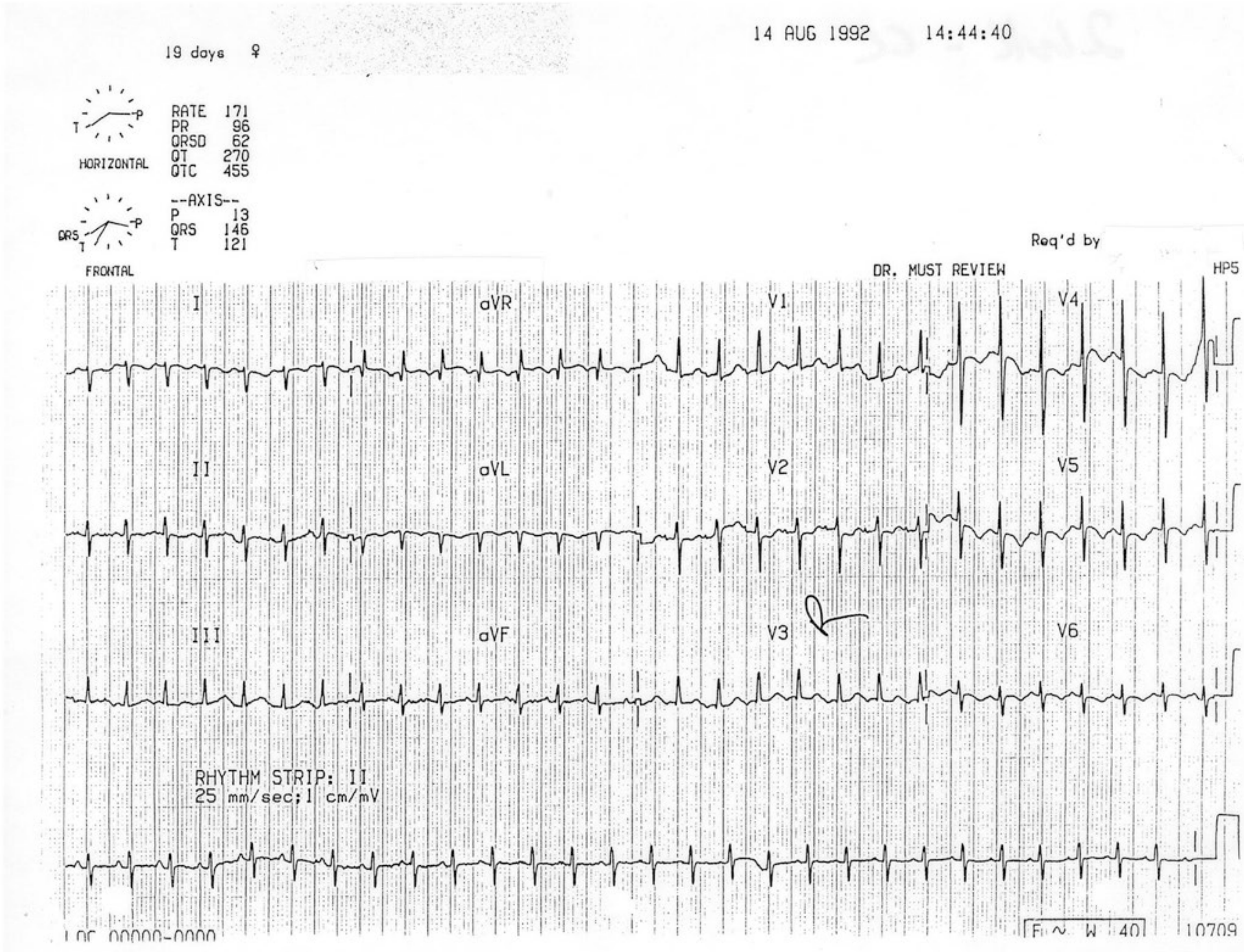

Fig. A1.4 EKG RVH (normal for age), upright t wave V1(abnormal after 3 days of life)

PTT (21.0–33.0) SEC:	24	PCO2	28
		PO2	25
Urinalysis		HCO3	8
SG	1.031	BE	−20
Ph	6	HCT	45
Nit –	neg	Glu	20
LE –	neg		
Prot -	neg		
Blood -	neg		

Actors and roles

- **Parent**: will be present and extremely concerned and will become distraught if not managed well by the team. They will be able to provide the history as described above. If team is not informing parent of what is going on, parent has the option of escalating "What is going on with my son? Why isn't anyone telling me what's wrong with him, he was fine 2 days ago!!" When they go to intubate, if not informed, will ask "Does that hurt him, what are you doing??"

Fig. A1.5 Chest x-ray of an intubated infant with NG tube in place

- **Nurse (embedded participant)**: This is a critical role to provide the physical findings since infant mannequins do not simulate poor perfusion. He/She will say "I am really concerned about the baby's color, he looks grey and mottled." The nurse will attempt and fail at IV insertion, "I can't seem to find a good vein, the perfusion is very poor." The nurse standardized participant will need to present physical findings as the team examines the patient. See Physical Exam below.
  After Prostaglandins are started, the nurse will report "the perfusion is much better".

Case Flow/Timeline

- **TIME 0** (Initial state)
  – What does patient look like?
  – Patient is pale, lethargic, with a weak intermittent cry.
  – Vitals: BP 60/30 right arm (45/15 on lower extremities if checked), HR 145 RR 60 T 99.0 rectal O2 Sat – 94% (RA) on right arm, O2 sat will be not present if any other extremity
  – Estimated wt. 4 kg
  – IV: none
  – Monitor: Sinus tachycardia at 180
  – Potential information with HPI and ROS if asked:
  – 2-week-old former 37-week gestation
  – NSVD with lethargy which has gradually increased over the past 2–3 days
  – Less interested in feeding
  – Last UOP was last night
  – Sleeping more
  – Felt warm but no documented fever
  – GBS neg, no risks for infection
  – No trauma
  – No emesis
  – No diarrhea
  – No URI symptoms
  – Sister has a cold
  – No meds
  – No allergies
  – No PMHx
  – Physical exam:
  – Gen: pale, lethargic, does open eyes to stimulation
  – Airway: cries intermittently, weak cry
  – Breathing: shallow respiration, coarse breath sounds bilaterally
  – CV: tachycardia, you may hear a systolic murmur but difficult to tell with tachycardia, no femoral or LE pulses palpable with cap refill >4 seconds, right radial pulse is palpable.
  – HEENT: anterior fontanel is sunken, (remove foam insert is using SimBaby) and dry mucous membranes
  – Neck: supple, no meningismus
  – Abd: soft NT, liver edge 2–3 cm below costal margin
  – Skin: mottled, no bruising and no petechiae
  – Expected interventions I:
    Request vital signs and monitors
    Request IV access and oxygen
    Request D-stick
    Request fluid bolus
    Request IV antibiotics (amp/gent or amp and cefotaxime)
  – Nurses are unable to get IV access, will require an I/O
  – Patient will be hypoglycemic (fingerstick point of care 25 mg/dl)(55 mg/dl on chemistry panel)
  – Father rushes to the bed and keeps asking, "what's wrong with my baby, what's wrong with my baby?" If the leader doesn't address the situation, he continues to get more hysterical.
- **TIME 2 MIN-4 MIN** (hypoglycemia and begins to decompensate)
  – Vitals: BP- 60/30 right arm (45/15 on lower extremities if checked), HR 180, RR 60, O2 Sat – 90% (on NRB) on right arm
  – Expected Intervention II:
    I/O access
    Administer antibiotics
    Administer fluids and dextrose
  – Recognizes hypoglycemia should give D10 W 5-10 cc/Kg (20-40 cc)
  – Nurse can report that the baby becomes a little more active after dextrose given
- **TIME 4 MIN-7 MIN (**remains in shock/poor perfusion)
  – Vitals: BP - 60/30 right arm (45/15 on lower extremities if checked), HR 180, RR 60, O2 Sat – 90% (on NRB) on right arm
  – Vital signs and perfusion no better with oxygen and fluid resuscitation
  – If point of care VBG requested, will be available
  – Point of care VBG (will state sample is before dextrose if dextrose administered)
  – Glucose 20, pH -7.10, PCO2–28, PO2–25, HCO3–8, BE – (−20) HCT – 45
  – CBC (elevated WBC and PLTs)
  – Chemistry panel (metabolic acidosis, hypoglycemia)
  – U/A (high spec gravity)
  – PT/INR, PTT (normal)
- **TIME 7 MIN-10 MIN** (worsening shock)
  – Expected Intervention III:
    Intubation
    NG tube
    Prostaglandins
  – If 7 minutes pass and no PGE given, will decompensate, worsening hypoxia with HR 180, BP 50/30, RR-60, O2 sat of 70% (on NRB)
  – If PGE are given and not intubated, one minute after PGE, will become apneic and require airway management (either BVM or intubation)

- Intubation will stabilize HR at 160, BP 60/30, and O2 sat at 70% (on 100%)
- If intubated without dextrose HR remains 200, BP 60/30 and O2 sat 70% (on 100%)
- Nurses will be required to mix up Prostaglandin E drip
- After PGE drip started, HR comes down to 140, BP 70/35, RR-0 and O2 sat gradually go to 98%. Nurse reports "the perfusion is significantly better"
- Should be intubated with:
  - 4.0 uncuffed ETT or 3.5 cuffed ETT
  - Straight blade size 1
  - Approximately 12 at the lip
- RSI:
  - Atropine 0.1 mg (depending on heart rate)
  - Midazolam 0.4 mg
  - +/− fentanyl 4 mcg
  - Vecuronium 0.4 mg or Rocuronium 4 mg or Succinylcholine 4 mg
- Ketamine is an option but will exacerbate tachycardia
- Would not recommend barbiturates with cardiovascular side effects
- Would not recommend etomidate if sepsis is on the differential due to adrenal suppression
- They will have available an EKG and Chest X-ray if they request them. They will come in a realistic time frame.

• **10 MIN-12 MIN** (Final actions)
  - Expected intervention IV:
    - Cardiology consult or transfer
    - Discuss situation with parent

Key Action Items

This case does not have definitive actions to move the case along but is more driven by time and the patient decompensating until the prostaglandins are started.

- Actions for hypoglycemia – HR improves by 20 bpm and verbal report that patient slightly more active
- Actions for hypoxia – hypoxia will progressively worsen until PGE started to reinforce that the etiology is cardiac and pulmonary
- Actions for hypotension – hypotension will also slightly worsen until PGE started to reinforce it is primarily cardiac related and not fluid responsive

Critical actions

- Recognition of ductal dependent lesion as part of differential of lethargic 2 infant
- Treatment of hypoglycemia
- Prostaglandin E for ductal dependent lesion
- Airway management for an infant
- Antibiotics for lethargic infant

Chapter 20: Trauma

Supplemental Case Scenario (a): Pediatric Head Trauma

Scenario overview

A 2 year previously healthy male, fell from a second-story window, landing on his head and right side on a dirt surface. Immediately following the fall, the patient had a brief episode of seizure-like activity which resolved spontaneously. Emergency Medical Services (EMS) responded to the scene, secured the patient to a backboard, placed a hard cervical spine collar, and transported the patient to the Emergency Department. During the transport, the patient was reportedly agitated, crying, and had intermittent apneic episodes. On arrival to the ED the patient is on a backboard with cervical spine collar in place, there is no vascular access, and the patient is agitated and crying.

