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Immediate Care of Burn Patients and Burn Care in Combat Zone

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Introduction

Prehospital emergency care is the first step in the health care system of burn care and is a major determinant in survival. Prehospital care commences at the site of injury and ends at the burn center. Hence, it starts or must start immediately after burns and is provided mostly by bystanders and at best by paramedics. The importance of prehospital care is also emphasized by the fact that a large number of mortality occurs during the preadmission phase.[1] Hence, having an organized prehospital emergency care and a structured evacuation protocol is a vital element of burn care. Prehospital emergency care essentially includes rescue, first aid, onsite assessment, transportation to nearest medical emergency unit and stabilization, and finally transportation to burn unit (**Boxes 6.1 and 6.2**).[2]

The occurrence of fire mishaps can never be predicted both in terms of time and place. And, most of the time in these events nonprofessional first responders generally provide or attempt to provide prehospital care and first aid. Hence, it is prudent to have policy in place to educate people about the basics of first aid, so that victims can be attended to without any lapse of time and before professional medical help arrives. It is important that the first aid modalities and procedures are easy to use, so that it can be administered by anyone and with things that are readily available.

History of Prehospital Care

The history of first aid and prehospital management can be found in war history as most of the wound care techniques and protocols developed during wars. The outstanding military surgeon of the Napoleonic Wars (1792–1815), Baron Dominique Jean Larrey (1766–1842), generally is regarded as the originator of modern military trauma care and what would become known as triage.[3] He placed surgical teams near the front lines to shorten the time elapsed after injury and instituted specially designed horse-drawn "flying ambulances" in which the wounded rode with an early version of emergency medical technicians.[4,5] Care was prioritized to provide first for the most badly wounded, without regard to the patient's chances of survival or the need to restore less gravely wounded soldiers to the front lines quickly.[6] After Larrey's system was used during the Battle of Metz (1793), he was ordered to organize medical care for the entire French Army.[3]

In the late 19th century, von Esmarch emphasized prioritizing patients by severity of injury but did so to make the most effective use of medical resources, not necessarily to treat the most badly injured first.[7] The familiar concept of triage (from the French "trier," to sort) would be given its name by French physicians in World War I.[8] However, institution of a rationalized approach to prioritizing care was a decades-long development, from Larrey to von Esmarch to the massive armies of World War I.

During World War I (1914–1919), with the advent of motorized transport helped make possible the establishment of British Casualty Clearing Stations (CCSs) approximately 6 to 9 miles behind the front lines. These were advanced surgical units, staffed by surgeons, anesthetists, and nurses—the closest women had gotten to the front lines in a modern conflict.[8–10] A British manual listed the goals of triage as first conservation of manpower and second the interests of the wounded.[11]

During the Korean War (1950–1953) new Mobile Army Surgical Hospital (MASH) units were developed under the leadership of the pioneering surgeon Michael DeBakey (1908–1999) to provide resuscitative surgical care within 10 miles of the front lines.[10] Helicopter ambulance companies supported the MASH, allowing treatment of patients within 3 to 12 hours of wounding.[10] The nature of combat and improvements in evacuation during the Korean and Vietnam conflicts thus allowed for development of fixed hospitals. Unlike previous wars, armies of the Gulf War (1990–1991) moved rapidly, and even though several MASH units were staged in trucks, hospitals were unable to keep up with the rapidly advancing front. Although there were few casualties, it was painfully obvious MASH units were too cumbersome to effectively support armored units as they raced into Kuwait and southern Iraq. A new organizational structure was needed.[12] A 20-person Forward Surgical Team (FST) was created to provide resuscitative surgery close to the front lines. The role of the fixed-base hospital was taken by a Combat Support Hospital (CSH), a modular unit capable of supporting between 44 and 248 beds. The reorganization was completed in 2003 when the 212th MASH becoming the 212th CSH while in Iraq.[12]

Organized mass evacuation and prehospital care resulted in drastic fall in mortality from wounds across the

Box 6.1 Components of prehospital care

- Rescue
- First aid
- Onsite assessment
- Transportation to nearest medical unit
- Stabilization
- Transportation to burn unit

Box 6.2 SAFE approach in prehospital care in burn

"SAFE" approach

- Rescue
- Stop the burning process
- Cool the burn wound
- Onsite assessment: primary and secondary
- Wound care
- Prevent hypothermia
- Call for help

20th century, from 8.5% among U.S. troops in World War I,[13] to 3.3% in World War II,[14] to 2.4% in Korea,[15] and leveling at 2.6% in Vietnam.[16–19] The speed of evacuation increased dramatically from the horse carts of the 19th century and even the motorized transport of World War I; in World War II, the average time from injury to hospitalization was 12 to 15 hours, but by Vietnam it generally was less than 2 hours. As noted, wounded troops in Iraq and Afghanistan can be transported to a CSH in 30 to 90 minutes.

