1 Organization of Urgent Medical Aid, Including Mass Casualty and Triage

James R. Ficke, Anthony E. Johnson, and Joseph R. Hsu

1.1 Introduction

Modern armed conflict is notable in that the violence of today's weaponry and the profound severity of wounds create frequent situations in which trauma care providers are faced with situations that severely strain available resources. When those resources are strained beyond existing capacity to treat the sheer volume of wounded, the event becomes a mass casualty incident. This chapter addresses the organization of urgent medical aid for trauma, primarily in the military setting. However, the concepts and application are readily applicable to civilian settings, and the intent is to outline key aspects of a successful system for the spectrum of urgent medical care for the individual as well as the mass casualty event.

In consideration of the factors related to organization for care of urgent trauma patients, a continuum ranges from the solitary severely wounded patient, where every available resource may be utilized to preserve life and function, to the mass casualty situation, where the high numbers of injured overwhelm available resources. Modern military medical facilities and many civilian hospitals have adopted models of successful organizations and health systems directed toward a regional response to a massive terrorist event or natural disaster. We will also address individual considerations of triage and initial assessment of the immediate care patients. Recent armed conflicts internationally have focused on awareness of the requirement for not only military but civilian facilities and care providers to understand and be confident in addressing these potentially chaotic conditions. The focus in these events, where resources are constrained or overwhelmed, becomes that of preserving the most lives and doing the most good for the highest number of patients [1].

1.2 Surge Capacity

The organizational structure for any center with potential for management of multiple casualties in rapid sequence or simultaneously is essentially identical for military or civilians. In Israel, where there are no fixed military hospitals, a strategic national approach has been quite effective [2]. This system is based upon preservation of hospital surge capacity, a concept that must be defined clearly and completely before other considerations are discussed. When a hospital is functioning at a typical or normal tempo, the ability to react to unexpected urgent requirements has been termed surge capacity. In order to remain relevant to surge, the hospital must balance successful utilization and the business of medicine, while retaining a reserve. Historically, there has been no clear consensus on the definition of surge capacity, but the concept has been well described in a recent paper by Hicks et al. [3, 4]. They describe four interrelated resources that absolutely require attention in planning and execution. Those are simply system, space, staff, and supplies.

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Further examination into these areas yields thresholds of capacity to include conventional, contingency, and crisis. Conventional capacity refers to the hospital's daily workload and their normal functions that are carried on without modification of routine practices. Contingency capacity requires temporary expansion into existing space, staffing models, and logistics for mass casualty management, but can generally be sustained within the existing system. Finally, crisis capacity requires that routine hospital systems and all usual practice patterns are diverted toward sustainment and execution of the hospital wide emergency operating plan. In other words, every resource becomes committed to the care of the injured delivered to that facility. Sustainment generally requires outside support. The Israeli national system has identified several factors that are critical to success (Table 1.1).

Without a surge capacity, any hospital facing reception of multiple urgent casualties is ineffective. These guidelines present a validated list of priorities to enable the facility to be prepared. Preparation, however, only begins with development and maintenance of surge capacity. Additional factors often dictate the effectiveness once reception has begun. The resources available are critical, and include broad categories of logistic supply – blood products, ventilators, surgical equipment, and capacity to reprocess sterile material; space; personnel, and their training or level of preparation; communication capabilities; information technology systems; and medical records. Command and Control of the facility, entry access to the hospital, and security for both patients and hospital personnel are additional keys to success.

Any aspect of operating the facility may become the constrained resource, and therefore all sections of the organization play a critical role in preparation, execution, and recovery [5–7]. Additional factors in organization require confident leadership; continuing training; being alert to the potential contamination of patients or even the treatment facility with hazardous material [8]; expanded mortuary affairs facilities; and information technology and medical records [9]. Finally, planning requires consideration for rapid recruitment of external resources (personnel, space, and equipment) and hospital staff support in the context of sustainment, rest cycles, emotional protection/resiliency. Many civilian trauma centers never experience a mass casualty incident, and very few care providers will ever participate in multiple events. These are stressful and life changing and consideration of the personal impact on the hospital staff is an extremely important area when the team faces these situations on a recurrent basis.

Table 1.1 Israeli Surge Capacity Essential Tasks [2]

1.	Nationally coordinate resources – central authority for defining and enforcing policies; ensuring sufficient equipment, supplies, and stockpiles are prepositioned
2.	Establish goals – for each facility's surge capacity
3.	Prepare standard procedures – supplies, leadership, communication
4.	Continually monitor surge capacity – daily reporting bed, ICU occupancy, critical resource availability including ventilators, CT scanners
5.	Design expandable facilities – prepare nonstandard patient areas for contingencies- medical gas, ventilation, power supply
6.	Avoid emergency department overcrowding – rapid throughput
7.	Promptly clear EDs – immediate dispositions on notification
8.	Augment medical workforce – maintain current staffing rosters, contact information, communication plans, and reporting centers
9.	Designate an adjoining site for minimal injury patients
10.	Distribute severely injured casualties among several hospitals
11.	Assign an EMS liaison to each receiving hospital – direct link to hospital leadership to transmit numbers, types, arrivals of injured patients, and relay capacity
12.	Designate a triage hospital – if the closest hospital is overwhelmed, it stops admitting and begins triaging to other facilities; focus changes to stabilizing and transport
13.	Frequently conduct rigorous full scale drills – annual full-scale exercise to include surgery times, resource elimination, security, and possible Weapons of Mass Destruction involving nuclear, biologic, and chemical hazards. Mandatory after action reviews
14.	Continually maintain surge capacity – establish balance between economic and cultural barriers; create incentives for hospital preparedness

1.3 Leadership

Leadership is the paramount factor that influences the outcome of an event. When the leader is strong, the organization yields to the direction and confidence of the leader. In the absence of a strong leader, a well defined organizational structure can preserve the institution until a leader emerges. At the bedside level, a well trained and confident trauma treatment team begins with the team leader, most often an emergency physician or surgeon. The team includes an airway expert; one or two medics who establish IV access; a procedure expert, addressing chest tubes, arterial access, and more difficult intravenous access; and a medical recorder (Fig. 1.1) The US military trauma training centers train personnel based on this concept and practice routinely in order to develop a spirit that fosters cooperation, communication, confidence, and competence [10]. As the scope of an event escalates, the leadership within the trauma department becomes another key to organizing what may rapidly devolve into chaos [11, 12]. Issues such as direction of traffic flow, communication, and accountability of patients require a central command location, where the leadership manages this operating picture. Many centers identify an external triage officer, directing priorities of patients into various areas of the hospital, and a surgical or internal triage within the emergency department. This individual maintains situational awareness of definite urgent surgical patients and the tentative order of priority into a surgical suite or bed. The surgical priority officer will also work with overall hospital leadership to prioritize assets like the Computerized Tomography (CT) scanner or ICU beds for postoperative patients. At the hospital level, the Incident Command System provides a logical and universally consistent model that will be described in detail shortly. Outcomes ultimately depend on leadership at every level and empowerment of every person involved, with constant training, frequent rehearsals, and consistent after-action reviews to improve the process. Clear lines of communication and unity of the decision making process are critical and must be understood by all members of the team (Photo 1.1).