Teaching Objectives

• *Clinical and Medical Management.*
  - Identify steps to prepare for the potentially critically injured pediatric patient
    - Select appropriately sized equipment for a potentially critically injured pediatric patient using a color-coded, length-based resuscitation tape
    - Identify appropriate medication dosing for a potentially critically injured pediatric patient using color-coded, length-based resuscitation tape
  - Recognize the indications for endotracheal intubation (definitive airway management) in the head-injured pediatric patient.
    - Respiratory distress/failure
    - Patient inability to control airway
    - Predicted course
  - Describe the approach to rapid sequence intubation (RSI) of the head-injured pediatric patient.
    - Pre-oxygenation
    - Pre-medication for suspected increased intra-cranial pressure
    - Choice of induction agent
    - Choice of paralytic agent
  - Identify the diagnostic evaluation of the head-injured pediatric patient
    - Neurologic examination including pediatric Glasgow Coma Scale (GCS)
    - Appropriate imaging study (CT of head)
  - Describe the initial management of the pediatric patient with an intra-cranial bleed
    - Monitor for signs of increased intra-cranial pressure
    - Interventions to avoid hypotension

Interventions to avoid hypoxia
Immediate Neurosurgical consultation

- *Communication and Teamwork.*
  - Identify team roles and team leader
  - Demonstrate call-out (team member verbalization of observation or change to make team aware) within the team communication framework
  - Demonstrate closed-loop communication within the team communication framework

Target Audience

- Resident (PGY1, PGY2, PGY3, PGY4)
- Fellow
- Attending Physician
- Nurse
- Physician Assistant

ACGME Core Competency

- Patient Care
- Medical Knowledge
- Systems Based Practice
- Professionalism
- Interpersonal Skills and Communication

Supplies and Moulage

- Length-based, color-coded resuscitation tape
- Appropriately sized airway equipment for a pediatric patient (endotracheal tube, laryngoscope and blade)
- Intraosseous (IO) drill for vascular access
- Pediatric cervical spine collar
- Infant/toddler mannequin with scalp hematoma

Images

- CT head – demonstrates skull fracture with epidural bleed

Labs

- Not necessary for scenario

Actors and roles

- EMS – Describe brief overview of event (fall from 2nd story window and ground surface) including seizure-like activity following fall. Provide details of patient's condition at the scene (agitated and crying, unable to console), interventions (cervical spine collar and backboard for transport), and patient's condition during transport (agitated, crying, inconsolable, intermittent apnea that terminates with stimulation). Also communicate that there is no vascular access on arrival to the ED.
- Nursing – Facilitates management of case with physical examination findings. Provide closed-loop communication during progression of case.
- Patient simulator – Crying on arrival, does not respond appropriately for age, intermittently becomes somnolent and then apneic (patient responds to stimulation by crying). Apneic episodes become more frequent as scenario progresses.

Case Flow/Timeline

- **TIME 0** NOTIFICATION: 2-year-old male status-post fall from second story window. BP 94/70 HR 151 RR 40 Sat 97%
  - What does the patient look like?
  - Patient is agitated and crying loudly on arrival. Patient's eyes are closed, moving all extremities symmetrically, and does not respond appropriately to voice or physical stimulation.
  - Vitals
  - BP 94/70 RR 40 HR 151 O2 sat 97% T 98.6 ° F
  - Weight – estimated 12 kg on length-based, color-coded tape (to be performed by participants – is not offered by EMS).
  - IV: None
  - Monitor: Sinus tachycardia at 150's
  - Physical Exam:
  - Head-Ears-Nose-Throat: right temporal-parietal hematoma, blood in nose and right ear (unable to visualize TM on right)
  - Neck: cervical spine collar in place, no cervical spine step-off
  - Cardiovascular: tachycardic but regular; no murmurs, rubs, or gallops
  - Lungs: clear, equal breath sounds bilaterally
  - Abdomen: non-distended, no bruising or abrasions on abdominal wall, difficult to assess further secondary to patient agitation
  - Neuro: pupils mid-position and sluggishly reactive, does not open eyes to verbal or physical stimuli, crying, moving all extremities
  - Extremities: abrasion to right shoulder and elbow, no deformities
  - Back: no abrasions or bruises, T-spine and L-spine have no obvious step-off
- **TIME 1 MIN-2 MIN** (Transition point 1)
  - Vital Signs
  - BP 101/73 RR 40 HR 157 O2 saturation 98% on room air (100% if placed on non-rebreather) T 98.6 °F
  - Weight is not initially known for patient – must be estimated using length-based, color-coded resuscitation tape. If not performed, "nurse" will prompt action by asking for weight from EMS (EMS does not know weight), and then asking for tape.
  - Patient becomes progressively somnolent, then apneic. If not stimulated, oxygen saturation will start to drop. Patient will take spontaneous breaths with stimulation and start to moan/cry, but becomes apneic again when not stimulated.
  - Must recognize need to secure airway.

  - Initiate pre-oxygenation with non-rebreather mask.
  - "Nurse" is unable to obtain vascular access.
- **TIME 4 MIN** (Transition point 2)
  - Vital Signs
  - BP 101/73 RR 40 HR 157 O2 saturation 97% on non-rebreather T 98.6 °F
  - IO needs to be placed to proceed with RSI.
  - RSI
  - Set vent parameters
- **TIME 6 MIN** (Transition point 3)
  - Vital Signs
  - BP 104/75 RR? /min (per vent setting) HR 138 O2 sat 100% on vent settings
  - Complete primary and secondary assessment.
  - Chest X-ray, pelvis X-ray (both normal).
  - If FAST completed, is normal.
  - Should proceed to CT of head and cervical spine.
- **TIME 8–10 MIN** (Final Actions)
  - Vital Signs
  - BP 104/75 RR? /min (per vent setting) HR 138 O2 sat 100% on vent settings
  - Identify ICB on head CT
  - CT cervical spine with no abnormalities
  - Elevate head of bed (reverse Trendelenburg)
  - Maintenance fluids (isotonic fluids)
  - Consult Neurosurgeon

Key Action Items

- Actions for Transition point 1
  - Identify estimated weight using length-based, color-coded resuscitation tape
  - Recognize need for RSI and initiate pre-oxygenation
- Actions for Transition point 2
  - Vascular access is not available; IO must be placed
  - RSI with in-line stabilization
- Actions for Transition point 3
  - Complete assessment of patient
  - Chest and pelvis X-ray
  - Confirm stability prior to traveling to CT scanner.
  - CT of head and cervical spine
- Final Actions
  - Recognize ICB
  - Consult Neurosurgeon

Critical actions

- Identify weight by measuring patient on length-based, color-coded resuscitation tape
- Obtain vascular access by placing IO in proximal tibia
- Recognize need to secure airway and proceed to RSI
- Obtain CT of head
- Recognize ICB and consult Neurosurgeon

Chapter 20: Trauma

Supplemental Case Scenario (b): Intracranial Hemorrhage Secondary to MVC with Ejection

47-year-old male involved in a single vehicle accident with roll-over is transported to the Emergency Department by Emergency Medical Services (EMS). The patient reportedly lost control of the vehicle at an unknown rate of speed, veered off the road, and the vehicle rolled over several times. The patient was unrestrained and was ejected from the vehicle. Per EMS, the patient was initially agitated and cursing at the scene, but now has become less responsive. Currently the patient does not open his eyes and is moaning and making incomprehensible sounds.

Teaching Objectives

- Clinical and Medical Management
  - Recognize the indications for endotracheal intubation (definitive airway management) in the poly-trauma patient
  - Respiratory distress/failure
  - Patient inability to control airway
  - Predicted course
  - Describe the approach to rapid sequence intubation (RSI) in a patient with a potential severe head injury
    - Pre-oxygenation
    - Pre-medication for suspected increased intra-cranial pressure
    - Choice of induction agent
    - Choice of paralytic agent
  - Demonstrate the management of a pneumothorax
    - Identify a pneumothorax on a chest X-ray
    - Demonstrate tube thoracostomy placement
  - Identify management interventions for hypotension in the poly-trauma patient
  - Appropriate vascular access (2 large-bore IVs)
    - Hemorrhage control
    - Initial resuscitation with intravenous isotonic crystalloid solution
  - Display the initial management strategies for a traumatic intra-cranial bleed (ICB)
  - Interventions to avoid or correct hypotension
  - Interventions to avoid or correct hypoxemia
  - Neurosurgical consultation
- Communication and Teamwork
  - Identify team roles and team leader
  - Demonstrate call-out (team member verbalization of observation or change to make team aware) within the team communication framework
  - Demonstrate closed-loop communication within the team communication framework

Target Audience
- Resident (PGY1, PGY2, PGY3, PGY4)
- Fellow
- Attending Physician
- Nurse
- EMT
- Physician Assistant

ACGME Core Competency
- Patient Care
- Medical Knowledge
- Systems Based Practice
- Professionalism
- Interpersonal Skills and Communication

Supplies & Moulage
- Non-rebreather mask
- Endotracheal tube (8.0)
- Laryngoscope with both Macintosh and Miller blades
- Cervical spine collar
- Thoracostomy tube and thoracostomy tray
- One liter of Normal Saline (NS) × 2 (with IV tubing)
- Large scalp hematoma with bloody gauze wrapped around head
- Right chest wall bruising

Images
- Chest X-ray – may use either depending on progression of scenario: 1) multiple rib fractures on right with large pneumothorax; endotracheal tube is present and in appropriate position, or 2) multiple rib fractures on right with right thoracostomy tube appropriately placed; endotracheal tube is present and in appropriate position
- CT head – subdural intra-cranial bleed

Actors and roles
- EMS – Describe brief overview of event (motor vehicle crash with roll-over and ejection of unrestrained driver). Provide details of patient's condition at the scene (initially agitated and cursing), interventions (cervical spine collar and backboard for transport), and patient's condition during transport (declines during transport; patient moaning incomprehensibly on arrival, eyes closed, withdraws from physical stimuli). Inform team that patient has a single IV
- Nursing – Facilitates management of case with physical examination findings. Provide closed-loop communication during progression of case
- Patient simulator – Moaning incomprehensibly on arrival, eyes closed, withdraws from physical stimuli; will rapidly decline following arrival to ED

Case Flow/Timeline
- **TIME 0** NOTIFICATION: 47-year-old male, unrestrained driver in single vehicle accident with roll-over and ejection from the vehicle
  - What does the pt. look like?
  - Patient is moaning and making intermittent incomprehensible sounds on arrival. Patient's eyes are closed (does not open eyes even for noxious physical stimuli), and he withdraws to noxious physical stimuli. Labored breathing.
  - Vital Signs:
  - BP 109/70 RR 27 HR 122 Sat 95% (on non-rebreather mask) T 98.6 °F
  - IV: single

    Participant should request 2nd IV to be placed upon hearing there is only one IV. Failure to request 2nd IV either upon arrival or soon after will result in IV failure when requesting fluid bolus later in scenario. If 2nd IV is requested there will be no IV failure later in scenario
  - Physical Exam:
  - HEENT: large scalp hematoma, pupils are 4 mm bilaterally and sluggishly reactive, blood in nose, bloody gauze wrapped around head
  - Neck: cervical spine collar in place, no cervical spine step-off
  - Cardiovascular: tachycardic but regular; no murmurs, rubs, or gallops
  - Lungs: labored breathing with coarse bilateral breath sounds and questionably decreased breath sounds on right
  - Abdomen: non-distended, no bruising or abrasions on abdominal wall, difficult to assess further secondary to patient condition
  - Neuro: pupils' mid-position and sluggishly reactive, does not open eyes to verbal or physical stimuli; withdraws to noxious physical stimuli; moans and makes incomprehensible noises. GCS = 7 (E-1, V-2, M-4)
  - Extremities: abrasion to extremities, no deformities
  - Back: no abrasions or bruises, T-spine and L-spine have no obvious step-off
- **TIME 1–2 MIN (Transition point 1)**
  - Vital Signs- BP 109/70 HR 122 RR 27 Sat 95% (on non-rebreather mask) T 98. °F
  - Request 2nd large bore IV if not done so on arrival
  - While performing primary assessment, there is a decline in patient's mental status -patient is no longer making any verbal noise (even with noxious physical stimuli) and is not withdrawing to noxious physical stimuli
  - Change in mental status should prompt initiation of plan for RSI – pre-oxygenate with 100% non-

rebreather mask, call for medications (to include premedication for suspected intra-cranial injury, induction agent, and paralytic)
  - Failure to address airway at this point will lead to agonal respirations and then respiratory arrest
  - Successfully complete RSI (with in-line cervical spine stabilization)
  - Requests initiation of sedation following RSI
- **TIME 4 MIN (Transition point 2)**
  - Vital Signs - BP 91/57 RR (per vent settings) HR 129 O2 saturation 94% (on
  - 100% FIO2)
  - Should recognize progressively decreased breath sounds on right side during confirmation of endotracheal tube placement
    May place right chest thoracostomy tube based on compilation of signs (right chest wall bruising, decreasing breath sounds on right following intubation, failure for O2 saturation to improve significantly)
    Failure to place thoracostomy tube will result in persistent O2 saturation in the low 90s
  - Should recognizes decreased blood pressure and initiates fluid bolus (2 liters isotonic crystalloid)
    Failure to initiate IV fluid resuscitation in timely fashion will result in progressive hypotension (systolic BP in low 80s) on repeat vital signs
  - Must recognize right pneumothorax on CXR and place right chest thoracostomy tube
    Failure to place thoracostomy tube at this point will result in progressively declining O2 saturation
- **TIME 6 MIN (Transition point 3)**
  - Vital Signs- BP 111/71 RR (per vent settings) HR 114 O2 saturation 99% (on 100% FIO2)
  - Re-evaluates BP and O2 saturation following interventions (fluid bolus and thoracostomy tube placement) – vital signs improve if interventions completed
  - Complete primary and secondary survey
  - Following stabilization of patient (blood pressure improves with fluid bolus and O2 saturation improves following thoracostomy tube placement), patient may go to CT
  - CT of head and cervical spine
- **TIME 8–10 MIN (Final Actions)**
  - Vital Signs- BP 110/71 RR (per vent settings) HR 109 O2 saturation 99% (on 100% FIO2)
  - Identify ICH on head
  - CT cervical spine with no abnormalities
  - Elevate head of bed- reverse Trendelenburg
  - Maintenance fluids- isotonic fluids
  - Consult Neurosurgeon
  - Reassess for signs of herniation (pupils, vital signs) – failure to do so will prompt Neurosurgeon to ask about re-evaluation of patient following return from CT scanner.