The lessons learnt from the history of military emergency medicine are now being widely accepted and used by various armies around the world, India being no exception. The military medical organizations have a strategy for care, from the training received by an individual soldier, to his regimental medical officer, to the provision of a forward surgical station, to immediate evacuation for emergency surgery, to eventual transport for definitive care at a tertiary-level hospital and recovery.

On-Site Management of Burns

On-site management of burns commences at the site of mishap soon after the accident and continues till specialized medical care is obtained. This part of burn care constitutes a major part of first aid. The basic premise of on-site management is to rescue, prevent further harm, assessment, and stem the progression of injury.[2,20] No step or procedure is done at this stage, which can hinder subsequent evaluation and treatment by specialists. A prompt first aid at the site of injury not only reduces the quantum of injury in terms of extent and depth but also identifies high-risk cases like inhalation injuries. Hence on-site first aid reduces morbidity, mortality, and provides a foundation for subsequent organized triaging.[20] It should always be emphasized the safety of the person providing first aid should operate within the limits of his/her personal safety. Under no circumstances first aid provider should indulge in firefighting.

"SAFE" approach: The priorities of prehospital care is per "SAFE" approach. The acronym is **S**hout for help, **A**ssess the scene, victim, and possibility of danger to the rescuer, **F**ree from danger (rescuer's safety first), and **E**valuate the victim (**Box 6.2**).[21]

Rescue

Rescuing the victim from the flames is the first step, and it is emphasized again that this must take precedence over extinguishing the fire. The commonly used euphemism "Stop and Drop" aptly applicable in these situations. "Stop" refers to preventing the patient from running which can fan the flames. "Drop" means asking the victim to lie flat on the ground, which prevents flames from involving other parts of the body especially the head and face. The earlier policy of "Drop and Roll" is also not advisable as rolling can transfer fire to unburnt areas of the body. Unconscious patients should be made supine and with arms extended by sides and dragged out of fire by holding his or her legs.[20] Rescuing unconscious victims from smoke-filled enclosed areas can pose serious risk to the rescuers. Hot smoke generally rises toward the ceiling, hence it is prudent to crawl on the floor where visibility is better and toxic fumes are less.[20] For the sake of rescuer's safety, it is advised to breathe through a wet handkerchief in absence of a gas mask.

Stop the Burning Process

If the burning process is continuing on the victim, the flames should be immediately doused by pouring large quantity of water. Running tap, shower, or hosepipe can be used for dousing the flames or simply by pouring water manually. However, while using water jets one should be cautious in not directing it at face as it can cause damage to the eyes. If water is not available at the site, burning process can be stopped by wrapping the victim with a heavy cloth to cut off the oxygen from combustion. However, the cloth should be removed immediately as it can retain heat and can increase the extent and depth of burn. It is advisable to use heavy cotton cloth or blanket and not synthetic material, which are highly combustible. All smoldering garments should be removed including ornaments. Ornaments like rings can be constricting once the edema sets in and hence should be removed as early as possible.[20–22] If fire extinguisher is available, it should be used, but the jet should never be directed at the face.

Cooling the Burn Wound

Cooling the burn wound limits the extent and depth of burn injury. The tissue temperature remains high for approximately 3 minutes even after removal of heat source.[23] Hence, the first step in burn wound first aid is to dissipate heat by cooling. Although a matter of controversy, a general consensus is to cool the burnt area immediately for 10 minutes. This dissipates heat from burnt tissues, provides pain relief, and reduces edema by decreasing histamine release. Although the benefits of cooling is only till 10 minutes, it is advisable to continue cooling by cool soaks or packs of the wound while in transit as it reduces pain.[2,23,24] Cool running water from tap is enough to cool the burn wound, and ice packs or ice cold water should not be used as it can cause vasoconstriction leading to further tissue damage. A sound caution here is "cool the burn wound but warm the patient." Care should be taken while cooling the wound as patients of thermal injury are prone to hypothermia, especially children.[24]