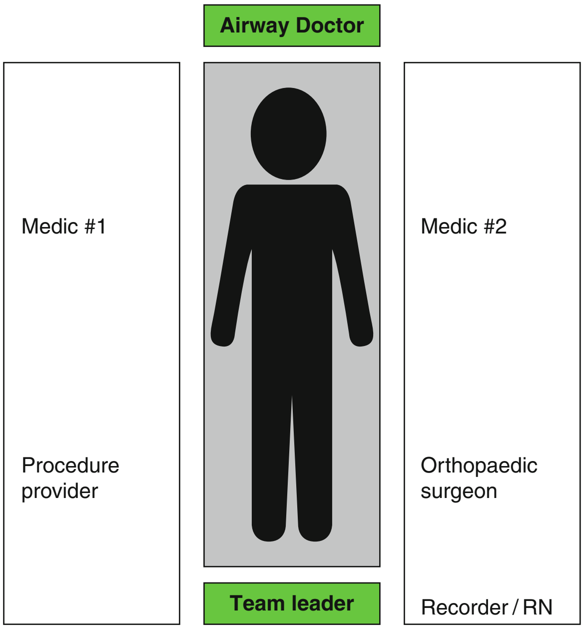

Fig. 1.1 The standard trauma team organization – medics establish IV access, vital signs, assist surgeons or airway; team leader and recorder run surveys from foot of bed; airway management by emergency physician or anesthesia provider

The trauma team organization addresses single patient resuscitation, while the hospital leadership addresses factors affecting multiple patients, the entire hospital staff, as well as the external entities also impacted. In the United States Military, highly High mobile Forward Surgical Teams or FSTs, are surgical teams are designed to travel with combat units, or shortly behind, with the mission to provide far-forward trauma life support and damage control resuscitation or surgery. The civilian counterparts to this is are the International Medical-Surgical Teams, or IMSuRTs [5, 12, 13]. These teams are fairly similar in size, capability, and function. Consisting of 30 personnel, the IMSuRTs can be deployed worldwide in support of contingencies including trauma, burns, blasts, and natural disasters, such as the recent earthquake in Haiti. These teams can augment existing facilities or provide crisis and contingency management when existing infrastructure is eliminated by the event. Neither the IMSuRT nor the Forward Surgical Team is capable of sustained independent surgical or critical care operations without external support. These teams include the commander and deputy and experts in trauma and orthopedic surgery; emergency medicine; anesthesia and critical care specialists; respiratory therapist; registered nurses trained in emergency care, operating rooms and critical care; as well as paramedics and logistics staff [5, 13]. Above these mobile teams, the organization of medical facilities capable of providing level III definitive care are major trauma centers, with intensive care units, advanced radiographic imaging capabilities, blood bank, and major surgical resuscitation. Each national military has its own specific organizational structure, and each branch of service within the United States military has distinct compositions. The critical components, however, all include competent surgical, emergency medical, critical care physicians, nurses and technicians, as well as intrinsic laboratory, radiology, and pharmacy sections that actively participate in the direct care. The requirements for blood mandates that this area

Photo 1.1 Trauma team focuses on initial airway management, resuscitation access, and primary survey, while team leader observes and directs interventions, and recorder maintains details of surveys and treatment

receives direct attention from the hospital command. In the event that requirements necessitate fresh whole blood drives, two way communication between the senior hospital leadership, the remote supply units charged with maintainting stock levels, and supporting units is vital. The requirements for blood mandate that this area receives direct attention from the hospital command, and two-way communications with the senior hospital leadership, the remote supply units charged with maintaining stock levels, and supporting units, in the event of requirement for fresh whole blood drives, a topic to be discussed later. The command group includes the senior physician or chief of hospital professional services, the senior nurse, and chief of logistics. This element must be geographically situated in an area where visibility and communications of any event and minute-by-minute tracking of resources, patients, and available personnel are directly fed into the command center. Within these, the organization is similar to fixed civilian facilities. The difference is primarily in the expectation in a military unit that the mass casualty incident will happen at any moment, and it often does.

1.4 Hospital Incident Command System

In order to establish effective control, there must be a clear hierarchy within the decision-makers. A well practiced and validated system, known as the Incident Command System, or HICS, has been implemented within many civilian as well as military facilities [7, 11–14]. HICS represents an organizational structure, not a specific disaster plan. It should be flexible and adaptable to varying situations, capabilities, and nature of the event. This system establishes key leaders in the broad areas of operations, administration, planning, and logistics who all answer to a single incident commander [13]. This Incident Commander may be in charge of the disaster site, or the emergency department, and represents unity of authority within the receiving hospital. The Operations Chief is responsible for execution of all tactical operations. In the mass casualty, this includes scene or hospital security, triage, evacuation, and within the hospital- treatment and mapping of the various collection areas. The Planning Chief is responsible for preparation of actual contingency plans, training and after action revisions of plans. This section should have a plan for everything from personnel protection to specific contingencies for anticipated disasters. The Planning Chief develops the comprehensive detail of event management from alerting hospital staff to providing protection of patients, hospital personnel and facilities or expanded mortuary services. Communication with neighboring units to provide additional personnel support, power generation, or nonstandard evacuation resources [11]. Planning should also include forging relationships with every possible source of assistance or support. The challenge is to forecast the need, to establish communication, to develop relationships, and to forge agreements in advance of a crisis [11].

The Logistics section is critical to bolster diminishing supplies or resources during the execution of an event and maintenance of resources beforehand. In the austere environment of contemporary armed conflict, nothing can be taken for granted. Power generation of electricity and medical gases, environmental control to patient areas or even to prevent overheating of medical equipment such as CT scanners become critical when degraded. In these enviornments, resupply is often addressed in terms of weeks rather than hours for surgical equipment, blood, or evacuation assets.

Less critical in military settings, but important in extension of civilian resources, the financial or administration chief handles costs, payments, and collections from an event.

1.5 Blood Product Management and Planning

Blood product management is one critical resource in every situation, from a single event to the worst mass casualty. Not infrequently, allocation in a massive transfusion protocol for a single patient in extremis can result in loss of other subsequent lives potentially savable. Commitment of blood products is important in the discussion of the organization, as this becomes a significant resource. Between 1975 and 2006, there had only been five disasters in the United States in which more than 100 units of blood were transfused, yet the potential is constantly present [15]. In contrast, deployed hospitals routinely transfuse at substantially higher rates, indicating the difference in injury patterns with armed conflict. In deployments supporting Warriors, procurement and handling of blood products is managed at the highest levels of the health care system, as an indication of the product importance. As high as 20% of combat casualties from Iraq and Afghanistan require blood transfusion and 7% will require massive transfusion exceeding 10 units of red blood cells in 24 h [16–18]. Soffer et al. [19]. analyzed blood product utilization during 18 consecutive terrorist attacks in Israel with the goal of predicting resource requirements related to patient volume and severity of their injuries. These researchers described the packed cells per patient index (PPI). The group observed that the units of packed red blood cells (PRBC) transfused per patient were related to incident size. Smaller incidents, defined as less than 25 evacuated casualties averaged a PPI of 0.7 and larger incidents resulted in average PPI of 1.5. Half of the units of PRBCs were required in the first 2 h after the incident. An initial analysis of data from a single combat support hospital (CSH) data supported this concept. Beekley and coworkers noted a 22% transfusion rate for all evacuated casualties during mass casualty incidents, and 4.2% requiring massive transfusion [16]. The similarity of findings between these two studies led to a conclusion that the number of casualties triaged to receive urgent hospital care, in the face of effective scene triage, may provide a baseline estimate of blood requirements. It is important to recognize the requirements for blood early, and anticipate resupply quickly.