Key Action Items

1. Actions for Transition point 1
   (a) Request 2nd large bore IV
   (b) Recognize rapid decline in patient's mental status
   (c) Initiate plan for RSI – pre-oxygenate with 100% nonrebreather mask, call for medications (to include premedication for suspected intra-cranial injury, induction agent, and paralytic)
   (d) Successfully complete RSI (with in-line cervical spine stabilization)
   (e) Requests initiation of sedation
2. Actions for Transition point 2
   (a) Recognizes progressively decreased breath sounds on right side post-intubation
   (b) May place right chest thoracostomy tube based on compilation of signs (right chest wall bruising, decreasing breath sounds on right following intubation, failure for O2 saturation to improve significantly)
   (c) Recognizes decreased blood pressure and initiates fluid bolus (2 liters isotonic crystalloid)
   (d) Must recognize right pneumothorax on CXR and place right chest thoracostomy tube
3. Actions for Transition point 3
   (a) Re-evaluates BP and O2 saturation following interventions (fluid bolus and thoracostomy tube placement)
   (b) Complete primary and secondary survey
   (c) Following stabilization of patient (blood pressure improves with fluid bolus and O2 saturation improves following thoracostomy tube placement), patient may go to CT
   (d) CT of head and cervical spine
4. Final Actions
   (a) Recognize ICH
   (b) Elevate head of bed (reverse Trendelenburg)
   (c) Monitor BP (prevent hypotension)
   (d) Monitor O2 saturation (prevent hypoxia)
   (e) Re-evaluate for signs of herniation (pupils, vital signs)
   (f) Consult Neurosurgeon

Critical Actions

- Recognize rapid decline in patient's mental status, need to secure airway, and proceed to RSI
- Place right chest thoracostomy tube
- Initiate fluid bolus (isotonic crystalloid)
- Obtain CT of head
- Recognize ICB and consult Neurosurgeon

Chapter 21: Emergency Medicine Critical Care

Supplemental Case Scenario (a): Anaphylaxis

45-year-old female being treated as an inpatient for pneumonia. She has no other medical history. Reports allergy to penicillin. ICU team called during the night because patient is complaining of SOB and abdominal pain.

Teaching Objectives
- Clinical and Medical Management
  – Recognition and management of anaphylactic shock
  – Recognition and management of a difficult airway
  – Recognition of wrong medication administration
- Communication and Teamwork
  – Effective team leadership
  – Delegation of critical tasks

Target Audience
- Resident
- Fellow
- Attending Physician
- Nurse
- EMT
- Physician Assistant
- Medical Student

ACGME Core Competency
- Patient Care
- Medical Knowledge
- Practice Based Learning and Improvement
- Systems Based Practice
- Professionalism
- Interpersonal Skills and Communication

Supplies & Moulage
- Mannequin with simulated airway angioedema and tight vocal cords
- Medication vial with "Piperacillin/Tazobactam" label
- Penicillin allergy bracelet
- Intubation tray, LMA, cric kit, BVM
- Diffuse urticarial rash
- Airway swelling

Images
- CC Sim CXR 1: normal (Fig. A1.6)

Actors and roles
- Floor Nurse: panicking, continues to state that she gave the medicine sent from pharmacy.

Case Flow/Timeline
- **TIME 0** NOTIFICATION: ICU Team arrives in patient room. Nurse reports having just given Vancomycin and Gentamicin which were sent up from pharmacy per physician orders. States symptoms began 2 minutes after giving meds.
  – What does the pt. look like?
  – Pt is distressed, diaphoretic, able to speak with muffled voice
  – Vitals:
  – BP 80/40 HR 110 RR 30 SaO2 95%
  – IV: ripped out by patient when she was panicking
  – Monitor: narrow complex regular rhythm
  – Physical Exam:
  – Gen: A&Ox3, distressed
  – HEENT: Lip and facial swelling, tongue swelling with mallampati IV view.
  – Neck: No tracheal deviation, no JVD
  – Chest: Wheezing in bilateral lung fields
  – Heart: regular tachycardia
  – Abdomen: Soft, mildly tender
  – Rectal: normal exam
  – Skin: flushed, diffuse urticaria
  – Ext: normal exam
  – Neuro: normal exam
- **TIME 2 MIN** (Patient decompensation)
  – Vital Signs
    If no intervention, BP drops to 60/30 and tachycardia increases
    If Epinephrine 0.3 mg IM given, BP improves to 100/60
    SaO2 begins to drop to 85%, improves to 90% with NRB

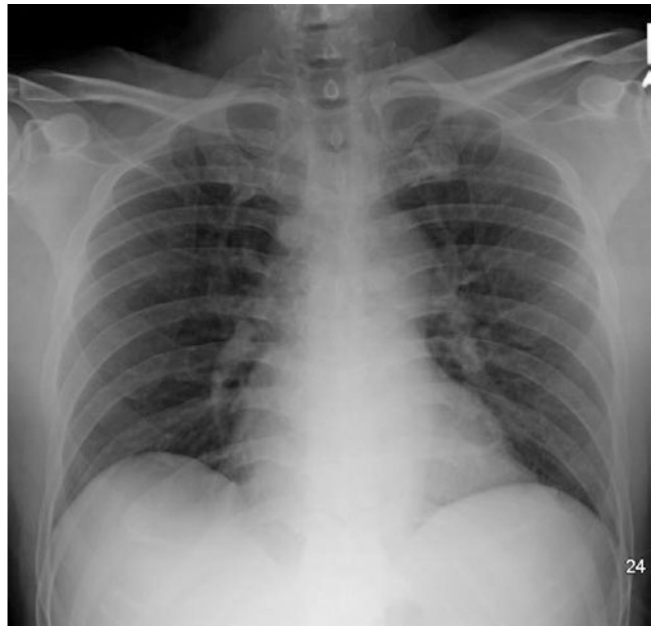

Fig. A1.6 CC Sim CXR 1

- Pt becomes more distress and starts holding her throat, unable to speak
- ICU Nurse having difficult time with IV due to patient movement
- Floor nurse keeps saying "I gave the medicine pharmacy gave me", if asked to retrieve the medicine vial she leaves to go search trashcan
- If asked for central line or IO kit, none available on the floor
- If physician asks for CXR, shown CC Sim CXR 1
- Physical Exam Changes:
  HEENT: increased oral swelling

- **TIME 4 MIN** (Respiratory Arrest)
  - Vital Signs
    If no intervention thus far, BP continues to drop and patient codes
    If Epi initially given, BP drops again to 80/40
    Repeat Epi 0.3 mg IM dose improves BP
    SaO2 continues to be 85% despite NRB, RR and SaO2 then decrease
  - Pt becomes limp and stops breathing
  - At this point, RN is able to get IV established
  - Pt continues to have a pulse
  - Airway intervention
    BVM ventilations ineffective
    Laryngoscopy reveals swollen/tight cords, cannot pass tube
    If repeated intubation attempted, patient codes
    If LMA inserted, BVM successful and SaO2 improves
    If cric performed properly, it is successful and SaO2 improves
  - Epinephrine administration
    Repeated IM injections effective, but wear off quickly
    If Epi drip started through IV, BP improves
    If push dose of code cart epi given, patient has arrhythmia and codes
- **TIME 6 MIN** (Final Actions)
  - Vital Signs
    If LMA placed or cric performed correctly, SaO2 90%
    If Epi drip or repeated Epi IM injections, BP 100/60
  - If patient coded due to intubation earlier, continues until LMA or cric utilized
  - Floor nurse returns with vial from trash
    Vial says "Piperacillin/Tazobactam"
    Checking chart confirms Gentamicin was ordered.
    Communication with pharmacy confirms wrong medicine was sent.
  - With continued Epi infusion and positive pressure ventilation, patient stabilizes for transfer to ICU

Key Action Items

- Actions for anaphylactic shock
  - Initial IM epinephrine
  - Repeated IM doses or epi drip
- Actions for airway
  - Recognize impending airway emergency
  - Recognize difficult airway
  - Utilize alternative airway device/method after failed intubation
- Actions for medication error
  - Investigate medication given
  - Contact pharmacy

Critical action

- IM epinephrine injection
- Repeated epi IM or drip
- LMA or cric airway
- Locate medication vial
- Feedback to pharmacy

Chapter 21: Emergency Medicine Critical Care

Supplemental Case Scenario (b): Ventilator Emergencies

60-year-old male is intubated and on mechanical ventilation in the ICU for COPD exacerbation. At 0200, resident called to bedside by RN for ventilator alarm.

Teaching Objectives

- Clinical and Medical Management
  - Analysis of vent alarm
  - Organized approach to vent alarm
- Communication and Teamwork
  - Utilization of respiratory therapist
  - Delegation of critical tasks

Target Audience

- Resident
- Fellow
- Attending Physician
- Nurse
- Physician Assistant
- Medical Student

ACGME Core Competency

- Patient Care
- Medical Knowledge
- Practice Based Learning and Improvement
- Systems Based Practice
- Professionalism
- Interpersonal Skills and Communication

Supplies & Moulage

- Intubated mannequin with ventilator, alarm sounding due to high airway pressure, decreased lung sounds on left side
- Chest tube tray
- Patient chart with "Robert Smith" patient label. Respiratory sheet shows change in tube depth from 23 to 25 cm 20 minutes prior

Images

- Sim CC CXR 2: right main stem endotracheal tube (Fig. A1.7)

Actors and roles

- ICU Nurse: Reports coming into room due to alarm sounding, no knowledge of any changes to treatment overnight
- Respiratory therapist: reports to room after being paged, if asked about any recent intervention states "I was called by the resident and told to advance the tube on Mr. Smith 2 centimeters"

Case Flow/Timeline

- **TIME 0** NOTIFICATION: Resident arrives in room. Alarm is sounding on vent with "High Airway Pressure" reading
  - What does the pt. look like?
  - Pt is fighting vent, diaphoretic, moving around in bed

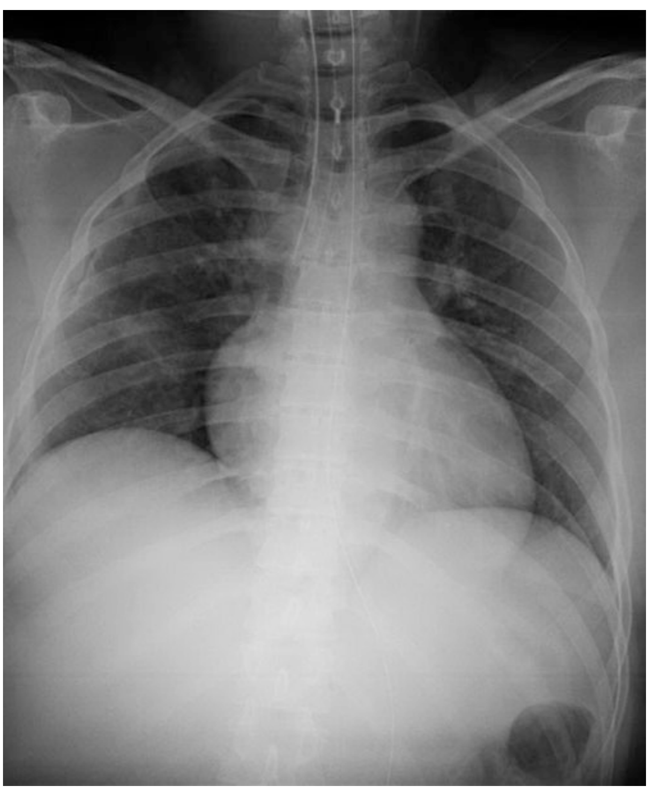

Fig. A1.7 CC Sim CXR 2

  - Vitals:
  - BP 150/80 HR 120 RR 40 SaO2 90%
  - IV: in place
  - Monitor: narrow complex with regular rhythm
  - Physical Exam:
  - Gen: Sedated but fighting vent
  - HEENT: Tube in mouth, (if asked) 25 cm at the lips, PERRL, no teeth
  - Neck: No tracheal deviation, mild JVD
  - Chest: Decreased breath sounds on left, no chest rise on left
  - Heart: regular tachycardia
  - Abdomen: Soft
  - Rectal: normal exam
  - Skin: diaphoretic
  - Ext: normal exam
  - Neuro: Sedated
- **TIME 2 MIN** (Patient decompensation)
  - Vitals- SaO2 continues to drop to 85%
  - If disconnected from vent and placed on BVM
    Airway person states "difficult to bag"
    No improvement in SaO2
  - If resident asks for respiratory tech, she is paged and, on her way
  - If resident asks for chart, RN will go to obtain it
  - If resident asks for chest tube set up, RN will go obtain it
  - If resident opts to perform needle decompression
    No rush or air and no clinical improvement
  - If resident asks for tube suctioning, told respiratory tech is on her way
  - If CXR ordered, X-ray team is on their way
  - Physical Exam Changes: None
- **TIME 4 MIN** (Respiratory tech arrival)
  - Vitals: SaO2 75–80% despite high flow O2. Tachycardia persists
  - Respiratory tech (RT) arrives
    If resident asks for suctioning, no mucus returned with suction
    If resident asks RT about tube depth, she states "I was called and told to advance the tube 2 cm on him, this is James Smith, right?"
    If resident asks for tube to be retracted 2 cm, RT does so and pt. slowly improves
  - Nurse returns with chart
  - If chest tube placed, no rush of air and no improvement
  - If CXR ordered, shown CC Sim CXR 2
- **TIME 6 MIN** (Final Actions)
  - Vital Signs
    If tube retracted
    - SaO2 improves to 90%
    - Tachycardia improves
    - Alarm stops sounding