Assessment of the Patient

Assessment of the victim at the site of the injury is done in two phases. The immediate and prompt primary assessment

is to identify life-threatening conditions.[25] The evaluation should be swift and methodical and should be assessed in terms of airway, breathing, and circulation (ABC). Airway can be compromised by edema because of direct thermal damage by hot gases, inhalation of toxic fumes from combustion. Victim can be unconscious and hypoxic because of histotoxic poisoning by carbon monoxide. Impending upper airway obstruction can be predicted by hoarseness, and urgent intubation is indicated before laryngeal edema obliterates the glottic anatomy. Humidified 100% oxygen should be administered to all patients who have history of burn in concealed area or inhalation of fumes. Adequacy of breathing and chest expansion must be ascertained by exposing the chest. Circumferential burn over upper trunk can impair chest movement and breathing effort. Adequacy of circulation is best assessed by pulse rate as blood pressure measurement may not be feasible. If there is suspicion of cervical injury, cervical spine stabilization is mandatory till formal evaluation is done. Following primary assessment, a secondary assessment should also be made of any other injuries at this stage.[26] The burn wound is assessed in terms of extent and depth. If the on-site health care provider is conversant with burn assessment tools, the extent of burns is recorded by the rule of nine and a specific mention of burns over special areas like head and neck, hands, and genitalia must specifically be mentioned. Depth can be broadly classified as superficial and deep but should always be reassessed after admission in hospital. A photographic record of the burn wound prior to any application of medication is vital. The level of contamination needs to be assessed, and if gross contamination is there, then irrigation and cleaning of the wound should be done on site. A proper wound assessment record plays a vital role in triaging and referral of patients. Any injury to chest, abdomen, and head needs to be identified at the earliest. Any readily available material like stick, scale, or wooden plank can immobilize limb fractures. Bleeding should be controlled by compression and tourniquet should be avoided. Patients with suspected head and spinal injury should be handled with care with minimum movement. An AMPLE history is taken: A (allergy), M (medication), P (past medical history), L (last meal), E (event of injury).

Wound Care

The aim of wound care in prehospital setting is to reduce pain and prevent contamination. The blisters on the wound are best left alone till definitive wound care is available.[27,28] It is also advisable not to apply any medication, lotion, or ointment, as these can confound formal assessment of wound, in terms nature, depth, and extent. It is quite common that people apply toothpaste, butter, ash on wound surface; such practice should be strongly discouraged. Removal of these from the wound can be very painful. Wounds should be covered with any material which is easily available, pliable, and nonadherent. The material used may not be sterile but should be clean. It can be food wraps or plastic sheets. In case these are not available clean sheet of cloth, plastic bags can also be used. Covering the wounds not only provides protection to wounds while in transit but also prevents contamination and reduces pain. A broad assessment of superficial deep burn can be made in prehospital stage. A pink glistening wound surface and/or with blisters can be classed as superficial burns, and wounds which are waxy white or parchment like are classed as deep burns.

During the prehospital phase analgesics may not be necessary if proper cooling is done and wounds are covered. Continuing with cooling over the covered wound reduces pain obviating the need of analgesics during transit.

Call for Help

During the course of secondary assessment, it is important to call for help and transport to nearest center. It is important to transfer the patient to a burn center in close proximity. If the center is far away, it is wise to transfer the patient to the nearest hospital where formal assessment and resuscitation can be started without delay.

Transfer of Patients

The need for transferring a burn patient is based on the referral guidelines of American Burn Association (**Box 6.3**).

The basic premise of transferring is to bring the victim to the appropriate level of care as soon as possible. Urgent transportation of burn victims is limited to cases where there is imminent danger to life. The referral of nonurgent cases is done in an organized and unhurried manner. Once the indication for transfer is defined, the process of transferring the victim starts with a one-to-one call from the primary responder and the receiving physician. The transfer process has two components, primary transfer and secondary transfer. The primary transfer involves evacuation of victims from the site of injury to the nearest medical unit, which can provide basic burn care. The secondary transfer is transport of the burn patient from the nearest medical unit to a specialized burn unit.[26,29]

Box 6.3 Indications of transfer in burn injury

- Deep dermal burns > 10%
- Full-thickness burns
- Burns involving face, hands, genitalia, perineum, and major joints
- Chemical burns
- Electrical burns
- Burn with associated trauma
- Inhalation injury
- Preexisting medical illness
- Hospital not appropriately equipped for burn care

