Simulation in Emergency Medical Services

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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].

S. Goldberg (✉) · A. Eyre
Department of Emergency Medicine, Brigham and Women's Hospital, Boston, MA, USA
e-mail: sagoldberg@bwh.harvard.edu

V. Storie
Professional EMS Center for Medics, Cambridge, MA, USA

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 re-

allocating 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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