If tube left in place, SaO2 in 60s and pt. begins to have bradycardia
  - If patient improving, may be placed back on vent, no alarms sounding

Key Action Items
- Actions for vent alarm
  - Disconnect patient from vent
  - PPV with BVM
  - Check lung sounds
- Actions for decreased unilateral lung sounds
  - Check tube depth
  - Investigate last tube depth on chart
- Actions for wrong patient
  - Communicate with RT to determine which patient verbal order placed on and confirm with name on chart

Critical Actions
- Disconnect patient from vent
- Attempt PPV with BVM
- Auscultate lungs and recognize decreased breath sounds
- Communicate with RT
- Retract tube
- Recognize wrong patient

Chapter 21: Emergency Medicine Critical Care

Supplemental Case Scenario (c): Atrial Fibrillation with Aberrancy

36-year-old-male presents to resuscitation bay for palpitations. He was placed in resuscitation for tachycardia. In speaking with him, he is very distress and slightly altered. Unable to give great history as he can't sit still and can't speak full sentences Denies any injury or drug use. Denies syncope or fever. Denies any known medical problems. No medications or allergies

Teaching Objectives
- Clinical and Medical Management
  - Analysis of tachycardia ECG
  - Recognition of atrial fibrillation
  - Thorough medical history
  - Treatment of stable and unstable tachycardia
- Communication and Teamwork
  - Patient and family communication to determine adequate medical history
  - Informed consent from family member

Target Audience
- Resident
- Fellow
- Attending Physician
- Nurse
- EMT
- Physician Assistant
- Medical Student

ACGME Core Competency
- Patient Care
- Medical Knowledge
- Practice Based Learning and Improvement
- Systems Based Practice
- Professionalism
- Interpersonal Skills and Communication

Supplies & Moulage
- Mannequin
- Monitor/defibrillator

Images
- CC Sim CXR 1: normal (Fig. A1.6)
- CC Sim ECG 1: A-fib with RVR with evidence of WPW (Fig. A1.8)
- CC Sim ECG 2: normal sinus with delta waves (Fig. A1.9)

Actors and roles
- Resus Nurse
- Mother:
  - Arrives in the middle of case, comes running through door
  - Lays on patient, very distraught
  - If treated kindly and calmed down she states son used to go to a heart doctor because of a "weird rhythm" in the past

Case Flow/Timeline
- **TIME 0** NOTIFICATION: Patient arrives in Resus.
  - BP 110/60 HR 220 RR 40 SaO2 94% Afebrile
  - What does the pt. look like?
  - Pt is very distress, diaphoretic, won't focus, difficult to answer questions
  - Vitals:
  - BP 110/60 HR 220 RR 40 SaO2 94% Afebrile
  - IV: placed by RN
  - Monitor: irregular tachycardia, QRS slightly widened

    If physician orders IV fluids, they are given, no improvement of tachycardia

    If physician order CXR or ECG, techs are paged and are on their way

    If physician orders labs, they are drawn and sent
  - Physical Exam:
  - Gen: Distress, diaphoretic, agitated
  - HEENT: Normal exam, PERRL/midrange

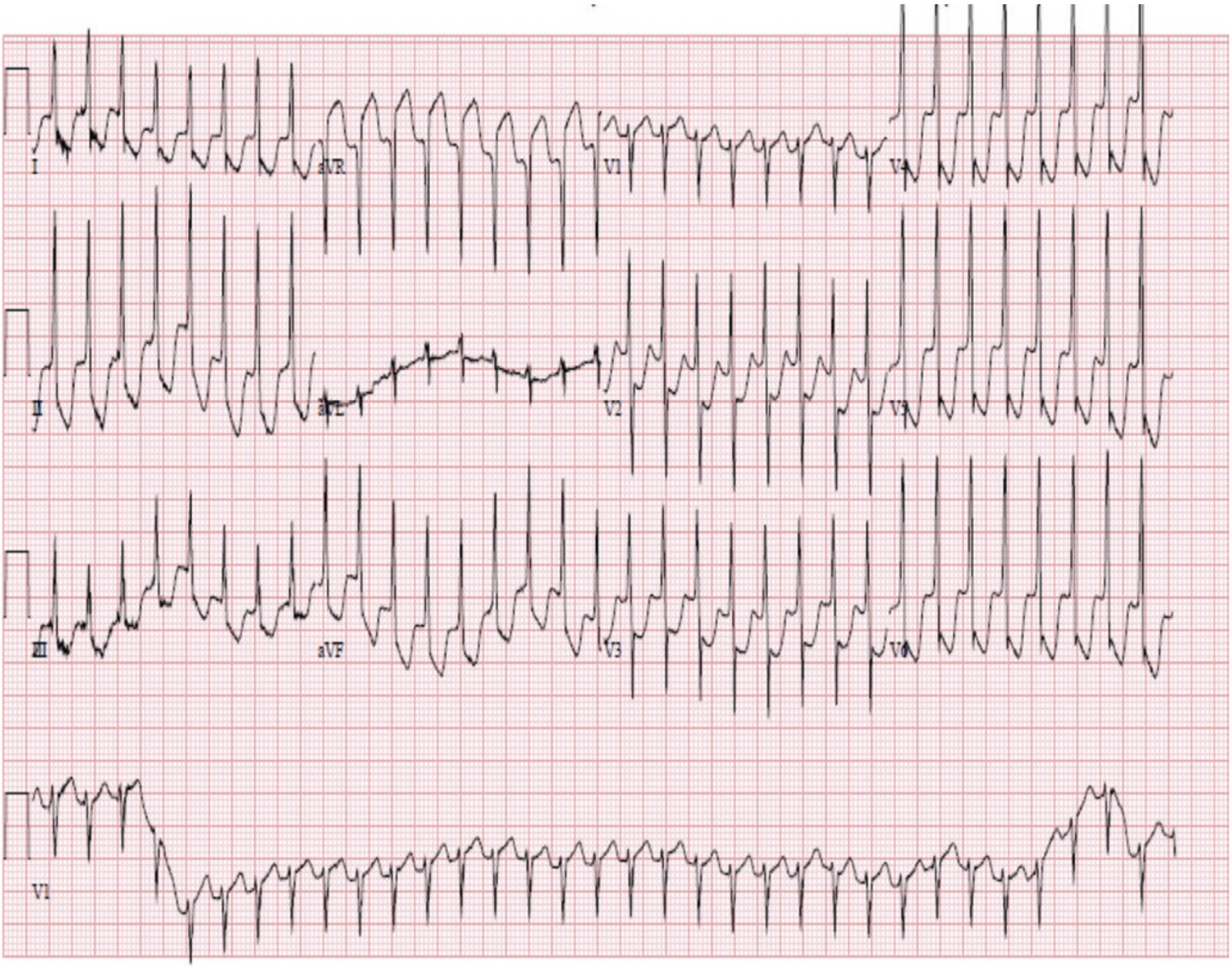

Fig. A1.8 CC Sim ECG1

- – Neck: Normal
- – Chest: Tachypnea, normal breath sounds
- – Heart: Irregular tachycardia, no murmurs
- – Abdomen: Soft
- – Rectal: normal exam
- – Skin: diaphoretic
- – Ext: normal exam
- – Neuro: Normal

- **TIME 2 MIN** (ECG)
  - – Vital Signs- Same as previous
  - – If patient questioned again about drugs, becomes very upset and yells
  - – If ECG ordered, shown CC Sim ECG 1
  - – If physician speaks to patient about cardioversion, he refuses
  - – If physician orders meds, they are being obtained from pharmacy
  - – If CXR order, shown CC Sim CXR 1
  - – If labs were ordered, shown to physician
- **TIME 4 MIN** (Mother arrives)
  - – Vital Signs- Same as previous
  - – Mother arrives, very distraught and lays on patient.

    If she is yelled at she becomes violent.

    If she is kindly calmed down she is calmed easily and states that her son used to be seen by a cardiologist for a "weird rhythm".
  - – Medications available

    If adenosine given, patient goes in to ventricular fibrillation and codes

    If diltiazem given, after 30 seconds, HR increases to 250 and BP drops

    - If proper cardioversion performed after diltiazem, rhythm converts to regular bradycardia at 30 BPM, which slowly improves. Pt will require BVM ventilations for next minute

    If procainamide started, patient remains stable

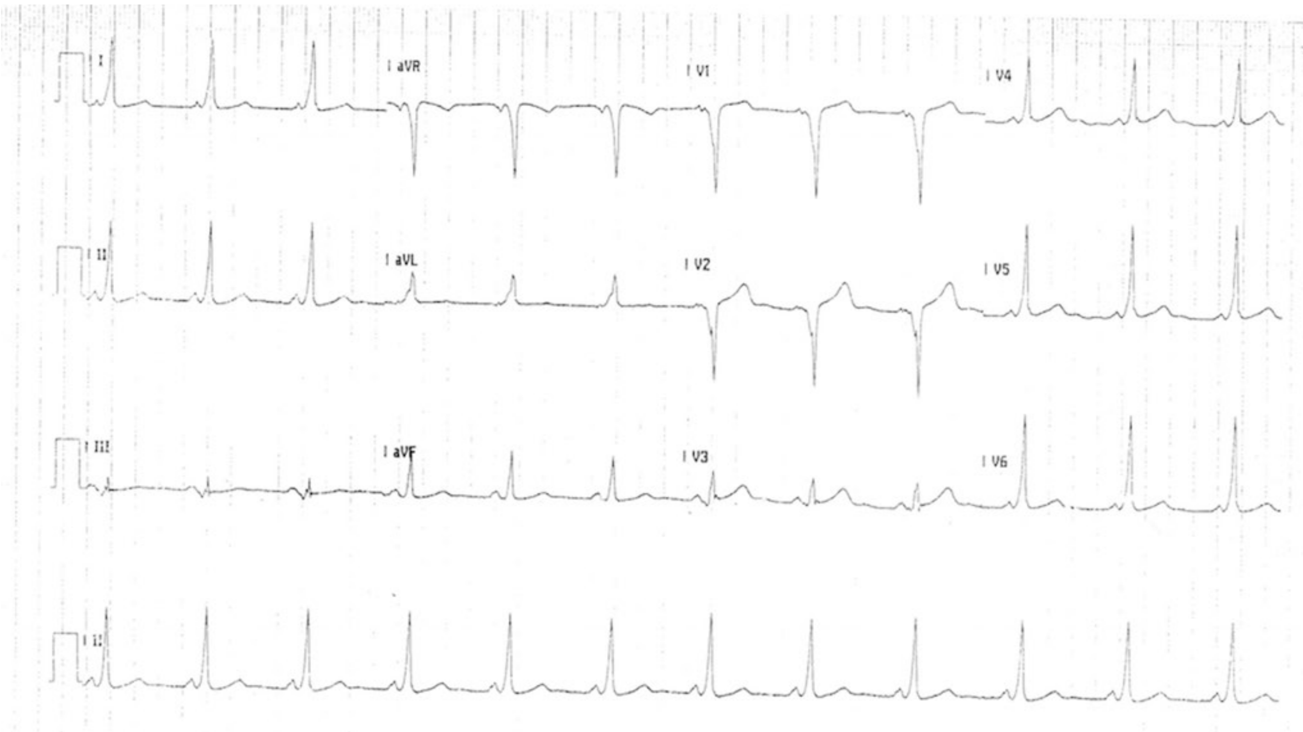

Fig. A1.9 CC Sim ECG2

- **TIME 6 MIN** (Final Actions)
  - Vital Signs
    - Based on previous action
    - If no intervention at this point, BP drops <90 and patient becomes altered
  - If procainamide started, tachycardia begins improving
  - If no intervention at this point, BP drops <90
    - Mother provides verbal consent for cardioversion
    - Proper cardioversion converts to regular sinus rhythm on monitor
    - If cardioverted and physician asks for repeat ECG, shown CC Sim ECG 2
  - If no cardioversion after BP drop, patient codes

Key Action Items

- Actions for tachycardia
  - Start IV fluids
  - Obtain ECG
  - Interpret ECG as irregular wide tachycardia
- Actions for medical history
  - Attempt history from patient
  - Once mother arrives, obtain further history
  - Recognize possibility of WPW
- Actions for WPW
  - Avoid CCB and adenosine
  - Treat with cardioversion

Critical actions

- Recognize A-fib
- Obtain history of WPW
- Avoid use of adenosine
- Convert with cardioversion

Chapter 22: Ultrasound in Simulation

Supplemental Case Scenario: Motor Vehicle Collision

30-year-old male without significant past medical history is brought in by EMS for evaluation s/p MVC. Patient was the restrained driver involved in MVC. Per EMS unknown speed. Accident occurred on road with 45 mph speed limit. Airbags deployed. Patients car totaled. A passenger died on scene. Approximately 30-minute extraction. Patient arrived boarded and collared.