Transport Ambulance

The ambulance should be equipped with vital sign monitor which can allow monitoring of electrocardiography (ECG), heart rate, oxygen saturation, and blood pressure (**Fig. 6.1**). The monitor should be compact, fixed to the interior of the vehicle at a vantage point where it is visible from all sides. Alarms for all monitored parameters should be set in high volume, which can be audible over high background noise. The monitor should have rechargeable battery which can be charged by the power supply of the vehicle. Transport ventilator should be an integral part of the ambulance (**Fig. 6.2**). The ventilator should be lightweight, compact with simple breathing circuits and should provide pressure-limited time-cycled ventilation either controlled mode of ventilation and/or synchronized intermittent-mandatory ventilation (SIMV) mode. It should be docked on the sidewall at the head end of the stretcher and control panel should be orientated in such a way that it can be handled easily by the caregiver sitting opposite the stretcher. It should have power supply from the vehicle with adequate power backup allowing it to be moved out with the patient. Ideally, infusion pump should be there in the ambulance so that continuous and predetermined drug or fluid infusion is maintained during transport. It should have rechargeable battery (**Fig. 6.3**). The ambulance should also be equipped with defibrillator and suction machine (**Fig. 6.4**). All equipment should have defined docks and be securely fixed so that they do not fall while the vehicle is moving (**Fig. 6.5**). There should be provision for intravenous fluids, lifesaving drugs, and oxygen. Regular maintenance of all equipment's is mandatory, and daily checking of equipment with defined checklist is done to ensure flawless functioning.

Ambulance Staff

The transport staff should be able to render care to the same standard as the care provided by the receiving hospital. The

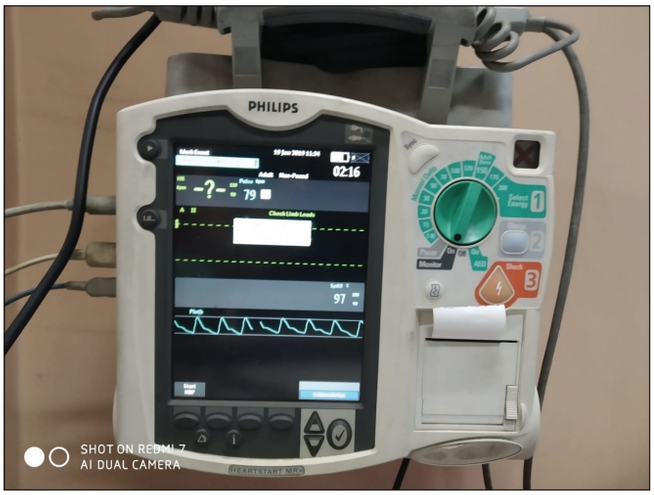

Fig. 6.1 Vital sign monitor.

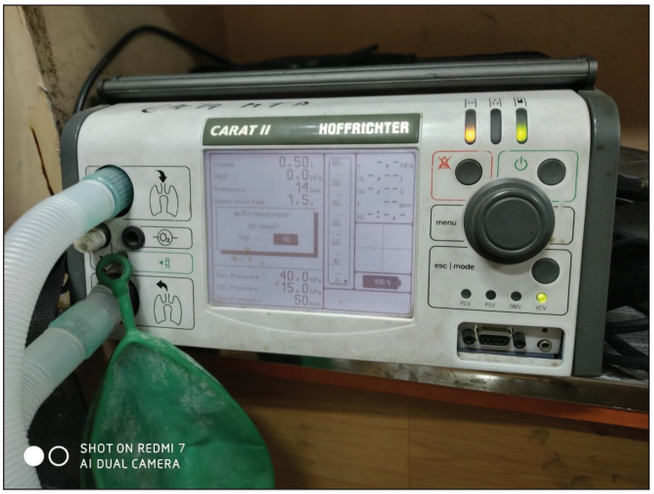

Fig. 6.2 Transport ventilator.

Fig. 6.3 Infusion pump.

Fig. 6.4 Suction machine.

Fig. 6.5 Interior of patient transport ambulance.

care provided by the ambulance staff should be based on a strict protocol and under the guidance of specialist of the receiving hospital with whom the staff should be in constant contact. The transport staff should be proficient in advanced life support like Advanced Cardiac Life Support (ACLS), Advanced Trauma Life Support of Advanced Burn Life Support. They should ideally be trained in basic burn care as well. They should be able to work in high-stress situation and have experience of patient transport. The transport team generally comprises a resident doctor, anesthesia/respiratory technician, and a nurse. They are trained specifically as a composite transport team with an emphasis on cross-training, which empowers all of them to function at defined level of competence. All are well versed with all equipment in the ambulance and have basic troubleshooting knowledge. The team should also be conversant with burn treatment protocol of the receiving hospital and should be in constant communication with the burn specialist of the hospital during transfer. Ideally, the driver should also be trained in basic life support.

Recently, course on prehospital trauma technicians has started in all major central government hospitals. These technicians are being trained specifically as first responders and are being recruited as ambulance staffs.