1.6 Communication/Information Systems

A comprehensive discourse on organization of urgent medical aid requires detail on the critical role of communications and information technology within the hospital. Here, civilian facilities may be at a significant disadvantage, due to the association of military units with robust field communications networks. Regardless of scope of care, there is always a need to recall physicians and associated health care providers to render aid. Communications, therefore impacts direct links with physicians, internal communications between hospital sections and the leadership, and external links with evacuation resources, security elements, on-scene responders and triage officers, as well supporting elements and the public.

Effective planning and execution of communications for contingencies and mass casualty incidents mandates reliable systems and redundancy in these systems. The scope of reliability ranges from messenger – the most effective and secure – to wired telephones to radio, including hand-held walkie-talkie style devices, and cell phones and two-way pagers, now popular in many civilian organizations.

A recent study of a major US civilian center demonstrated inadequate transmission and ineffective return communication or timely response in 48% of providers by cell phone and 22% by short message signal (text messaging) [20]. The conclusions of this study were that alternative forms of communication are preferable. In military settings, use of cell phones and other wireless methods carries additional risk of breaches in security. The most secure method is by conventional land telephone, and this mode does not require power to continue. Within a hospital, where decision-makers may be mobile during the course of a major event, radio transmissions via handhelds works very well, with reasonable range. The use of human messengers is an excellent application of a labor pool, if people are available, and this can be extended to external communications as well when interacting with neighboring military units, or other facilities in the event of power or infrastructure failure.

One very important aspect of communications rests with the release of information to the public. Family members, municipal organizations, volunteers, and media all have varying needs to be met. A Public Information Officer, identified beforehand, and trained on techniques to release appropriate information, in a sensitive and factual manner is extremely valuable in these situations. As a hospital trains and practices in crisis management, so can a Public Information Officer. In any event, the information provided to outside parties must respect individual patient privacy, yet strive to positively identify the casualties; to protect the hospital staff and facilities; and remain as consistent as possible in a very fluid environment. This conveys confidence, and therefore gains trust within the community or region.

The advent of electronic medical records, and computerized information technology in urgent medical treatment has advanced the sophistication, and reliability of record retrieval. Whether the existing systems improve patient care in the mass casualty situation remains unanswered. Access to terminals when resources are overwhelmed has the potential for additional complexity. Reliable recordkeeping is best done at the bedside, as events are occurring in extremely rapid sequence. Regardless of the electronic support for a particular facility, training and familiarity with these systems is mandatory, and as in spoken communication, redundancy of distinct systems is critical.

The last aspect of communications that is important in this area involves the training and appraisal process following events. The After Action Review is a dialogue of staff and leadership that shapes future responses to such incidents. These are incredibly important, and equally important to involve all who had a role in the event. An open forum, permitting people at all levels of the organization to contribute is ideal, and in large events is best to conduct by sections initially, following resumption of normal activities, but before surge personnel depart. The emergency department may conduct their AAR hours before the surgical section or intensive care units. Regardless of approach, the opportunity to remodel previous plans, improve major care processes, as well as to decompress much of the energy and frustration that may linger is essential to sustained well being of the group or section or even the hospital.

1.7 Characterization of Injuries

One important recent study reported on the activity of a large military hospital supporting high intensity stability operations over a 1 year period. The authors analyzed all activity for that year, and defined a mass casualty event as a single episode or multiple simultaneous events precipitating a surge in trauma resuscitations by more than one standard deviation above the mean daily emergency department admissions. The hospital responded to 25 mass casualty events, of which 10 (40%) were from mortar attacks, 7 (28%) were associated with an explosive device, and 8 (32%) occurred as a result of combined explosions and gunfire [16]. Out of 539 patients treated in 26 collected events, 415 of these patients (77%) required operation. Wound excision was the most common surgery performed, in 168 (41%); laparotomy was second, performed in 76 (18%); and extremity amputation or fracture stabilization in 64 (15%) of the 415 patients managed surgically [16]. This pattern of wounding and the subsequent strain on resources becomes the single greatest factor in planning for surgical capacity. In contrast, reports from recent events not related to explosions demonstrate major impact on other resources, but globally lower injury severity, and clearly less surgical requirement. As an example, the bridge collapse in Minneapolis Minnesota, in the United States in 2007 resulted in far lower surgical response [21]. In that significant natural disaster, 127 people were injured, and on-scene triage resulted in emergent medical transport of 50 patients to receiving hospitals, and 33 additional self-referrals over then initial 24 hours following the event. Sixteen of the 25 patients transported to the major trauma center had an average Injury Severity Score of 17 and required admission. This amounted to 13% admission rates and approximately half of these requiring surgeries. Similarly, analysis of the London bombings of July 2005 demonstrated that of 775 injured people, 55 were severely injured, and 17 required surgery [15]. They did not report injury severity scores, but in this confined space explosion event, 30% of severely injured required surgery, although this amounted to 3% of the total injured. Among this large group, wound debridement (15) was the most common surgery, followed by lower limb amputation (11) and then laparotomy in five patients. Of the 58 total operations, 37 of these were extremity injuries accounting for 64% of surgeries. Also of note, in the resuscitation of these 55 patients, 264 units of blood products were transfused over the first 15 h. This utilization was only slightly higher than an average daily use.

1.8 Triage

Modern casualty evaluation, treatment, and evacuation (in civilian and peacetime military and combat scenarios) have become so immediate and efficient that a mass casualty situation can result at the receiving medical treatment facility (Fig. 1.2) [23–40].

A mass casualty situation occurs when the number of casualties exceeds the medical treatment capabilities available (medical personnel, supplies, or transportation/evacuation assets). Triage – from the French *trier* (to sort) – is a casualty management system/process for sorting a large number of injured personnel on the basis of where resources can be best used, are most needed, and/or are most likely to achieve success [41]. Triage is a dynamic patient care process that occurs, and is repeated, at every entry and egress point in the evacuation chain.

Unlike civilian trauma, military trauma (especially combat trauma) is predominantly multicasualty due to a mixture of blast and/or penetrating injuries affecting multiple organ system [24, 28–31, 36]. The ultimate goal of military medicine is to preserve life, limb, and eyesight while simultaneously returning the greatest number to combat. Situations where the decision needs to be made with regard to withholding or curtailing care to a wounded individual who in another setting may be salvaged, are rare in civilian and peacetime military trauma settings. This is, however, the essence of combat triage [41].

1.8.1 Triage – A Brief History

Napoleon's surgeon, Baron Dominique-Jean Larrey, is often credited with establishing the ambulance corps, as well as, the modern battlefield triage system that set the priorities for evacuation [42]. During Napoleonic warfare; the larger force was often victorious. Hence, the highest priority patients were the ones that could be returned to duty quickly. Often, the severely wounded were left on the battlefield until the conclusion of the battle. Larrey altered the established pattern of the times by going forward with his ambulances to evacuate the wounded who could potentially survive with surgical care (often amputations) [42].