Teaching Objectives

- Clinical and Medical Management
  - Recognition and management of Traumatic Abdominal Injury
  - Recognition and management of shock in trauma
  - Proper pain management
- Communication and Teamwork
  - Identify team roles and leader
  - Obtaining information from EMS
  - Conflict resolution with family

Target Audience
- Resident (PGY1, PGY2, PGY3, PGY4)
- Fellow
- Attending Physician
- Nurse
- EMT
- Physician Assistant

ACGME Core Competency
- Patient Care
- Medical Knowledge
- System Based Practice
- Professionalism
- Interpersonal Skills and Communication

Supplies & Moulage
- C Collar
- Simulator clothes
- Seat belt sign
- Ultrasound

Images
- CXR – Normal, without evidence of pneumothorax or widened mediastinum
- EKG – sinus tachycardia
- Pelvis XR- no evidence of fracture or dislocation
- CT Abdominal/Pelvis – unable to obtain (will be prompted that Radiology unable to perform)

Actors and roles
- EMS: EMS will not provide information regarding MVC unless asked. They will provided that patient was restrained driver. They will provide information regarding condition of automobile and of fatality at scene.
- Patient: Alert but only responding to questions. Will complain of abdominal pain. Will not recall incident.
- Mother: Will be crying and hysterical. Will interfere with evaluation and management of patient.

Case Flow/Timeline
- **Time 0** NOTIFICATION: 30-year-old male. MVC. Front seat Passenger. BP 90/60 HR 120 RR 20 Saturation 100% on NRB.
  - What does the pt. look like?
  - Pt is lying on bed, C Collar in place, appears calm, not in acute distress.
  - Vitals:
  - BP 90/60 P 130 RR 22 T 98.6 Saturation 100% on NRB
  - IV: None
  - Monitor: ST at 130
  - Physical Exam:
  - Gen: A&OX3, calm, responds to questions
  - HEENT: Eyes open, PERRLA 4 mm, EOMI. No evidence of facial trauma
  - Chest: + ecchymosis on chest (in shape of seat belt), No deformity. Tenderness to palpation. No crepitus. CTA bilaterally with equal breath sounds.
  - Heart: Tachy rate, without M/R/G
  - Abdomen: Ecchymosis extends onto abdomen. Nondistended. Generalized tenderness, no rebound, no guarding. Normal bowel sounds
  - Rectal: Normal tone, brown stool, no gross blood. (Guaiac negative if performed)
  - Skin: cool and clammy
  - EXT: No deformity, minimal abrasions. No edema present
  - Neuro: A&OX3, moving all extremities symmetrically, CN2–12 grossly intact.
  - FAST: if performed will be normal initially
- **Time 1MIN- 2MIN** (Initial State- hypotensive and tachycardic)
  - Vitals: (**If two large bore IV's place and 2 L IVF given**) BP 100/60 P 110 RR 22 T 98.6 Saturation 100% on NRB. (**If no IVs or no fluid administered**) BP 80/50 P 140 RR 24 T 98.6 Saturation 100% on NRB.
  - Shock: Patient continues to complain of abdominal pain. (Based on learner level, if lower level provider, nurse will prompt that abdomen looks more distended). If bedside FAST repeated will now have + fluid in Morrison's pouch.
  - Pain medicine: If patient given fluid and fentanyl given, patient's pain will decrease. If no fluid provided or longer lasting medication given patient's blood pressure will drop.
  - Scene control: cannot proceed until mother removed from bedside. Chaplin services or social work available if requested.
- **TIME 2 MIN – 4 MIN** (Continued Trauma Management)
  - Perform secondary survey
  - Disability
  - Exposure
  - Labs (Including type and cross)
  - Activate trauma team – request DPL
  - CXR and PXR
- **TIME 4 MIN – 5 MIN** (worsening of shock)
  - Pt blood pressure drops. BP 70/30 P 150 RR 28 Saturation 100% on NRB
  - Need to re-page Trauma, advocate for immediate surgical management
  - Should consider activation of transfusion protocol
- **TIME 6 MIN – 7 MIN**
  - IF unable to have trauma team take pt. to OR pt. with will arrest.
  - If trauma team takes to OR, discuss case with mother.

Key Action Items
- Actions for Trauma
  - ABC –recognition of shock
  - ATLS
  - Repeat US in seating of worsening hypotension &/or increased abdominal distention
  - Trauma Surgery consult
  - Activation of massive transfusion protocol
  - Control Environment
- Actions for pain management in hypotensive patient
  - 2 large bore IV
  - Initiate fluid resuscitation
  - Type and cross
  - Transfusion
  - Advocating for definite management
- Final actions
  - Trauma Surgery
  - OR
  - Exploratory laparotomy

Critical Actions
- Bedside US, and then repeating US
- Fluid resuscitation
- Transfusion
- Trauma Consult
- Advocating for OR
- Careful consideration of management in the hypotensive patient

Chapter 23: Disaster Medicine

Supplemental Case Scenario: Mass Casualty Event START Triage Training

Case Scenario
A small craft airplane has crashed into an apartment building. Your team is the first team to respond. There is smoke billowing from a tenth-floor window, debris on the sidewalk and more and more people are congregating by the second. The team must develop appropriate triage zones and manage the influx of victims and passersby in the first 10 minutes after arriving on scene.

Teaching Objectives
- Clinical and Medical Management
  - Use START triage algorithm (or other preferred algorithm) to appropriately triage patients
  - Reposition airway of victim in respiratory distress
  - Control hemorrhage in victim who is bleeding out
- Communication and Teamwork
  - Develop chain of command and delegate tasks
  - Develop Red, Yellow, Green and Black areas
  - Seamlessly transition leadership when true scene command arrives
  - Manage passersby, moving them away from harm and distraction

Target Audience
- Resident (PGY1, PGY2, PGY3, PGY4)
- Fellow
- Attending Physician
- Nurse
- EMT
- Physician Assistant
- Medical Student (MS1, MS2, MS3, MS4)
- Other

ACGME Core Competency
- Patient Care 1 – Emergency Stabilization
- Patient Care 8 – Multi-tasking
- Interpersonal Skills and Communication 2 – Team Management

Supplies & Moulage
- Mass Casualty Triage Cards
- Tourniquet
- Bandages, gauze, tape
- Oxygen
- BLS EMS kit
- Fake blood
- Hemorrhaging leg wound
- Abrasions, minor lacerations for all body parts
- Soot
- Carbonaceous sputum
- Amputated arm

Images
- None required

Actors and roles
- Patient A – (Green)Walking wounded, abrasion to right cheek and right hand; was walking down the street when debris fell onto him, ducked down to avoid being hit and scraped his right side on the concrete, denies being hit in the head or passing out. Excited by what happened, but not disruptive
- Patient B – (Yellow) Was walking down the street when debris hit him on the head; dirty on head, bleeding controlled on wound to top of head; Repeatedly asking the same questions over and over because of a head injury, only intermittently follows commands.
- Patient C – (Black) Mannikin missing left arm, blood all over the street. Dead.
- Patient D – (Green) Was in the apartment that was struck, has soot and dirt all over body, but not in mouth or nose.

No respiratory distress. Was able to walk down ten flights of stairs to seek help. Will not stop telling everyone around what just happened. Needs to be given a task to be redirected.

- Patient E – (Red) Was in the same apartment, but by the time she makes it to you she has collapsed and stopped breathing.
- Patient F – (Red) Mannikin is found under debris with a hemorrhaging arm wound that can be controlled with a tourniquet. Screaming in pain and fear until redirected and given attention by the team.
- Patients G, H, I and J – Mother and three school age children were walking to school when this happened the kids got so excited they ran across the street and are taking pictures, calling their friends, yelling for mom to come see. No injuries at all.
- Crowd – can consist of as many people as are available, and will generally mill around, coming as close to the scene as the team allows, at times taking pictures or yelling that patient C needs attention
- EMS Chief – Arrives around 7 minutes and requests sign over from scene command. Needs to know what resources he should be calling for and can either be supportive and proud if things are going well or very angry and condescending if they are not.

Case Flow/Timeline

- **TIME 0** NOTIFICATION: Large explosion is heard. Team is told they are first to respond to the scene of a small aircraft crash into an apartment building. They can see a smoking hole in one of the upper floors approximately the size of one room and there is debris still falling to the ground.
- Patient A arrives at the same time as the team yelling to see if they saw what happened. He is ambulating and has abrasions to his right face and right arm.
  - Team should establish zones for Green, Yellow, Red, Black and central command
  - Team should pull out triage cards to begin tagging
  - Team leader should identify his/herself and delegate tasks
  - Team should don appropriate PPE and determine that scene is safe to explore – there are no downed power lines, unstable structures, leaks or active fires at ground level
- Patient B is also discovered wandering, repeating himself. He immediately sits down, will not walk anymore, is breathing at a rate of 25, has bounding pulses and normal cap refill but is perseverating and only intermittently following commands
  - Should be tagged yellow
- Crowd begins to grow
- **TIME 1 MIN-2 MIN (Transition point 1)**
  - The crowd screams that they see someone bleeding who needs help. Patient C is discovered missing his left arm. He has already bled out and is pulseless.
    - Should be tagged black
    - Crowd is distraught, one individual attempts to step in and help, slapping the face of the mannequin, trying to wake him up.
  - Patient D wanders out of the building covered in soot talking excitedly on her phone about what just happened. "You'll never believe what just happened!! A plane just hit my window! A plane!" She notes her roommate is also on the way down.
    - Team may triage as green or may look in mouth or nose first and then triage as green
  - Patient B starts asking what happened again, looking for his dog, asking the crowd for assistance.
  - Crowd will continue to ask what is wrong with Patient C until redirected
- **TIME 2 MIN-4 MIN (Transition point 2)**
- Patient E stumbles out of the building, falls to the ground, isn't breathing. Airway repositioning helps.
  - Patient should be tagged red
  - Team member should ask for oxygen, depending upon their skill level may ask permission from the team leader for active airway management and will need to request equipment which can arrive as quickly as instructor would like
- If s/he hasn't already, team leader should be prompted to get in touch with EMS chief to initiate discussion about necessary resources
- Patient D is still wandering away from green zone and talking to everyone
  - Team may give her a task to redirect her
- Family arrives, little kids begin running through the scene
  - One small child finds Patient E and yells "mom! This is so cool! Look at all that blood"
  - Another small child is crying
  - One team member needs to work with mom to gather the children and escort them away
- Patient E is slightly obstructed with debris, breathing normally with a rate of 25 but has thread pulses, is diaphoretic and has a hemorrhaging wound on the arm that can be controlled with a tourniquet
- **TIME 6 MIN (Transition point 3)**
- Scene command arrives
  - If team has established chain of command, controlled crowd and directed patients to appropriate zones s/he will ask for sign out to transition care and announce that ambulances are arriving requesting a prioritization of transfer

If team has failed to accomplish this, s/he will be condescending, disruptive and try to just take over loudly yelling about incompetence

Patient A is calm and in green zone

Patient B is still looking for his dog verbally

Patient C still draws a crowd until a shroud is placed over the mannequin

Patient D is calm if has been redirected

Patient E remains tachypneic, stridorous

- If airway hasn't been managed will develop worsening distress, need to ask arriving EMS for ET tube, bag valve mask
- If airway has been managed that team member will be bagging the patient

Patient F has controlled bleeding if a tourniquet is applied but continues to scream

- **TIME 8–10 MIN (Final Actions)**
  - Ambulances arrive and team must prioritize patients E and F, then B
  - If not yet intubated and the managing team has these skills, Patient E requires intubation or will become hypoxic and become bradycardic, or code
  - Team should maintain a perimeter anticipating more patients
  - Crowd requests information
  - Family is reunited

Key Action Items

Related to "transition points". These are the necessary clinical and communication items related to each transition point/condition.