Primary Transfer

The basic premise of the transfer is to provide optimal care at the earliest, and the care provided during transfer is the extension of the care to be provided by the receiving hospital. Hence, reaction time of the transport team and ambulance is more critical and not the transit time. The receiving hospital is intimated before evacuation, regarding the status of the patient, number of patients, and any special requirements. Optimal analgesia should be administered before transfer commences, but any form of sedation is avoided. While in transit, it is essential to administer 100% oxygen in case inhalation injury is suspected. Intravenous cannulation and fluid resuscitation are started in transit. The fluid resuscitation is started in transit as per the protocol followed in the receiving hospital. Most commonly used fluid is crystalloids in the form of Ringer's lactate. All records of fluid, drug, and oxygen administration in transit are maintained, which are handed over at admission to burn center. Patient should be covered while in transit to prevent hypothermia. It should be a smooth and safe transfer without any rash driving.[26]

Secondary Transfer

In case the burn patient is transferred to the nearest hospital, emergency procedures should be done to stabilize the patients before shifting to burn center. Optimization of the patient with fluid resuscitation, airway management, urinary catheterization, nasogastric tube insertion, and any other procedure warranted by the condition of the patient should be done at the nearest hospital. Escharotomies and fasciotomies also should be done without delay in the hospital of first contact if expertise is available. A concise referral note comprising of history of the injury, ABC details, resuscitation efforts, vitals, and examination findings must be sent to the receiving unit prior to the transfer. The burn center also informs the referring unit about the management protocol. The mode of transfer is based on the distance and the severity of injury. A fully equipped transport ambulance with portable monitor, ventilator, and infusion pump should be staffed with driver cum trauma technician, trained nurse, and a physician or resident. For distance less than 100 km, patients can be transported by land, but beyond 100 km air route is preferred.[26] Fixed-wing aircraft does long-distance transfer. Air evacuation can be done in usual passenger aircraft by creating space for stretcher by removing the seats. Specialized air ambulances are also available as specialized service (**Fig. 6.5**). Oxygenation in low cabin pressure can be a concern in air evacuation. Shorter distance of transfer can be done in helicopter ambulance.

Prehospital Care in Chemical Burn

There are over 25,000 recognized chemicals, which can cause chemical injury in the form of contact burns, inhalation of fumes, and corrosive injury to gastrointestinal tract. All chemical burns are generally categorized as major burns and are indications for admission in burn centers. Broadly, all chemical injuries are by acids and alkalis. While the former causes tissue damage by coagulative necrosis, the later by liquefaction necrosis. Alkalis cause deeper injury as liquefaction destroys tissue planes, which lets the alkali burrow deeper and continue tissue damage.

While approaching victims of chemical injury for providing first aid, it is important to wear protective clothing. All contaminated clothing must be removed immediately followed by copious irrigation by running water. The recommended duration of irrigation in acid burns is 2 hours and in alkali burns is 12 hours. Immediate and copious irrigation is the cornerstone of first aid in chemical burns. It should start as soon as possible and must continue during transportation as well. It must be emphasized that the affected part should be put under running water and not immersed in water.[30,31] It is important not to look for antidotes and concentrate on irrigation. Neutralizing acid with base and vice versa is also contraindicated as it results in exothermic reaction. However, in certain specific chemical injury by sodium, potassium, and calcium, water is contraindicated as these substances react exothermically with water. Instead, the chemical is brushed off carefully.

In ocular chemical injury, immediate copious irrigation is also the mainstay during the prehospital phase. In these cases, eyelid should be widely separated and chemical cleared out from both fornices and canthi. The cornea gets very fragile because of chemical injury, and hence, it is prudent to be gentle during irrigation, and avoid jet irrigation. While irrigating, the head should be tilted to the affected side so that the chemical does not trickle into the nasolacrimal duct, canaliculi, and the other eye.[1,31,32] Upon reception in the hospital, the patient should be attended by an ophthalmologist first.

Prehospital Care in Electrical Burn

Electrical injury can be either by contact or by flash leading to thermal injury. Electrical contact can lead to flexor muscle spasm in the upper limb, because of which there is prolonged contact. This not only results in muscle deep burns but also gangrene, fractures, and joint dislocation. While rescuing an electrical injury victim, utmost care must be taken to avoid eltrocution.[33,34] The rescuer must switch off the electrical source first. Following this, the victim should be pushed off from the electrical source by a nonconducting material like a wooden pole. While doing this maneuver, the rescuer must ensure he or she is on dry ground and is not in contact with the ground. It must be emphasized here that rescuer should not go near the victim who is connected to a high-tension source.[24] Once the victim is rescued and placed in a safe place, assessment for ABC is done. In case the patient is unresponsive, there is a possibility of cardiac arrest and cardiopulmonary resuscitation (CPR) should start immediately. A thorough examination must be done to rule out head injury, cervical spine injury, and fractures. The first aid of electrical burn wound and transportation protocol remains the same as for the thermal injury.[20,33,34]