During the U.S. Civil War, Charles Tripler and Jonathan Letterman further developed Larrey's principles by formally establishing a military ambulance service and forward aid stations. In the beginning of the war, wounded soldiers were often cleared from the battlefield after the fight, while medics rapidly returned the less seriously wounded back to their units to continue fighting. At First Manassas in 1861, it took nearly a week to get the 5,000 dead and injured soldiers off the field [43]. Tripler and Letterman formed teams of dedicated personnel to go forward and retrieve casualties who could benefit from the emergent treatments of the times with success. Following the 7 Days Battle that ended the Peninsular Campaign in July of 1862, the ambulance corps was established by U.S. Army Special

Operation	Timeframe	Deaths	Wounded	Total
Iraqi Freedom	19 March 2003–1 October 2009	4,329	31,494	35,823
Enduring Freedom	7 October 2001–5 September 2009	812	3,896	4,708
Total	7 October 2001–1 October 2009	5,141	35,390	40,531

Fig. 1.2 Total casualties from Operations Enduring and Iraqi Freedom [22]

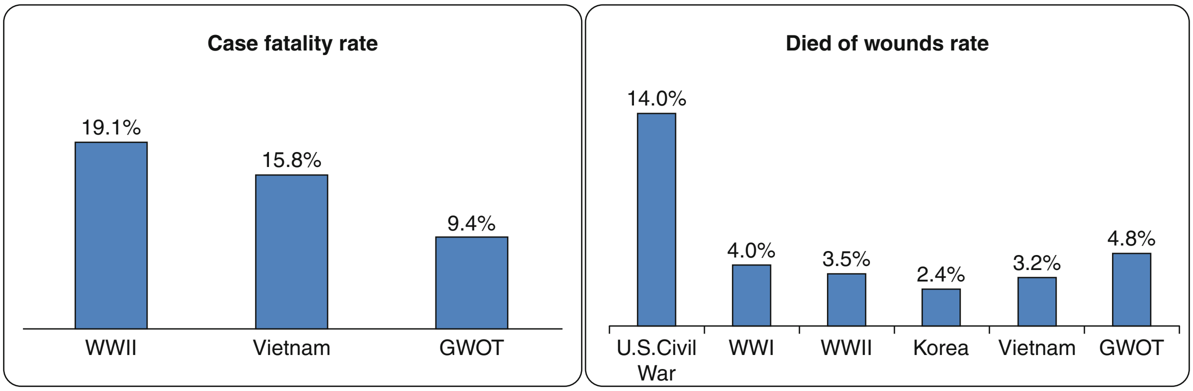

Fig. 1.3 Died of Wounds (DOW) rate is the number of all deaths that occur after reaching a medical facility minus the patients who are returned to duty. The Case Fatality (CFR) rate is measure of the overall lethality of the battlefield for all wounded. While the CFR has steadily declined since WWII, the DOW has increased reflecting the advanced in pre-hospital battlefield care [25, 26, 46]

Order 147 in August 1862. At Antietam in 1862, with about 23,000 dead and wounded, all the casualties were removed from the battlefield in 24 hours [44]. Letterman's refinement of Tripler's model of casualty management became the standard for the Union Army by an act of Congress in March 1864 [45–47].

Early in the twentieth century, technological revolutions in warfare (machine guns, chemical and trench warfare) outpaced evolutions in medicine – as well as the ability to care for casualties. During WWI, casualties in the thousands quickly overwhelmed the capabilities of hospitals designed with capabilities in the hundreds capabilities in the hundreds. WWII with its global nature and warfare advancements such as tanks and air support stretched the capabilities of the medical system, especially transport of the wounded. With the advent of aeromedical transportation during the Korean War, the transportation times decreased from 12 to 28 h in WWII to 4 h in Korea to less than 2 h in Operation Iraqi Freedom [33, 46]. The more efficient evacuation system necessitated a changed to the thinking in battlefield casualty care – from buddy care in WWII to standardized prehospital battlefield trauma care in the current Global War on Terror (Fig. 1.3).

1.8.2 Tactical Combat Casualty Care and PHTLS in the Military

Care of trauma patients advanced significantly with the advent of Advanced Trauma Life Support (ATLS) in 1979. While ATLS was geared towards surgeons, movement toward education of prehospital emergency personnel began shortly after. Prehospital Trauma Life Support (PHTLS) was launched in 1984. In 1988, the department of defense began to train its medics in PHTLS coordinated by the Defense Medical Readiness Training Institute at Fort Sam Houston, Texas. However, the differences between civilian and peacetime military trauma (predominantly blunt trauma, robust resources, relatively low risk to care provider) and battlefield trauma (predominantly penetrating trauma, austere conditions, high-risk to care provider) slowly gained recognition [1, 28, 30, 36, 48]. The tactical combat casualty care (TCCC) project was begun in 1993 by the Naval Special Warfare Command and development continued under the U.S. Special Operations Command [27]. TCCC guidelines were incorporated into PHTLS training manuals in 1999 as a chapter in military medicine. In 2001, the Army's 91WB program standardized the training of over 58,000 Army medics to include PHTLS.

TCCC's goals are to educate the combat medic on the interventions that would address preventable causes of death on the battlefield (massive external hemorrhage, airway obstruction, tension pneumothorax) until the tactical situation allows more comprehensive care. Typically, TCCC follows three major phases: Care under Fire, Tactical Field Care, and Tactical Evacuation Care (TACEVAC). TACEVAC was formerly known as Casualty Evacuation or CASEVAC. The effectiveness of TCCC is borne in the historically unprecedented low case fatality rate in GWOT [33] An unforeseen second-order effect of more efficient prehospital battlefield care is the increase in the died of wounds (DOW)

Fig. 1.4 Three main phases of Tactical Combat Casualty Care(TCCC) [1] TCCC's advancement of pre-hospital battlefield care has been a major contributor to the low case fatality rate seen in GWOT

Tactical combat casualty care phases	
Care under fire	Phase defined by direct and/or ongoing threat to patient and medic Aid is rendered quickly to address an immediate life threat. Typically little more than placement of tourniquet and movement of patient out of line of fire
Tactical field care	Phase defined by reduction on direct threat to patient and medic but still in a tactically unstable environment Patient is revaluated and HABCs are addressed. H=Hemorrhage, A=Airway, B=Breathing, C=Circulation. Typically only emergency measures are employed in this phase such as re-check of tourniquet, needle thoracotomy,and dressings. This phase is dynamic and threats can re-emerge.Dedicated efforts such as CPR are not initiated in this phase.
Tacevac (aka casevac)	Phase defined by movement of patient out threat zone and towards definitive medical care Patient is re-evaluated and dedicated care may proceed in this phase. This may be continuation of care by the first responder to advanced medical/surgical procedures performed by dedicated medical crews en route to the next echelon on care

rate, as the casualties that would have been classified as killed in action (KIA) in previous wars are surviving initial evacuation and succumbing to their injuries after arrival at the hospital (Fig. 1.4).

1.8.3 U.S. Military Triage and Underlying Principles

An exhaustive discussion of the philosophical principles as it relates to battlefield triage is beyond the scope of this chapter but a brief overview is presented. By definition, a true triage situation occurs when the number of patients exceeds a medical system's capability to provide optimum treatment to all (i.e., lack of medical providers, transportation, or logistics). As practiced and codified by doctrine, U.S. Military triage fosters the core values of human life, health, efficient use of scarce resources, and fairness while disregarding several prominent ethical values inherent to medicine such as autonomy and fidelity [49, 50]. The most important aspect of triage is that it requires strong leadership. At whatever level along the care chain it takes place, the triage officer must be decisive, as experienced as conditions permit, and effective in communications [11]. An effective triage instills confidence in patients and care providers, as well as delivering a certain degree of order to the chaos of a mass casualty event.