- Actions for Transition point 1
  - Establish Green, Yellow, Red and Black Zones
  - Establish team leader and delegate roles
  - Determine scene safety
- Actions for Transition point 2
  - Appropriate triage tagging of victims
  - Crowd control
  - Possible shrouding of dead victim, or redirection of people away from victim
- Actions for Transition point 3
  - Hemorrhage control for patient F
  - Airway control for patient E
- Final Actions
  - Prioritization of patient transfer to higher level of care
  - Crowd reassurance and safety
  - Airway management for patient E

Critical actions

- Establish scene commander/team leader and delegate roles
- Assign zones for Green, Yellow, Red, Black Victims and a border for crowd
- Appropriately triage patients using START algorithm
- Control hemorrhage in patient with obvious bleeding wound and poor perfusion
- Manage airway in burn victim who is originally not breathing
- Prioritize red, then yellow, then green patients for intervention and transfer
- Transition care to scene command
- Manage crowd expectations and fairs, maintaining their safety, team safety and victim safety

PART V: Appendix 2

Appendix 2a: Chapter 10- Virtual Scenario Template

Curriculum: ___________________________________
Scenario Title: ________________________________
Target Audience: _______________________________

Population
☐ Nurses
☐ Advanced Practice Clinicians
☐ Physicians
☐ Clerical staff
☐ Medical Assistants
☐ Medical Students
☐ Residents
☐ Paramedics
☐ Other

Learning Objectives
1.☐
2.☐
3.☐
4.☐

Environment	
Location(s)	Location Specificity (Real or General)
☐ Inpatient Hospital Room	
☐ Critical Care Room	
☐ Emergency Department	
☐ Outpatient Office	
☐ Patient Home	
☐ Other:	

A specific real-world location or a general representation (e.g. LVHN Sim Lab = real; Generic ICU = general)

Key Environment Elements			
Required Objects	Description and Representational Complexity	Interactivity Required	
		No	Yes

*Representational Complexity Key

- Low – The minimum amount of detail required for symbolizing a given object (e.g. basic shape, key colors, etc.).
- Med – A practical amount of detail that accurately represents the given object, but stops short of exact detail.
- High – The maximum amount of detail achievable for the selected platform(s) (e.g. intricate 3D models, realistic textures, etc.)

Design Tip: The complexity selected should generally align with the importance that the object holds to the simulation and environment as a whole.

Virtual Platform (Second Life, Avaya Engage, CliniSpace, OpenSim…)
1.
2.
3.
4.

C. Strother et al. (eds.), *Comprehensive Healthcare Simulation: Emergency Medicine*, Comprehensive Healthcare Simulation,
https://doi.org/10.1007/978-3-030-57367-6

Patient Demographics					
Patient Name	**Age**	**Race**	**Sex**	**Height** (short, medium, tall)	**BMI** (low, medium, high)

Patient Actor	
Check (✓)	Patient Depiction
	Patient represented by two-dimensional image or photograph
	Patient represented by video clips
	Patient represented by artificial intelligence interactions (if available)
	Patient avatar controlled / played by standardized patient actor
	Patient avatar controlled / played by clinician teacher
	Other:

Patient Elements	
Patient Interactive Element	**Description**

Elements (What parts of the virtual patient will be interactive? What stimuli will be created or integrated? i.e. roll-over heart for heart sounds, etc.)

Non-Patient Interactive Elements	
Non-Patient Interactive Element	**Description / Behavior**

Examples: web rendering surfaces that we click on to get something. i.e. click on ecg machine to see ecg, click on xray computer screen to get diagnostic image, etc. (include distraction elements if needed)

Patient History
Chief Complaint:
History of Present Illness:
Past Medical History:
Social History:
Family History:
Review of Systems (ROS): if asked
Medications:
Allergies:

Patient Vitals and Examination
Pulse:
Respiratory Rate:
Temperature:
Blood Pressure:
Pulse Oximetry:
Abnormal Physical Exam Findings:
Notable Normals (normal to be described specifically other than default):

Patient Lab Values (if applicable) This section may not be relevant for the scenario				
Test Name	**Test Date**	**Test Results**	**Normal Values**	**Interpretations**

Instructors Notes

- **CRITICAL INCIDENT BY CLINICAL ROLE**
- **SEQUENCING DETAILS**
- Key triggering events; hints to advance the scenario. Who will trigger? Who or what will give the hint?
- Script for SP actor or pre-written virtual character responses.
- Key branch points predicted for scenario. Keep in mind that allowing branches grows complexity rapidly. Giving two choices twice = four possible paths. Giving three choices twice = nine possible paths. Decisions might yield points that are higher or lower, but not change the scenario path.

  Critical Action Flow
- **INSERT FLOW DIAGRAM**

Debriefing Plan

- **DESCRIPTION…**
- Method of debriefing – individual feedback on critical actions (technical or communications), group feedback if virtual venue allows, degree of facilitator involvement.
- Method of non-debriefing feedback. Will they get points or a score of some kind and will specific reasons be given.
- If using facilitated debriefing, what are the questions you will ask?
- Is there brief didactic material or graphics to share during or after the scenario?

Faculty Observation Checklist

Clinical Faculty Observation Form

Observers Initials ____________________

Participant Group ____________________

Date/Time ____________________

Activity Iteration Number ____________________ **Scenario:** ____________________

Activity Time: Time index from start	Action: Actions do not necessarily have to be observed in sequence.		Observations:
00:00		☐ Yes ☐ No	
		☐ Yes ☐ No	
		☐ Yes ☐ No	
		☐ Yes ☐ No	
		☐ Yes ☐ No	
		☐ Yes ☐ No	
		☐ Yes ☐ No	
		☐ Yes ☐ No	
		☐ Yes ☐ No	
		☐ Yes ☐ No	

Faculty Debriefing

Faculty Debriefing Form

Researchers Initials ____________________
Participant Group Number ____________________
Activity Iteration Number ____________________

Debriefing Questions	**Notes**

Pilot Testing and Revisions

- Number of participants to date.
- Performance expectations from various learner groups.
- Evaluation feedback from past participants

Authors and Affiliations

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Appendix 2b: Chapter 18- Sample Curriculum: Cardiovascular Medicine

Module: Cardiovascular Medicine		
1	Electrical basis of the ECG Anatomy of the cardiac conduction system Approach to ECG interpretation	
2	Arrhythmias 1 (sinus, atrial, junctional) Electrical therapy 1 (cardioversion & defibrillation)	
	Unstable atrial fibrillation with RVR *Students should complete a simulation involving a patient in afib with RVR who is hemodynamically unstable. A second case should involve an unstable patient in sinus tachycardia.* Acquire and interpret an ECG following the proscribed format; Identify atrial fibrillation with a rapid ventricular response; Describe the appropriate treatment for hemodynamically-unstable narrow complex tachycardia; Identify sinus tachycardia and describe the appropriate treatment of this arrhythmia.	**Acute coronary syndrome (NSTEMI)** *Students should complete a case involving a patient with typical anginal pain concerning for ACS. Students do not know how to obtain or interpret a 12-lead ECG and should be informed that the patient's ECG demonstrates no changes consistent with STEMI.* Obtain an appropriate history from a patient presenting with chest pain; Perform an appropriate physical exam, including obtaining an ECG, on a patient with chest pain; Correctly identify ACS; Treat ACS per protocol.

Module: Cardiovascular Medicine			
3	Pathophysiology of arrhythmia Arrhythmias 2 (ventricular, AV blocks, paced) Electrical therapy 2 (pacing)		
	Unstable ventricular tachycardia *Students should complete a case involving a patient in unstable ventricular tachycardia requiring cardioversion. The patient may develop cardiac arrest if appropriate.* Identify a hemodynamically unstable patient; Recognize monomorphic ventricular tachycardia; Utilize the appropriate ACLS algorithm for treating unstable ventricular tachycardia; Recognize cardiac arrest and manage according to ACLS protocols.		**Unstable angina (risk factors)** *Students should complete a case involving a patient presenting with unstable angina who, based on presentation and risk factors, is at high risk of having an MI.* Obtain an appropriate history and physical exam on a patient presenting with ACS-like symptoms; List several important cardiovascular risk factors (e.g. CAD, hyperlipidemia, HTN, DM2, obesity) and their effect on the clinical assessment of patients presenting with chest pain; Appropriately manage ACS.
4	Anatomy of the coronary circulation Physiology of myocardial oxygenation Pathophysiology of atherosclerosis		
5	Introduction to the 12-lead ECG		
	AMLS cardiology case #2 (pericarditis) *See case for discussion points and learning objectives. A careful approach to differential diagnosis should be encouraged.* Obtain an appropriate history from a patient with chest pain; Develop an appropriate differential diagnosis of chest pain; Provide appropriate initial medical management of a patient with possible ACS.	**Unstable bradycardia** *Students should complete a case involving a patient in an unstable bradycardia requiring transcutaneous pacing.* Demonstrate an appropriate assessment of a patient presenting with unstable bradycardia; Identify unstable bradycardia requiring pacing; Appropriately apply and initiating pacing and monitor for patient response; Describe methods to increase blood pressure while pacing (e.g. increasing the rate); Discuss general considerations when pacing a patient (e.g. pain management, sedation, on-going monitoring).	**Chest pain and 12-lead acquisition** *Students should complete a case involving a patient presenting with chest pain. Focus of the station is on the technique of obtaining a diagnostic-quality 12-lead ECG.* Obtain an appropriate history of a patient presenting with chest pain; Identify the landmarks and locations of each precordial electrode; Appropriately prepare the skin for electrode placement; Appropriate place the electrodes for a 12-lead ECG; Correctly obtain a 12-lead ECG.
6	Electrocardiographic patterns of ischemic heart disease Pathophysiology of ischemic heart disease		
	Unstable angina *The students should complete a simulation involving a patient with unstable angina.* Perform an appropriate history and physical exam of a patient with suspected ACS; Appropriately manage a patient with suspected ACS; Describe the distinction between STEMI, NSTEMI, and UA; Describe the appropriate disposition for a patient with UA.	**STEMI** *Students should complete a simulation involving a patient experiencing an anterior STEMI who is hemodynamically stable.* Perform an appropriate assessment of a patient with ACS; Obtain and interpret a 12-lead ECG; Appropriately manage a patient with a STEMI, including hospital notification.	**VF cardiac arrest** *Students should complete a scenario involving a patient who suffers VF cardiac arrest.* Describe an algorithmic approach to the management of cardiac arrest; Appropriately manage VF cardiac arrest; Describe the necessary team roles in the management of a patient in cardiac arrest.

Module: Cardiovascular Medicine			
7	Physiology of preload and afterload Pathophysiology, clinical manifestations, and management of acute coronary syndromes		
8	Conduction delay Physiology of cardiac contractility		
	Complications of AMI (arrhythmia) *Students should complete a case involving a patient with an extensive anterolateral wall STEMI who then suffers VT arrest.* Appropriately assess a patient presenting with chest pain; Obtain and correctly interpret a 12-lead ECG demonstrating an anterolateral STEMI; Manage a patient with an anterolateral STEMI; Identify and manage VT cardiac arrest; Discuss potential electrophysiologic complications of AMI	**Heart failure** *Students should complete a scenario involving a patient presenting with an acute exacerbation of CHF requiring CPAP support.* Appropriately assess a patient presenting with dyspnea; Identify signs and symptoms of left-sided heart failure; Discuss the management of heart failure, including the use of nitrates and PEEP; List potential causes of acute decompensated heart failure, including AMI.	**Inferior STEMI with RV involvement** *Students should complete a case involving a patient with an inferior wall MI requiring a fluid bolus.* Appropriately assess a patient presenting with chest pain; Obtain and correctly interpret a 12-lead ECG demonstrating an inferior STEMI; Manage a patient with an inferior STEMI, including obtaining a right-sided ECG; Discuss the use of nitrates and intravenous fluids when managing a patient with RV infarction; Discuss the potential for cardiogenic shock in the setting of AMI.
9	Correlates & mimics of ACS Chamber enlargement		
	LBBB *Students should complete a scenario involving a patient with chest pain and old LBBB. Time-permitting, the patient can suffer cardiac arrest.* Demonstrate an appropriate assessment of a patient with chest pain; List the ECG criteria for the diagnosis of STEMI in the setting of a LBBB; Appropriately manage a patient with ACS.		**LVH (heart failure, dyspnea)** *Students should complete a scenario involving a patient with dyspnea secondary to heart failure with preserved ejection fraction.* Appropriately evaluate and initially manage a patient with dyspnea; Provide appropriate supportive care for a patient with cardiogenic pulmonary edema, including CPAP; Discuss the use of the ECG in recognition of heart failure (e.g. identification of LVH); List several potential precipitants of acute deterioration of previously-stable heart failure.