Prehospital Management in Combat Zones

The prehospital management in combat zones per se differs from civilian mass disaster sites because of the concept of triage and availability of trained medical help at the front lines. The learnings from military trauma care in a way influenced the modern day civilian emergency care in mass disaster. The history of military trauma care must be understood in terms of the wounding power of weapons causing the injury and how the surgeon understood the healing process.[35] Perhaps the most basic problem faced by physicians during wartime historically has been whether (and how) to transport the wounded to care or the caregivers to the wounded. A secondary problem historically has been how best to organize the delivery of care as modern nations began to dispatch vast armies and navies to fight across vast distances.[36]

Concept of Triage

Triage during wartime conforms to a different principle as compared with civilian mass casualty situation. As a particular and relatively modem aspect of military medicine, the concept of triage reflects the interest of the military leadership in maximizing the fighting capacity of the force. Military physician in a mass casualty situation often faces the dilemma in which on one side as a military triaging has to be done according to the military principle of maximizing the fighting force and on the other end is the responsibility of a physician toward an individual patient.[36] The World Medical Association in 1956 prepared a statement on the code of ethics for physicians in wartime, referring obliquely to this triage dilemma, by rejecting all forms of distinction among patients,' except those justified by medical urgency.[36]

Modern combat casualty evacuation has become so immediate and efficient that it can result in a mass casualty situation at Forward Surgical Center (FSC) of Field or Border static hospitals.[37] Triage is an attempt to impose order during chaos and make an initially overwhelming situation manageable. Triage is the dynamic process of sorting casualties to identify the priority of treatment and evacuation of the wounded, given the limitations of the current situation, the mission, and available resources (time, the equipment, supplies, personnel, and evacuation capabilities). Triage occurs at every level of care, starting with buddy and medic care, extending through the operation theater (OT), the intensive care unit (ICU), and the evacuation chain.[38] The ultimate goals of combat medicine are the return of the greatest possible number of soldiers to combat and the preservation of life, limb, and eyesight in those who must be evacuated. The decision to withhold care from a wounded soldier, who in

another less overwhelming situation might be salvaged, is difficult for any surgeon or medic. Decisions of this nature though infrequent, are nonetheless, the essence of military triage. The modern Armies work on the principle of Golden hour, striving to reduce the evacuation time of those in dire need to within this hour.[39]

Triage Categories

It is anticipated that triage will be performed at many levels, ranging from the battlefield to the field hospital. Traditional categories of triage are emergent, urgent, and minimal.[38]

Priority I (Red Tag/Disc)

This group includes those soldiers requiring lifesaving surgery and resuscitation. It is anticipated that 10 to 20% of casualties presenting to a surgical unit will be in the emergent category, requiring surgery. Although this category has been historically subdivided into immediate (unstable and requiring attention within 15 minutes) and urgent (temporarily stable but requiring care within a few hours), except in the most overwhelming circumstances, such division is rarely of practical significance. This group of wounded will require attention within minutes to several hours of arriving at the point of care to avoid death or major disability. Types of Priority I cases include airway obstruction/compromise (actual or potential); uncontrolled bleeding; shock—systolic blood pressure (BP) less than 90 mm Hg; decreased mental status without head injury; unstable penetrating or blunt injuries of the trunk, neck, head, and pelvis; threatened loss of limb or eyesight.

Priority II (Yellow Tag/Disc)

This group includes those wounded who are badly in need of time-consuming surgery, but whose general condition permits delay in surgical treatment without unduly endangering life. Sustaining treatment will be required (e.g., stabilizing intravenous [IV] fluids, splinting, and administration of antibiotics, catheterization, gastric decompression, and relief of pain). The types of cases include large muscle wounds; fractures of major bones; intra-abdominal and/or thoracic wounds; and burns less than 50% of total body surface area (TBSA).

Priority III (Green Tag/Disc)

These casualties have relatively minor injuries (e.g., minor lacerations, abrasions, fractures of small bones, and minor burns) and can effectively care for themselves or can be helped by nonmedical personnel.

Some Armed Forces have an expectant group (**Priority IV, Black Tag/Disc**), in which any treatment would be of no use as these casualties are usually beyond salvage.