Human life: The triage system inherently seeks to maximally protect human life. However, given the scarcity of resources, the preservation of all human life is not the absolute goal. Many triage systems allow for the loss of an individual life in order to provide life-saving treatment to other patients in need if the first patient's injuries are so severe that the chance of success is too low, or would otherwise consume too many resources at the expense of other patients (e.g., a single patient treatment would exhaust the entire blood supply of a treatment facility currently taking casualties).

Human health: While triage systems prioritize patients in need of immediate life-saving treatment, it also provides priority to patients in need of emergent or urgent treatment to restore or preserve function (i.e., the dysvascular limb). In theory, triage systems provide opportunity to meet patients' needs for both life-saving and non-life-threatening treatment. However, the less urgent condition may need to wait until the more seriously injured have been treated or evacuated – even at the risk of pain, complications, or poor outcomes.

Efficient resource utilization: The goal of any triage system is to maximize the use of scarce resources to achieve the best overall outcome. Hence, the triage system may direct the use of resources towards patients whose needs are the greatest and who have the greatest chance of a benefiting from the treatment. It may simultaneously direct resources away from patients who are too severely injured to be successfully treated at the time or whose injuries are too minor. It is important to note that the triage process is a continuum that cycles until either all patients are treated or all available resources have been expended. Thus, the patient who was deemed mid-priority in the first triage cycle may become a high priority in the next cycle, or even mid-cycle should his/her condition deteriorate.

Fairness: An action is defined to be procedurally fair if it conforms to the rules governing the practice. Substantively, an action is fair if it conforms to an accepted standard. Because triage decisions are made according to established criteria and rules, they can be judged to be both procedurally and substantively fair.

Autonomy: Contemporary biomedical ethical theories, especially in U.S. health care systems, heavily values to the principle of autonomy. This principle emphasizes the patient's right to make choices about their health care (i.e., their right to informed consent) as well as the physician's right to accept patients as well refuse requests for harmful treatment. However, in emergency situations (where triage is most applicable) expectations of autonomy are diminished by both the patient and the medical provider. The patient is assigned to a treatment category based on their condition without consultation or consent. The triage officer, in turn, must curtail their clinical autonomy and must conform to established criteria and assign patients to appropriate categories.

Fidelity: In the traditional physician-patient relationship, the physician has a responsibility to act in the best interest of the individual patient above self-interest and above the interest of others. In triage situations, however, the physician cannot pledge unqualified commitment to any patient but must conform to the established rules.

1.8.4 Triage – Practical Application

The responsibility for sorting critically ill patients, triage, ultimately is a life or death decision. This role cannot be relegated to the untrained or unprepared medical personnel. The ideal situation is that the most experienced physician, preferably with a surgical background and trauma experience, takes this position at level III facilities, or the trauma hospital. The process is rapid, and delay in decision-making or to permit treatment, risks the lives of many. Decisions for each event will be predicated upon situational awareness of the available surge capacity, access to resources to include the CT scanner, the Operating Room, ventilators, or evacuation to higher levels or secondary facilities [1, 32, 51]. In armed conflict, as occurred in Mosul Iraq with the Dining Facility explosion of December 2004, the triage may be performed under risk of incoming hostile fire. Additionally, weather and distance to nearby support facilities influence decisions (Photo 1.2).

As previously stated, triage is a dynamic process that is performed at many levels from the battlefield to the combat support hospital and throughout the evacuation chain. Each patient's status can and often does change. Resource availability is equally dynamic. Vital signs or level of consciousness can deteriorate, as well as obstructions of airways and failure of tourniquets, and these all may serve to alter the condition status [1]. The essential step in triage is the categorization process. Traditionally, the triage categories follow the DIME mnemonic – Delayed, Immediate, Minimal and Expectant. In mass casualty situations where both medical and surgical patients are encountered, the category of Urgent has been used to differentiate the patient in need of surgery, but who can wait several hours (Figs. 1.5 and 1.6) [12].

However, surgical units such as the forward surgical teams may find that the division of patients into the traditional categories of little benefit. For surgical units, the division of patients into emergent, non-emergent, and expectant may be more useful. In this model, the emergent category will comprise of Immediate (requiring attention within the next 15 min) and Urgent (temporarily stable but requiring intervention within the next few hours). Up to 20% of patients presenting to a surgical unit will require urgent surgery and fall into the emergent category [41]. The non-emergent category is comprised of the Delayed and Minimal patients.

Photo 1.2 Triage officer and registration team for Mass casualty situation in US Combat Support Hospital. The surgeon is surrounded by medics and security team with critical care personnel standing by to escort immediate care patients into trauma bay to initiate resuscitation

Triage category	Characteristics	Example
Immediate	Unstable and requiring attention in the next hour Threat to life, limb or eyesight without prompt intervention	Tension pneumothorax, Dysvascular limb
Urgent	Temporarily stable but requiring care within the next few hours Patient is at risk if treatment or transportation is delayed unreasonably	Penetrating abdominal wound in a hemoddynamically stable,alert patient
Delayed	No risk to life or consequence if more definitive care is not rendered quickly	Large muscle wounds Long bone fractures
Minimal	Relatively minor injuries that can be helped by non-medical personnel	Lacerations with controlled bleeding, fractures of small bones
Expectant	Wounds so extensive chance of survival unlikely even with optimal medical resources	Penetrating head wounds Mutilating explosive wounds involving multiple anatomic sites 3rd degree burn > 60% TBSA

Fig. 1.5 Standard military triage categories [26]

These patients, while injured and requiring medical care, are without significant risk to life, limb, or eyesight and do not require the same level of care as the emergent group (Fig. 1.7).

The expectant category is the most controversial and the most emotionally challenging for medical personnel, especially the triage officer [41, 49, 50, 52]. The distinction between the most severely injured emergent patient and the expectant patient has been blurred by the success of TCCC [28, 31, 33]. In civilian trauma centers with unlimited resources, this category would receive immediate treatment. However, in combat situations with multiple casualties, the resources expended on a severely injured patient with

Fig. 1.6 Special triage categories specific to combat environments [26]

Special triage categories	
NBC enviornment	1. The contaminant on these patients poses a threat to the medical staff and other patients 2. Must be segregated from other patients 3. Must be decontaminated prior to entering the main treatment are 4. Specially protected personnel may provide care to emergent contaminated patients prior to decontamination as necessary
Retained/unexploded ordinance	1. The ordinance poses a continuing threat to patient, medical facility and personnel, and other patients 2. Must be segregated immediately 3. Requires special handling Explosives Ordinance Detachment personnel
Enemy prisoners of war	1. Medical care is same as friendly patients 2. Potential for "suicide bombers" poses threat to medical staff and other patients 3. Must be thoroughly screened prior to movement into triage area

Fig. 1.7 International Committee of the Red Cross triage categories [20, 26]

ICRC Triage categories	
Category I–Priority for surgery	Patient requires surgery to save life, limb, or eyesight with good chance of survival or satisfactory recovery
Category II–No surgery	Patients who are so severely injured they are unlikely to survive -OR- Patients wounds do not need surgery
Category III–Can Wait for surgery	Patient who need surgery not emergently

a low chance of survival may mean that a less severely injured patient with a high chance of survival will not receive treatment. This is a difficult decision for all concerned, but it is essential to remember that this is a risk shared by all military personnel in wartime and that the triage process is not static. The expectant patient may become the immediate patient at the next triage cycle dependent upon the tactical situation at the time. As always, prior planning, taking into account all the internal and external factors affecting the triage decision making process, is essential to mitigate these concerns (Fig. 1.8).