<table>
<tr><th colspan="4">Module: Cardiovascular Medicine</th></tr>
<tr><td>10</td><td colspan="3">Pathophysiology, clinical manifestations, and management of heart failure
Physiology of vascular tone</td></tr>
<tr><td rowspan="2">11</td><td colspan="2">PEA cardiac arrest
Students should complete a scenario involving a patient presenting with a PEA arrest.
Recognize PEA cardiac arrest and immediately begin resuscitation;
Appropriately manage PEA cardiac arrest following ACLS protocols;
Review the reversible causes of cardiac arrest;
Describe the various team positions that should be used during resuscitation.</td><td>Post-cardiac arrest
Students should complete a scenario involving a patient initially presenting in cardiac arrest who then experiences ROSC.
Appropriately resuscitate a patient in cardiac arrest following relevant ACLS algorithms;
Identify ROSC and perform an appropriate initial assessment of a post-cardiac arrest patient;
Identify and manage post-cardiac arrest hypotension, including the use of vasoactive mediations;
Describe the management priorities for a post-cardiac arrest patient (e.g. optimization of oxygenation, optimization of perfusion);
Briefly discuss the role of therapeutic hypothermia in post-cardiac arrest management.</td></tr>
<tr><td>Megacode practice session
Students should complete a scenario involving a patient in cardiac arrest. Students should rotate being team leader and through the different team positions.
Appropriately management cardiac arrest due to a variety of arrhythmias;
Utilize effective communication and leadership strategies to optimize performance of a resuscitation team;
Appropriately perform relevant psychomotor skills (e.g. chest compressions, airway management).</td><td>CVA
Students should complete a scenario involving a patient with a suspected CVA.
Recognize the signs and symptoms of a stroke;
Perform an appropriate rapid neurological evaluation of a patient with a suspected stroke;
Provide appropriate initial management of a patient experiencing a suspected stroke;
Discuss the point-of-entry protocols for patients with stroke and demonstrate a “stroke alert” entry note.</td><td>STEMI
Students should complete a simulation involving a patient experiencing an anterior STEMI who is hemodynamically stable.
Perform an appropriate assessment of a patient with ACS;
Obtain and interpret a 12-lead ECG;
Appropriately manage a patient with a STEMI, including hospital notification.</td></tr>
<tr><td rowspan="2">12</td><td colspan="3">Megacode practice sessions
Students should complete scenarios involving a patient in cardiac arrest. Students should rotate being team leader and through the different team positions.
Appropriately management cardiac arrest due to a variety of arrhythmias;
Utilize effective communication and leadership strategies to optimize performance of a resuscitation team;
Appropriately perform relevant psychomotor skills (e.g. chest compressions, airway management).</td></tr>
<tr><td colspan="3">ACLS testing (written and practical)</td></tr>
<tr><td>13</td><td colspan="3">Vascular disease
Valvular and pericardial disease</td></tr>
<tr><td>14</td><td colspan="3">End of module exam</td></tr>
</table>

Appendix 2c: Chapter 24- Procedural Skills

Part 1a: Formatted Hemorrhage

Scenario: Point of Injury Hemorrhage Management
Intended Audience: Line Medics / Combat Life Savers

Time Requirements:

Set Up:	Simulation:	Debrief:	Reset:	Total:
30 min	15 min	30 min	15 min	90 min

Simulation Modality:

Optimal:	Acceptable:
• M - LFM	• SP • HFM • Hybrid

Equipment requirements:
- Field medical aid bag with:
  - Basic / Advanced airway management tools
  - Hemorrhage control bandages (pressure or chemical)
  - Tourniquet
  - IV / IO cannulation devices
  - IV / IO fluids
  - Trauma sheers
- Moulage
- M – LFM / SP / HFM Equipment for Hybrid scenario
- Combat uniform with all standard equipment (IBA, helmet, weapons, etc.)

Simulation Set Up:
- M – LFM (or selected modality) should be placed in a field environment (or simulated field environment)
- M – LFM (or selected modality) should be dressed in appropriate equipment for scenario
- M – LFM (or selected modality):
  - Left leg removed to simulate traumatic amputation above the knee with associated bleeding.
  - Shrapnel wounds to face with significant superficial bleeding
  - Shrapnel wounds to LUE

Time Line / Conduct of Simulation:
- Scenario Set Up completed
- Learner assessed for knowledge of didactic information
- Learner readiness for simulation assessed
- Learner briefed on situation, as appropriate to learning objectives (Situation, Patient, and Scene)
- Commence scenario
- Evaluate Learner achievement of learning objectives
- Terminate scenario
- Debrief Learner
- Reset scenario

Assessment Tool: See Attachment A | **Debrief Points:** See Attachment B

Situation:
- A checkpoint was struck by a VBIED.
- The Pt was thrown 5 yards from impact blast zone.
- Contact was made with hostile forces followed by a brief exchange of small arms fire.

Patient Information:

Patient:
- 25 YO M
- SAMPLE:
  - S: Left BKA
  - A: NKDA
  - M: None
  - P: No significant medical history
  - L: MRE 4 hours ago
  - E: VBIED strike to check point

Mechanism of Injury:
- Traumatic amputation
- Blast injury

Injuries to Patient:
- Superficial shrapnel wounds for face and neck
- Left BKA partial traumatic amputation
- Altered LOC

Symptoms:
- Localized bleeding to Left BKA / Facial injuries
- Altered LOC
- Tachypnea
- Pain

Treatment Given:
- None at time of MIST

Scene:
- Hostile forces have been removed
- Defensive perimeter is set

Assessment Elements:

Element:	Assessment:	Intervention:
Circulation:	• Steady flow of blood on ground near left BKA • Bleeding from face lacerations	• Control external hemorrhage • Apply tourniquet 2-3" above wound • May apply a second tourniquet above first if instructor chooses • Pack open wound with Combat Gauze • Identify superficial bleeding wounds on face
Airway:	• Open	• None Required
Breathing:	• Clear	• No intervention required
AVPU:	• Altered LOC ○ Pt cannot remember any events leading up to injury	• Note alterations
Head:	• Superficial wounds to face from shrapnel	• Minor hemorrhage control
Neck:	• No injuries	• N/A
Chest:	• Equal chest expansion • No visible wounds to chest noted	• Identify potential for blast injury to chest
Abdomen:	• Soft • No TTP or distention • No exit wound noted	• None Required
Pelvis:	• Stable	• None Required
Extremities:	• Left BKA with profuse bleeding • Facial lacerations	• Controlled in Circulation section • Learner should initiate IV and administer Hextend 500 mL bolus

Vital Signs:

Initial:		With treatment:		Without Treatment:	
Pulse:	136	Pulse:	112	Pulse:	140
Resp:	22	Resp:	18	Resp:	30
B/P:	70/P	B/P:	90/64	B/P:	60/P
SpO2:	92%	SpO2:	94%	SpO2:	90%
Cardiac:	Sinus Tach	Cardiac:	Sinus Tach	Cardiac:	Sinus Tach

Attachment A:
Assessment Tool

Element:	Exceeds Expectations	Meets Expectations	Below Expectations
Safety:			
Scene Evaluation:			
Assessment / Interventions:			
Circulation:			
Airway Management:			
LOC Assessment:			
Head:			
Neck:			
Chest:			
Abdomen:			
Pelvis:			
Extremities:			
Human Factors / Scene Management:			
Critical Thinking:			
Situational Awareness:			
Resource Management:			
Time Management:			

Attachment B:
Debrief Points

Safety:

Assessment:

Interventions:

Critical Thinking:

General Management:

Part 2a: Formatted Pneumothorax

Scenario: Point of Injury Pneumothorax Management				
Intended Audience: Line Medics / Combat Life Savers				
Time Requirements:				
Set Up:	**Simulation:**	**Debrief:**	**Reset:**	**Total:**
15 min	15 min	30 min	15 min	75 min
Simulation Modality:				
Optimal: • SP		**Acceptable:** • HFM • M - LFM • Hybrid		

Equipment requirements:
- Field medical aid bag with:
  - Basic / Advanced airway management tools
  - Hemorrhage control bandages
  - IV / IO cannulation devices
  - IV / IO fluids
  - Trauma sheers
- Moulage
- SP / HFM / M – LFM / Equipment for Hybrid scenario
- Combat uniform with all standard equipment (IBA, helmet, weapons, etc.)

Simulation Set Up:
- SP (or selected modality) should be placed in a field environment (or simulated field environment)
- SP (or selected modality) should be dressed in appropriate equipment for scenario
- SP (or selected modality) should have moulage applied to simulate GSW / Penetrating Trauma to Left axilla

Time Line / Conduct of Simulation:
- Scenario Set Up completed
- SP briefed on expected actions to facilitate learner care, stabilization, and evacuation from simulated environment
- Learner assessed for knowledge of didactic information
- Learner readiness for simulation assessed
- Learner briefed on situation, as appropriate to learning objectives (Situation, Patient, and Scene)
- Commence scenario
- Evaluate Learner achievement of learning objectives
- Terminate scenario
- Debrief Learner
- Reset scenario

Assessment Tool: See Attachment A	**Debrief Points:** See Attachment B

Situation:
- A platoon of dismounted troops was patrolling a village in the AOR.
- Contact was made with hostile forces followed by a brief exchange of small arms fire.

Patient Information:

Patient:
- 22 YO M
- SAMPLE:
  - S: GSW to left chest
  - A: NKDA
  - M: None
  - P: No significant medical history
  - L: MRE 4 hours ago
  - E: Dismounted troop in contact with enemy

Mechanism of Injury:
- GSW

Injuries to Patient:
- Penetrating trauma to left chest (axilla)

Symptoms:
- Localized bleeding
- Tachypnea
- Pain

Treatment Given:
- None at time of MIST

Scene:
- Hostile forces have been removed
- Defensive perimeter is set

Assessment Elements:

Element:	Assessment:	Intervention:
Circulation:	• Pooling of blood on ground near left axilla	• Control external hemorrhage • Place occlusive dressing on entrance wound
Airway:	• Open	• None Required
Breathing:	• Tachypnea	• Chest needle decompression, 2nd ICS mid clavicular line or 4th/5th ICS anterior axillary line
AVPU:	• Alert and oriented	• N/A
Head:	• No injuries	• N/A
Neck:	• No injuries	• N/A
Chest:	• GSW to left axilla • Unequal chest expansion, diminished on left • No exit wound noted	• Occlusive dressing • Chest needle decompression if not already done
Abdomen:	• Soft • No TTP or distention • No exit wound noted	• None Required
Pelvis:	• Stable	• None Required
Extremities:	• No injuries	• None Required

Vital Signs:

Initial:		With treatment:		Without Treatment:	
Pulse:	120	Pulse:	98	Pulse:	140
Resp:	34	Resp:	18	Resp:	50
B/P:	80/44	B/P:	110/84	B/P:	48/P
SpO2:	82%	SpO2:	96%	SpO2:	50%
Cardiac:	Sinus Tach	Cardiac:	Sinus Tach	Cardiac:	Sinus Tach

Attachment A:
Assessment Tool

Element:	Exceeds Expectations	Meets Expectations	Below Expectations
Safety:			
Scene Evaluation:			
Assessment / Interventions:			
Circulation:			
Airway Management:			
LOC Assessment:			
Head:			
Neck:			
Chest:			
Abdomen:			
Pelvis:			
Extremities:			
Human Factors / Scene Management:			
Critical Thinking:			
Situational Awareness:			
Resource Management:			
Time Management:			

Attachment B:
Debrief Points

Safety:
Assessment:
Interventions:
Critical Thinking:
General Management:

Part 3a: Formatted Obstructed Airway

Scenario: Point of Injury Obstructed Airway Management				
Intended Audience: Line Medics / Combat Life Savers				
Time Requirements:				
Set Up:	**Simulation:**	**Debrief:**	**Reset:**	**Total:**
30 min	15 min	30 min	15 min	90 min
Simulation Modality:				
Optimal: • M – LFM or Hybrid		**Acceptable:** • SP • HFM		
Equipment requirements: • Field medical aid bag with: o Basic / Advanced airway management tools o Surgical set o Oral / Nasal Airway adjuncts o Endo-tracheal tubes o Hemorrhage control bandages (pressure or chemical) o Tourniquet o IV / IO cannulation devices o IV / IO fluids o Trauma sheers • Moulage • M – LFM / SP / HFM Equipment for Hybrid scenario • Combat uniform with all standard equipment (IBA, helmet, weapons, etc.)				
Simulation Set Up: • M – LFM (or selected modality) should be placed in a field environment (or simulated field environment) • M – LFM (or selected modality) should be dressed in appropriate equipment for scenario • M – LFM (or selected modality): o Shrapnel wounds to face with simulated fractured mandible, mouth full of teeth and blood (surgical lube mixed with simulated blood, frozen corn or chickpeas for teeth and bone fragments) o Moulage burns to the mouth and face o Moulage superficial lacerations to upper extremities				
Time Line / Conduct of Simulation: • Scenario Set Up completed • Learner assessed for knowledge of didactic information • Learner readiness for simulation assessed • Learner briefed on situation, as appropriate to learning objectives (Situation, Patient, and Scene) • Commence scenario • Evaluate Learner achievement of learning objectives • Terminate scenario • Debrief Learner • Reset scenario				

Assessment Tool: See Attachment A	**Debrief Points:** See Attachment B
Situation: • Soldier was driver of vehicle, pulled from burning vehicle after it struck an IED. • Contact was made with hostile forces followed by a brief exchange of small arms fire.	
Patient Information:	
Patient: • 18 YO M • SAMPLE: o S: Fractured mandible with additional burns to face and shoulders o A: NKDA o M: None o P: No significant medical history o L: MRE 4 hours ago o E: IED strike and thermal burns to face	
Mechanism of Injury: • Blunt trauma to face • Blast • Thermal burns	
Injuries to Patient: • Superficial shrapnel wounds for face and neck • Partial and full thickness thermal burns to face and neck • Altered LOC	
Symptoms: • Partial and full thickness burns to face and neck • Altered LOC / Unconscious • Apnea	
Treatment Given: • None at time of MIST	

Scene:
• Hostile forces have been removed • Defensive perimeter is set

Assessment Elements:		
Element:	**Assessment:**	**Intervention:**
Circulation:	• Bleeding from superficial lacerations to upper extremities	• Non-life threatening bleeding do not require treatment
Airway:	• Occluded	• Attempt to clear and reposition airway (jaw thrust/chin lift) • Insert oral / nasal airway adjunct • Definitive control of airway requires cricothyrotomy • Learner should perform a surgical airway • If hybrid scenario, use partial task trainer
Breathing:	• Apnea	• Respirations return upon successful completion of cric • No change if needle decompressions attempted prior to cric
AVPU:	• Unconscious	• Note alterations
Head:	• Partial and full thickness burns to face • Singed nostrils • Singed lips and gums	• Insert oral / nasal airway adjunct (if not previously completed) • Perform surgical airway (if not previously completed)
Neck:	• No injuries	• Perform surgical airway (if not previously completed)
Chest:	• Prior to surgical airway: o Chest rise and fall absent • Post surgical airway: o Equal rise and fall	• Respirations return upon successful completion of cric • No change if needle decompressions attempted prior to cric
Abdomen:	• Soft • No TTP or distention • No exit wound noted	• None Required
Pelvis:	• Stable	• None Required •

Attachment A: **Assessment Tool**			
Element:	**Exceeds Expectations**	**Meets Expectations**	**Below Expectations**
Safety:			
Scene Evaluation:			
Assessment / Interventions:			
Circulation:			
Airway Management:			
LOC Assessment:			
Head:			
Neck:			
Chest:			
Abdomen:			
Pelvis:			
Extremities:			
Human Factors / Scene Management:			
Critical Thinking:			
Situational Awareness:			
Resource Management:			
Time Management:			

Attachment B: **Debrief Points**
Safety:
Assessment:
Interventions:
Critical Thinking:
General Management:

Part 4a: Cricothyrotomy

- Palpate thyroid and cricoid cartilage for orientation.
- Locate cricothyroid membrane.
- Cleanse the incision site with alcohol or betadine swabs.
- Stabilize the thyroid cartilage using your non-dominant hand.
- Make a vertical incision through the skin approximately 2.5 cm (1 inch) long over the cricothyroid membrane.
- Visualize the cricothyroid membrane.
- Make a horizontal incision through the cricothyroid membrane.
- DO NOT make the incision more than ½ inch deep or you may perforate the esophagus.
- Using either Kelly hemostat or knife blade handle, insert into incision and blunt dissect incision (turn the curved Kelly hemostat 90 degrees to open up the incision)
- Insert the shortened endotracheal tube into the incision, directing the tube distally down the trachea.
- Inflate balloon with 10 cc's of air, this serves two purposes, it holds the endotracheal tube in place and acts as a barrier and prevents fluids from entering the lungs.
- Ventilate the patient with two breaths using bag valve mask. During these first two ventilations Observe for bilateral rise and fall of the chest with each ventilation.
- Observe the ET tube for misting, fogging, or condensation.
- Auscultate for bilateral breath sounds.

Fig. A2.1 Equipment for Cricothyrotomy

ANATOMY

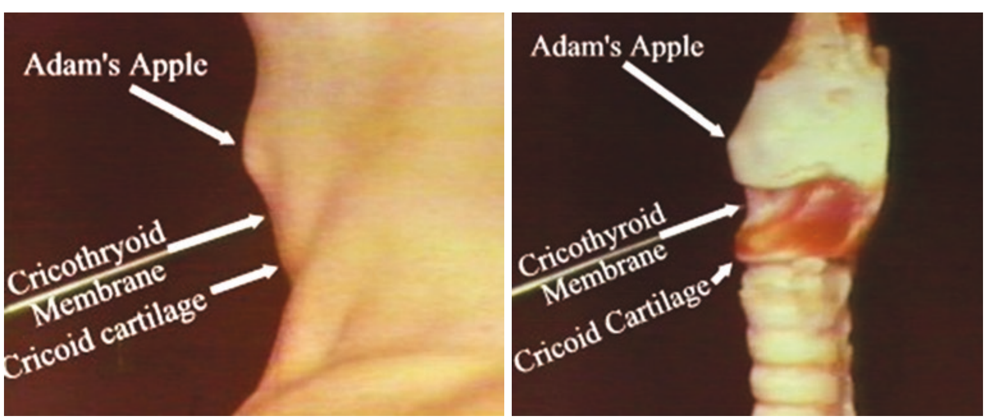

Fig. A2.2 Anatomy for Cricothyrotomy

Part 5a: Needle Decompression Card

- Identify the tension pneumothorax. Does the patient present with:
  - Difficulty breathing?
  - Absent breath sounds to the effected side?
  - Unequal rise and fall of the chest?
  - Tracheal shift?
  - Jugular vein distension?
- Position the patient in the supine position.
- Identify the mid-clavicular line on the affected side of patient
- Identify the 2nd intercostal space:
  - The 2nd intercostal space is found by dividing the clavicle in half. From that halfway point, palpate down one rib to the first space below that rib. This is the 2nd intercostal space (the space immediately after the clavicle is the 1st intercostal space).
- Cleanse the site with betadine or alcohol (whichever is available).
- Attach a 14 g × 3.25in IV catheter to a pre-filled 10 cc syringe.
- Remove plunger from syringe.
- Insert needle into 2nd intercostal space. Look for bubbles escaping into the syringe.
- Remove needle and syringe leaving the catheter in place.

Place the patient in upright position (if C-spine injuries have been ruled out) to assist with respirations. The patient may remain supine if C-spine injuries are suspected

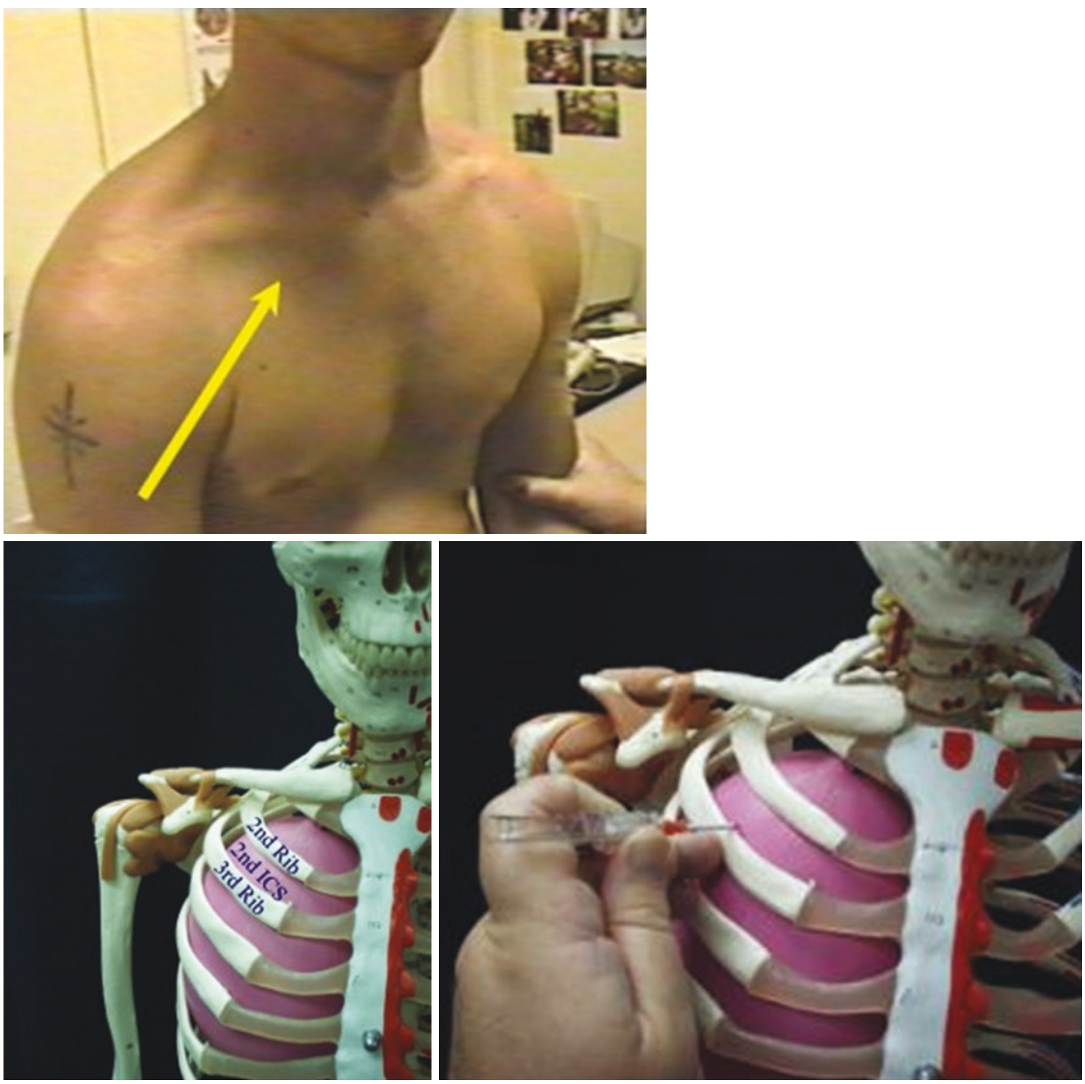

Fig. A2.3 Anatomy for Needle Decompression

Part 6a: Tourniquet Card

<u>TOURNIQUETS- HEMORRHAGE CONTROL</u>

<u>3 most common types of bleeds on the battlefield:</u>

1. Carotid bleed
2. Femoral bleed
3. Brachial bleed

<u>Most common types of tourniquets used:</u>

- Soft-t tourniquets
- C-A-T tourniquets

<u>General rules for applying a tourniquet:</u>

- **Place as high as possible**
- **Never place below a joint**
- **Tighten the tourniquet until the bleeding is stopped, NOT as tight as possible**
- **Tactical situation = used as the treatment of choice on the battlefield**
- **Non-tactical situation = used as a LAST resort**
- **Use a tourniquet if internal arterial bleeding is suspected**
- **NEVER remove a tourniquet on the battlefield after is has been applied**

~Exsanguination is the most common cause of death on the battlefield, but can be prevented~

Fig. A2.4 Tourniquets and Pressure Dressings

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C. Strother et al. (eds.), *Comprehensive Healthcare Simulation: Emergency Medicine*, Comprehensive Healthcare Simulation,
https://doi.org/10.1007/978-3-030-57367-6