Evacuation and Levels of Care in Combat Zone

Military doctrine provides an integrated health support system for triage, evacuation, and treatment of the injured soldiers. In Armed Forces, there are five levels of care, previously referred as echelons of care by North Atlantic Treaty Organization (NATO) and U.S. doctrine.

Level 1: Care is by self or buddy or at the Regimental Aid Post (RAP) level.

Level 2: Care is at FSC of the Field hospital. Here, life- and limb-saving surgery is done. Once the patient is stable enough, he or she needs to be evacuated further at the earliest as this echelon patient's holding capacity remains low because of limited number of beds (generally up to 30–40 beds).

Level 3: It is the highest care in the combat setting for the U.S. forces, while in Indian setup it would mean treatment at a large General or Zonal hospital.

Level 4: It is treatment outside combat zone for U.S. forces, while in India it would be Command Hospitals.

Level 5: It is the highest care in civil or military setup.[39,40] These levels are not to be confused with the American College of Surgeons designated civilian trauma centers where level 1 is the highest and the best facility and level 5 the least.[41] Evacuation of casualty is by air, motorized transport, or ambulances. Regional transfers are undertaken by train or fixed-wing aircraft. Aircraft have revolutionized the rapid evacuation of casualties for definitive care, but in the Indian setup, ambulances, mules, and stretcher-bearers are still used in varying terrains and mountainous regions.[38]

Blast Injuries

A blast or explosion happens when a chemical conversion occurs that changes a solid or liquid to highly pressurized gases in an extreme manner with substantial instantaneous release of gas and heat. This rapid expansion of gases compresses the surrounding air, creating incredible waves of pressure that move out from the point of explosion. This blast wave dissipates and disperses as it encounters more stable air and moves across solid or liquid surfaces. The friction of the blast wave encountering the stable air and other stationary objects aids in slowing and dispersing it.

However, the closer an object or person is to the point of the explosion, the more likely this incredible energy (which includes a thermal component) will be absorbed by that person or item. Items that are either a part of an explosion or carried by the blast wave are called shrapnel. Blast injuries are primarily produced by one or more of the three direct components of a blast: the blast wave, the thermal component, and/or shrapnel. Blast injuries are generally categorized as primary to quaternary (**Table 6.1**).

Table 6.1 Mechanisms of blast injury

Category	Characteristics	Body part affected	Types of injuries
Primary	Unique to high explosives, results from the impact of the blast wave with body surfaces	Gas-filled structures are most susceptible—lungs, GI tract, and middle ear	• Blast lung (pulmonary, barotrauma) • TM rupture and middle ear damage • Abdominal hemorrhage and perforation • Globe (eye) rupture • Concussion (TBI without physical signs of head injury)
Secondary	Results from flying debris and bomb fragments	Any body part may be affected	Penetrating ballistic (fragmentation) or blunt injuries: • Eye penetration (can be occult)
Tertiary	Results from individuals being thrown by the blast wave/wind	Any body part may be affected	Fracture and traumatic amputation: • Closed and open brain injury
Quaternary	All explosion-related injuries, illnesses, or diseases not because of primary, secondary, or tertiary mechanisms, includes exacerbation or complications of existing conditions	Any body part may be affected	• Burns (flash, partial, and full thickness) • Crush injuries • Closed and open brain injury • Asthma, COPD, or other breathing problems from dust, smoke, or toxic fumes • Angina • Hyperglycemia

Abbreviations: COPD, chronic obstructive pulmonary disease; GI, gastrointestinal; TBI, traumatic brain injury; TM, tympanic membrane.

Prehospital Care in Combat Zone

- Rapidly identify patients with life-threatening external hemorrhage and control bleeding; early use of tourniquets may be lifesaving, especially in the setting of multiple seriously injured casualties.
- High-flow oxygen should be administered to all patients with respiratory distress, abnormal findings on auscultation, and evidence of significant thoracic trauma.
- Avoid administration of large quantities of IV fluid in patients with a high suspicion of ongoing internal hemorrhage; judicious fluid boluses may be required if patients exhibit signs and symptoms of inadequate perfusion, such as deteriorating mental status.
- Initiate measures to reduce heat loss and prevent hypothermia.
- Screen for radioactive contamination with a handheld Geiger counter for any explosion that may involve radioactive material; if radioactive material is detected, decontamination of personnel and equipment as well as notification of the receiving hospital is required.