1.8.5 The Evacuation Chain

It is important to reiterate that the triage process is not synonymous with the treatment process, nor does it mean that treatment stops when a patient is placed into their respective treatment category. Treatment begins at the point of injury in the form of self care, buddy aid, or via the combat medic. A mini-triage should occur at the point of injury as the combat medic applying TCCC principles may elect to bypass a patient with an obvious penetrating head injury in favor of treating a conscious patient with active hemorrhage. At the

Fig. 1.8 Factors affecting the triage decision making process should be considered in the pre-mission medical planning process to mitigate the inevitable stress that occurs upon reception of casualties [5, 20, 26]

Factors affecting the triage decision making process		
External	Tactical Situation	Must coordinate with line commanders during medical planning in order to facilitate information flow Liaison with tactical operation force essential component of triage decision making process.
	Logistics (Resupply)	Information concerning how, when and where expended internal supplies (medical and non-medical) are critical elements to consider Influences decision to treat or not treat individual casualties
	Time	This factors confounds triage decision making process more than any other **PRE-MTF:** The time from injury to evacuation to MTF most critical. The shorter the time interval, the more complex the decision making process sorting the most emergent from the expectant. **MTF:** Time on the operating table is usually the choke point. Damage control concepts most applicable in triage situations. On-table triage and re-triage may be necessary. Expeditious evacuation to the next available echelon of care is the rule in order to preserve valuable local supplies. In OIF and OEF, the average time from injury to evacuation out of theater is less than 72-hours
	Evacuation Assets	Evacuation platforms may be land or air based. Air based assets decrease transportation time and increase the range but require more coordination and have more constraints.
Internal	Logistics (On-Hand)	Local availability of drugs, blood, surgical instruments, and sterilization capability greatly limits the number of patients that may be cared for at any one time. Prior coordination with MTF, local, and theater of operations logistical system is necessary to ensure adequate and timely resupply.
	Space / Capacity	The availability of the treatment facility to evaluate, treat, and hold patients affects triage categorization. The number of OR tables, ER/WARD/ICU beds, and available diagnostic capabilities such as X-ray and CT are important planning parameters. For instance, an MTF with an available CT scanner should plan to receive more head injuries than an MTF with only plain X-ray capability.
	Personnel	In the era of split operations for CSH and FSTs, the capability of the professional staff takes on special significance. The MTF with 2 OR tables but olny one available surgeon and/or aesthesia provider is effectively as limited as an MTF with only one OR table. The emotional stability and sleep status are important considerations. Casualities from tenant units can test the ability of the staff to remain clinically detached and lead to emotional instability. Likewise, 24–36 hours of continuous operations may subject the staff to fatique that may warrant diversion of casualities to allow sufficient crew rest.
	Stress	Triage is an emotionally challenging duty and best handled by trained staff. However, in triage situations, the medical staff are often diverted to direct patient care duties and the triage officer are often allied health officers. The personal impact of this duty, especially in sustained operations, can not be overemphasized. Unit cohesion directly improves the groups ability to tolerate stress. Stress management techniques should be employed as soon as possible and according to individual and unit traditions/belief systems.

casualty collection center, the patients will undergo the initial formal triage process. Once the patients have been categorized (whether the DIME-U or the emergent/non-emergent/expectant system is used will be a unit specific decision), each individual patient category will undergo further categorization where the priorities for evacuation will be set (Figs. 1.9 and 1.10).

Military medicine is hierarchically set according to echelons, or levels of care; with the higher levels possessing increasingly robust capabilities [41]. A mass

Military evacuation priority categories	
Priority 1	Requires evacuation within 2 h
Priority 1a	Requires evacuation to nearest facility with surgical capability within 2 h
Priority 2	Requires evacuation within 4 h
Priority 3	Routine evacuation within 24 h
Priority 4	Convenience

Fig. 1.9 Military evacuation priorities. Once casualties have been categorized according to emergent/non-emergent categories, they are then re-categorized for evacuation t o the next appropriate echelon on care [26]

Military Levels of Care			
Level/Role	**Definition**	**Careprovided**	**Example**
I	1ST medical care a patient receives	Immediate life saving procedures, combat stress support, casualty collection, and evacuation to supporting medical element	Self-aid Buddy aid Combat Lifesaver Combat Medic
II	Division level health support providing initial resuscitative treatment	Emergency resuscitative procedures are initiated or continued. Patients that can be returned to duty within 24–72 hour are held at this level	Medical Companies Support Battalions Forward Surgical Teams (FST)
III	Corps level health service support providing in-patient hospital support and intensive resuscitative support	Patients unable to survive movement over long distances receive surgical care. Care targeted to either return patient back to duty or stabilize them for evacuation	Combat Support Hospitals (CSH) Field Hospitals (FH)
IV	Communication-zone level health service support with receipt of patients evacuated form corps level facilities	Patients receive more definitive treatment in order to stabilize them for transport to CONUS treatment facilities	Landstuhl Regional Medical Center, Germany
V	CONUS- sustaining base of health support	Most definitive care provided to all categories of patients. The ultimate treatment capability for patients evacuated from theater of operations to include tertiary level care and full scope of rehabilitative care	San Antonio Military Medical Center Walter Reed National Military Medical Center Naval Medical Center San Diego

Fig. 1.10 Military levels or NATO Roles of care utilized in the evacuation chain from Level 1- point of injury care to Level-5 Tertiary care center in the continental US geographically closest to the patient's social support network [26]

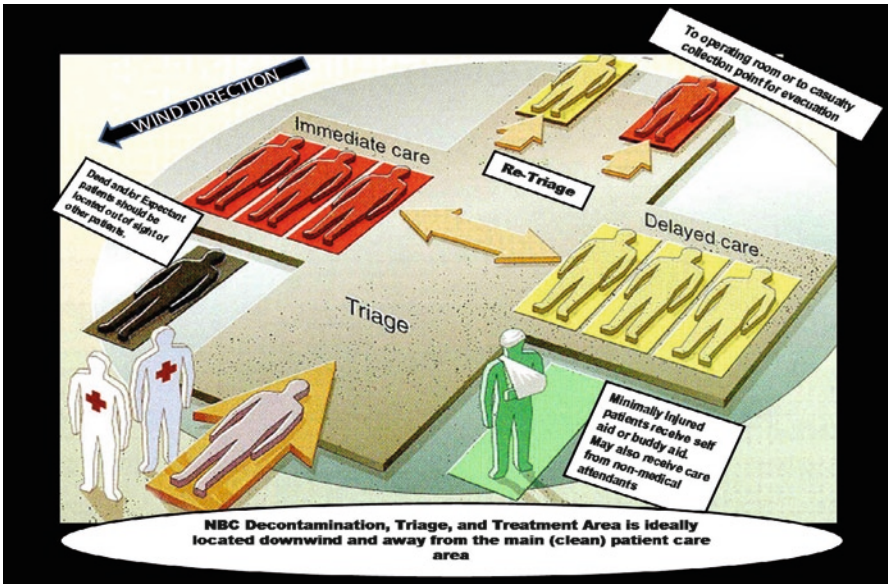

Fig. 1.11 A notional layout of a triage area is presented. The fact that triage is a continuous, dyanamic process that is repeated at every entry and egress point in the evacuation chain cannot be emphasized enough. If necessary, an NBC decontamination, triage, and treatment area can be setup away from and down wind of the main triage area. Care should be taken to locate dead and/or expected patients from and out of sight of the patients. Another area should be allocated to care for the minimally wounded. The emergent category patients should then be re-triaged prior to movement to a casuality collection area for evacuation, or to the operating room – if available

casualty situation that exceeds the capabilities of a lower level of care unit may not be overwhelming at a higher level of care. The medical officer designated to be the triage officer should be familiar with both evacuation priorities and the levels of care available (Fig. 1.11).