Burn and Blast Injuries in Nuclear War

The NATO field manuals and handbooks for medical officers, published by the U.S. Department of Defense, discuss at some length the management of mass casualties from nuclear war. The approach used derives directly from military medical practice in the two world wars. Its inapplicability to the disaster of a nuclear war arises from a failure to recognize the limits of our past experience and a failure to imagine what the next war might be.[37,42]

In two respects, the NATO guidelines acknowledge that nuclear war may be different from other wars. Radiation injury receives substantial attention, including a qualitative assessment of synergism with burn and blast. The triage protocol also makes explicit that in nuclear war the category of expectant may extend over a wide range of injury, including many who might in other, less-stressed circumstances be assigned greater chances of survival. What is not discussed in the NATO guidelines is the problem of numbers. Without direct attention to the fact that in nuclear war the word many may mean millions, protocols derived from wars in which many meant thousands may prove irrelevant and, prospectively, misleading.[37]

The burn and blast casualties of a nuclear war would be similar in essential respects to what has been seen in the past conventional wars, with the significant exceptions that these injuries would be created in enormous numbers and would be potentially complicated by the additional factor of radiation.

The thermal energy released from nuclear weapon explosions can cause human burns by direct radiation or by igniting clothing or other materials that secondarily engulf people in flames. Over 90% of burns seen among survivors of Hiroshima and Nagasaki were from direct thermal radiation, termed flash burns.[43] Flame burns, resulting from exposure to secondary fires or contact with ignited clothing, are identical to the burns seen in conventional war or peacetime disasters.[43] From the standpoint of patient management, flash burns, although limited to exposed surfaces and

tending, perhaps, to give rise to slightly less tissue swelling and fluid loss, can be seen as resembling first- and second-degree burns along the continuum routinely used in burn classification.[44]

Management of Radiation Burns

At the thermal energy levels delivered by the explosion of a 1-Mt bomb, measured in calories per centimeter squared (cal/cm^2), the range for flash burns is extensive. At approximately 15 to 16 km from ground zero, assuming that 25% of the population is exposed, approximately 2% of that population might be expected to receive first-degree flash burns on exposed surfaces and 18% would suffer second-degree burns. The thermal flux in that area would be approximately 5 cal/cm^2.[43]

A particular aspect of flash burns is their propensity to affect the eyes. The intensity of the brief light flash is sufficient to cause transient blindness (from the bleaching of retinal rods and cones) to all those looking in the general area of the explosion. This effect lasts for a matter of minutes to several hours and was reported among many survivors in Hiroshima. The risk of flash blindness extends for approximately 20 miles (~ 32 km) from ground zero for a 1-Mt explosion. True burns of the retina, which may cause permanent blindness depending on the extent and position of the burns, are caused by the heat of the thermal pulse hitting the eyes of someone who happens to look and focus on the flash of light from the explosion.[42]

Serious burns requiring emergency intervention and 3 to 6 weeks of intensive care are second- or third-degree burns extending beyond 20% of the body surface area (BSA); second- or third-degree burns in critical locations (from the viewpoint of infection and function), such as the face, neck, perineum, and hands; and pulmonary or airway burns (either thermal or toxic).[43] Failure to recognize that people with these injuries will require early and significant IV fluid and electrolyte replacement, scrupulous treatment of infection, and possibly, aggressive airway support has led in the past to significant mortality among initial survivors of major burn disasters.[43]

The interaction of either burn or blast with radiation injury has also enhanced mortality in all settings, clinical and experimental. Marked delay in wound healing, extending to immunological collapse and overwhelming sepsis, has been observed in both blast and burn subjects suffering acute radiation exposures.

Conclusion

In present era if such a nuclear catastrophe happens, modern triage protocols may just fail because of sheer number of casualties involved. Modern triage protocols apply to conditions in which the mix of transport and resource availability allows physicians to make early headway against the high mortality of the severely injured. From World War I on, the knowledge that complex support delivered within a matter of hours could save lives once thought lost has driven the development and design of the response to mass casualties. If it is acknowledged at the outset that no galvanization of effort can contribute to the salvage of the severely injured, the problem becomes less complex. The choices then revolve around how much time and material should be expended on humanitarian support of those who are probably going to die and how much should be devoted to the care of those with moderate injuries who might live. Those with minor injuries, in this setting, do not receive optimum care.[42] Population losses in such a catastrophe lie outside our experience and defy the human and technological systems we have so far devised to attempt to mitigate disaster and alleviate suffering. On the global scale of nuclear war, as described in the scenario of Harwell and Grover, people would face a picture of such devastation and death that the concept of mass casualty management loses all meaning. Historically, such medical management has constituted a highly complex human enterprise. In the bleakness of a postwar world, virtually every survivor would be a casualty, and social organization could well prove unsustainable. Mass casualty medicine, crafted and practiced in war, is a product of the process that may eventually drive it, and everything we know, into oblivion.[42]

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