1.8.6 Summary

Triage is a dynamic patient care/casualty management process for sorting a large number of injured personnel on the basis of where resources can be best used, is most needed, and/or is most likely to achieve success. The process is repeated at every entry and egress point in the evacuation chain. The ultimate goal of triage is to preserve life, limb, and eyesight while simultaneously returning the greatest number to combat. The crucial difference between combat triage and civilian trauma triage is that a decision to withhold or curtail care to a wounded service member, who in another setting may be salvaged, may be necessary. As such, triage is emotionally taxing. The triage officer should be familiar with the fundamentals of triage to include the underlying values, patient categories, evacuation priorities, and the services available in the evacuation chain to higher level of care.

1.8.7 Initial Assessment and Life Support

Initial assessment of a casualty at a NATO Role II or III facility includes: Primary survey, Resuscitation, Adjuncts to primary survey, Secondary survey, Adjunct to secondary survey, continued postresuscitation monitoring and reevaluation, and definitive care. Prehospital care focuses on hemorrhage control, since bleeding is the leading cause of preventable battlefield death [53, 54]. Once arriving at an Role II or III facility, care more closely parallels the ATLS model.

The Primary Survey [55] is a systematic assessment of a casualty's vital functions. The acronym ABCDE is utilized to assess patient systems in a prioritized manner. Life-threatening conditions should be identified and managed simultaneously.

The "A" is for Airway maintenance with cervical spine precautions. The airway must be evaluated and managed as the first priority, since airway compromise can be an imminently life-threatening condition. All providers must assume that there is a cervical spine injury in cases where there is a blunt trauma element to the mechanism of injury. This precaution protects the spinal cord until a more detailed assessment can be performed. This is especially a concern in patients with an altered level of consciousness and any blunt injury proximal to the clavicles.

The "B" is for Breathing and ventilation. Adequate ventilation can be negatively impacted by conditions such as tension pneumothorax, flail chest with pulmonary contusion, massive hemothorax, and open pneumothorax. These disorders should be identified and managed during this stage.

The "C" represents Circulation with hemorrhage control. Hemorrhage is the leading cause of preventable death after battlefield trauma [53, 54]. Hypotension in the setting of trauma must be considered hypovolemia until proven otherwise. Clinical signs of hypovolemia include decreased level of consciousness, pale skin, and rapid, thready pulses. External hemorrhage should be identified and directly controlled during this stage.

The "D" is for Disability with respect to neurologic status. Rapid screening for neurologic injury should be performed. This includes determination of level of consciousness, papillary size and reactivity, lateralizing signs, and spinal cord injury level (if present). The Glasgow Coma Scale (GCS) is a rapid method of determining the level of consciousness of a trauma patient and has prognostic value (Table 1.2). The GCS categorizes the neurologic status of a trauma patient by assessing eye opening response, motor response, and verbal response [56]. Possible causes of decreased level of consciousness include hypoperfusion, direct cerebral injury, hypoglycemia, and alcohol/drugs. Immediate reevaluation and correction of oxygenation, ventilation, and perfusion should be performed. Afterward, direct cerebral injury should be assumed until proven otherwise. One of the guiding principles in managing a patient with a Traumatic Brain Injury (TBI) is to prevent secondary brain injury from conditions like hypoxemia and hypovolemia.

The GCS (Table 1.2) can be utilized to stratify injury severity in patients with head injuries (TBI).

1. Mild brain injury (GCS 14–15) – Patients with a mild brain injury often have had a brief loss of consciousness (LOC) and may have amnesia of the event. Most have an uneventful recovery, but approximately 3% will deteriorate unexpectedly [55]. A CT of the head should be considered if the individual lost consciousness for greater than 5 min, has amnesia, severe headaches, GCS < 15, and/or a focal neurologic deficit.
2. Moderate brain injury (GCS 9–13) – All these patients require a CT of the head, baseline blood work, and admission to a facility with neurosurgical capability.
3. Severe brain injury (GCS 3–8) – Patients with severe TBI require a multidisciplinary approach to ensure adequa te management and resuscitation of other life-threatening injuries and urgent neurosurgical care.

Table 1.2 Glasgow Coma Scale (GCS)

Assessment area	Score
Eye Opening (E)	
Spontaneous	4
To speech	3
To pain	2
None	1
BEST Motor Response (M)	
Obeys commands	6
Localizes pain	5
Normal flexion (withdrawl)	4
Abnormal flexion (decorticate)	3
Extension (decerebrate)	2
None (flaccid)	1
Verbal Response (V)	
Oriented	5
Confused conversation	4
Inappropriate words	3
Incomprehensible sounds	2
None	1

Adapted from ATLS, 7th edn, p. 159 [55]

Finally, the "E" is for Exposure/Environmental control. This involves completely undressing the patient, while preventing hypothermia. All garments must be removed from the trauma patient to ensure thorough evaluation. Once the evaluation is performed, prevention of hypothermia is critical. Blankets, external warming devices, a warm environment, and warmed intravenous fluids should be used to prevent hypothermia.

Damage Control Resuscitation has proven beneficial in the setting of combat related trauma [17, 22, 55, 57]. In addition to airway and breathing priorities, circulatory resuscitation begins with control of hemorrhage. Further detail on hemotransfusion will be covered in detail in Chap. 5. Initial fluid resuscitation should consist of 2–3 L of Ringer's Lactate solution. All intravenous fluids should be warmed prior to or during infusion. If the patient is unresponsive to the fluid bolus, type-specific blood should be administered. O-negative blood may be used if type-specific blood is not urgently available. Insufficient fluid resuscitation may result in residual hypotension. Elevation of the serum lactate level (>2.5 mmol/L) is indicative of residual hypoperfusion [58, 59].

Adjunct to Primary Survey [55] should include Urinary and Gastric Catheters, continuous vital signs monitoring (ECG, blood pressure, pulse, pulse oximetry, temperature, respiratory rate), and ABG. Initial X-rays and Diagnostic Studies are CXR, AP pelvis, and Lateral C-spine (if any degree of blunt injury). Screening radiographs of injured extremities should be performed as part of the secondary survey.

The secondary survey is a head-to-toe examination that begins once the primary survey is complete and resuscitative efforts have demonstrated a stabilization of vital functions.

Relevant medical history is still important in combat situations. AMPLE is an acronym that can assist in collecting history information from the patient, unit, and/or prehospital personnel. It stands for Allergies, Medications currently used, Past illnesses/Pregnancy, Last meal, and Events/Environment related to the injury.

The head-to-toe physical examination should occur after the Primary Survey. The clinician must be sure to inspect the following body regions: Head, Maxillofacial, Cervical spine and neck, Chest, Abdomen, Perineum/rectum/vagina, Musculoskeletal, and Neurologic.

Adjuncts to the Secondary Survey [55] include specialized diagnostic tests. These tests may include radiographs of the extremities, CT scans of the head, chest, and abdomen. In addition, diagnostic procedures such as bronchoscopy, esophagoscopy, and angiography can be performed if the patient's hemodynamic status permits.

Reevaluation is a continuous process during the evaluation and management of a trauma patient. Injuries may evolve in a life-threatening manner, and non-apparent injuries may be discovered.

Definitive care for each injury occurs depending on the priority of the injury and the physiology of the patient. This requires coordinated multi-disciplinary care.

Combat injured patients often have multiple system injuries. These can be from combination of blunt, penetrating, and burn injuries. If not detected during the Primary Survey, the Secondary Survey should screen for life threatening injuries to the chest and abdomen.

Life-threatening thoracic injuries include tension pneumothorax, open pneumothorax, flail chest, massive hemothorax, and cardiac tamponade.

Tension pneumothorax is the result of increasing pressure within the pleural space from a pneumothorax with a flap-valve phenomenon. As air enters the pleural space without the ability to escape, it causes a mediastinal shift with impairment of venous return and cardiac output. The clinical scenario involves decreased/absent breath sounds, subcutaneous emphysema, and tracheal deviation. Emergent decompression is warranted without the need for a diagnostic x-ray.

Open pneumothorax is also called a "sucking chest wound." It occurs when there is a large chest wall defect. This external opening to the environment precludes the chest wall's ability to generate the negative pressure within the pleural space required to inflate the lung. Treatment is to close the defect with an occlusive dressing that is taped on three sides. This creates a valve that allows air to escape but not to enter the defect in the chest wall.

Flail chest is a severe impairment of chest wall movement due to two or more rib fractures in two or more places, so that the segment has paradoxical movement during respiration. The underlying pulmonary contusion is the true challenge in this clinical scenario. The pulmonary contusion may cause severe impairment of oxygenation. Management involves ensuring adequate ventilation and appropriate fluid management to prevent fluid overload of the injured lung. Mechanical ventilation may be necessary.

Massive hemothorax occurs when large amounts of blood (>1,500 mL) accumulate within the pleural space. This results in lung compression and impairment of ventilation. Urgent, simultaneous restoration of blood volume and drainage of the chest are indicated. Thoracotomy may be required in cases of ongoing blood loss.

Cardiac tamponade is due to fluid accumulation within the pericardial sac. Diagnosis has been described by Beck's triad: elevated venous pressure (distended neck veins), decreased arterial pressure, and muffled heart sounds. A focused assessment sonogram in trauma (FAST) or pericardiocentesis may be necessary to establish the diagnosis. The pericardiocentesis may be diagnostic and therapeutic.

Life-threatening abdominal injuries can occur with varying degrees of frequency depending on whether the mechanism of injury was penetrating or blunt. Blunt injury to the abdomen may result in damage to the viscera by a crush or compression mechanism. Penetrating injuries like blast injuries and gunshot wounds impart direct trauma to the viscera by laceration or perforation.

Pelvic ring injuries are of particular concern, since they may be the source of significant hemorrhage. Hypotensive patients with evidence of a pelvic ring injury should have urgent placement of a pelvic binder or circumferential sheet [60–62].

Shock is an abnormality of the circulatory system that results in inadequate organ perfusion and tissue oxygenation [55]. It can be divided into hemorrhagic and non-hemorrhagic shock. Non-hemorrhagic shock includes neurogenic, cadiogenic, tension pneumothorax, and septic shock.

Hemorrhage is the acute loss of circulating blood volume. An element of hypovolemia is present in nearly all polytraumatized patients. Hemorrhage is the most common cause of shock [55].

Class of hemorrhage [63]

1. Class I hemorrhage is characterized by no measurable change in physiologic parameters (heart rate, blood pressure, urine output, etc.) despite a <15% blood loss (<750 mL).
2. Class II hemorrhage is characterized by mild tachycardia (>100), a moderate decrease in blood pressure, and low normal urine output (20–30 mL/h). It represents a 15–30% blood loss (750–1,500 mL).
3. *Class III hemorrhage* is characterized by moderate tachycardia (>120), a *decrease in blood pressure*, and a decrease in urine output (5–15 mL/h). The patient is typically confused. It represents a 30–40% blood loss (1,500–2,000 mL).
4. Class IV hemorrhage is characterized by a severe tachycardia (>140), decreased blood pressure, and negligible urine output. The patient is lethargic. It represents >40% blood loss (>2,000 mL).

Nonhemorrhagic shock is shock secondary to a physiologic or anatomic derangement other than hypovolemia. Only after adequate resuscitation and control of hemorrhage should the diagnosis of nonhemorrhagic shock be entertained.

Neurogenic shock can occur as a result of loss of sympathetic tone to the heart and peripheral vascular system in cases of cervical spinal cord injury. Loss of sympathetic tone to the extremities results in vasodilation, poor venous return, and hypotension. Due to unopposed vagal tone on the heart, tachycardia in response to hypotension is not possible. The resultant clinical scenario called neurogenic shock is one of hypotension and bradycardia. Assessment of the hemodynamic status may be aided by a Swan-Ganz catheter [64, 65].

Cardiogenic shock is myocardial dysfunction that can result from blunt injury, tamponade, air embolism, or cardiac ischemia. Adjuncts such as ECG, ultrasound, and CVP monitoring may be useful in this setting.

As mentioned before, Tension pneumothorax can result in a mediastinal shift with impairment of venous return and cardiac output. Emergent decompression is necessary.

Septic shock may occur as the result of an infection. In trauma, this would be more likely in a patient presenting late with penetrating abdominal injuries.

1.9 Conclusion

While outcomes for individual patients who have sustained severe trauma depend greatly upon severity of the injury, immediacy of care, and skills of the trauma treatment team, they also rely heavily upon the organizational support within a hospital. Trauma involving multiple casualties requires a shift in the focus of priority to saving the greatest number with the available resources in a constrained environment. Resources including blood products, operating suite availability, diagnostic facilities, space, personnel and medical supplies can run short and thereby define or create the mass casualty situation. The organizational structure, prior training, appropriate planning and competent incident leadership play a substantial role in mitigating these constraints. Communications within the hospital staff, as well as among facilities receiving casualties requires reliable, secure mechanisms, and competent experts to maintain them as resources are strained. Communication with the community, the media, and especially family members who are seeking information or grieving adds a distinct level of complexity. Additionally, appropriate triage at the scene, within the trauma bays, and in hospital resource allocation impacts the outcomes for the greatest number of patients, while continued reevaluation as the event progresses permit additional emphasis to further improve survival. Finally, initial stabilization, according to the principles established with Advanced Trauma Life Support addresses urgent care of the individual thru application of an organized, rehearsed, and confident trauma team, and sets the stage for subsequent secondary surveys, and care for the extremity war injuries, as will be described in detail in subsequent chapters.

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