KOSOVA JOURNAL OF SURGERY

Volume 9
Issue 1
June 2025
ISSN: 3027-5008 (Online)
ISSN: 3027-5016 (Print)

This journal is a joint publication of the Kosova College of Surgeons & University of Prishtina

www.kosovajournalofsurgery.net

Emergency Management of War-Related Burn Injuries

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Abstract
Thermal injury has become a common and obligatory component of present-day wars affecting both military service members and civilians, particularly with the spread of asymmetric conflicts and urbanization of military operations. Burn injury is not predominant and is not the most common injury seen during armed conflicts, nevertheless, it is one of the most complex form of trauma and resource intensive to treat. It is invariably associated with other more severe injuries in most cases, and requires specialized care. Though each conflict presents with its own profile of casualties with differences between various branches of the army, and collateral civilian injuries, certain aspects of management are common to almost all situations. It requires quick adaptability with effective triage, rapid resuscitation, evacuation, and transport, together with proper allocation of usually limited resources. Emergency burn care during an ongoing conflict must be optimized to deliver "minimal acceptable care" before final transfer to units for definitive care.

Introduction
Wars and their hardships have plagued humanity since the dawn of time. Military and civilian war-related injuries are a major public health concern and a leading cause of mortality, morbidity, and disability globally, particularly in low and middle-income countries [1]. Since fire arms in combat were first used by Ottomans in the late 13th century in the Middle East [2], thermal injury has become an important common and obligatory cause of battlefield injury [3],[4],[5]. In addition to significant morbidity, burns often lead to disruption of a deployed military unit[4].

Classical conflicts in open fields between opposing armies are from the past. Evolving tactics and use of more complex, sophisticated and devastating weaponry, have increased the destructive power and raised the violence of present-day conflicts into an unprecedented sinister level [6]. However, use of protective gear by military service members has reduced the number of fatal thoracic and abdominal war injuries. It has, on the other hand, made the number of extremity injuries, brain injuries, inhalation injuries, and burns relatively more prevalent [7].

Burns of military service members can be either combat or noncombat related. Though frequency of noncombat burns has decreased due to better passive and active prevention, overall incidence of burns in current military operations has nearly doubled during the past years [3]. Noncombat injuries are secondary to waste burning, mishandling of ammunition or gunpowder, gasoline misuse, electrical burns and scalding. Combat burns, on the other hand, are predominantly secondary to explosive mechanisms, mostly due to close proximity detonation of explosive devices. They comprise about 5–10% of combat injury burden. Their emergency management is however one of the challenges in the new combat milieu. Mortality associated with burns is less than 5% of combat deaths since World War I (WW I). Nevertheless, relatively high mortality rate of approximately 20% has also been reported despite continuous improvement of medical care on the battlefield and rapid evacuation [4],[8],[9],[10],[11],[12],[13],[14],[15].

Incidence of combat and noncombat burns is highly dependent on the setting in which the injury occurrs. During the period from 2003 to 2005, 63% of U.S. military burns occurred on the battlefield [16]. Another study

reported that from 2001 through 2018, 86% of service members sustained their burn injury during combat activities. Blasts accounted for 82% of burns,10% of which were combined with inhalation injury. Most burns were however small, with 92% involving < 20% TBSA [12]. In contrast, a study about casualties during the 12-year UK military campaign in Afghanistan repatriated to the UK with burn injuries, revealed that most burn injuries were related to accidents with hazardous elements and poor adherence to safety protocols [5]. Similarly, settings associated with burn injury of Israeli soldiers during the years 2008 to 2016, were noncombat routine duties in 70.7%, while combat related burns were only 25.7%. There was also a gradual decrease in burn injuries during the investigated period, from 17.6% in 2008 to 2.3% in 2016 [16].

Vesicant blistering sulphur mustard has been used extensively in the past, and its potential use in present-day conflicts remains a significant threat. It produces severely incapacitating partial-thickness chemical burns characterized by considerably slow healing. Napalm and white phosphorus present also an actual risk of serious burn injuries [6]. White phosphorus has a significant incendiary effect. It has been recently used in military operations in Gaza Strip and Lebanon putting civilian populations at high risk.

Combat-related burn injuries of military service members

Most casualties in earlier wars were caused by bullet wounds. Thermal injuries became an important feature of armed conflicts since WW I [3]. Over the last hundred years, burn threat in combat situations has steadily increased. It has ranged from small shoulder-launched missiles to long range rockets and nuclear weapons to recently improvised explosive devices (IEDs) and thermobaric weapons [4,6]. Burns prevalence increased from 1-2% during World War II (WW II) to 7.6% during the Second Lebanon War in 2006. in the Vietnam War, the highest casualties resulted from gunshot wounds coupled with burns [11,16].

With current large-scale combat operations, many soldiers and civilians are being thermally injured [13]. However, each conflict presents with its own profile of number of casualties and type of injuries with differences between various branches of the army [17]. Changing combat equipment, weaponry, and protective measures employed, have significantly impacted the types of injuries sustained by soldiers [3,14]. Explosive wounds caused by fragmenting antipersonnel weapons such as rockets, artillery shells, mortar bombs and mines have become more frequent [3], resulting in a greater number of injury sites and greater severity [6]. On the other hand, increased use of improvised explosive devices created a new source of potential thermal injury [4]. Furthermore, use of thermobaric weapons that are relatively cheap to manufacture and highly efficient, initially used by the Soviet Union in Afghanistan in the 1980s, poses unique and devastating challenges in modern warfare. They result in unique injury patterns with more burns, blast injuries, smoke inhalation, and asphyxiation [11,18].

Unlike traditional explosives, thermobaric hand-held grenades, thermobaric rocket-propelled grenades, and rocket artillery thermobaric projectiles, lack a fragmentation effect. They rely primarily on incendiary effects in addition to a powerful shock wave. The Ukrainian Ministry of Defense determined their danger zones, including a blast fireball radius of 50 m, a severe burn/ blast overpressure wave radius extending to 150 m, an intermediate burn/blast radius reaching up to 200 m, and overpressure effects still able to cause physical damage up to 300 m. Traditional protective structures such as trenches, dugouts, and basements are not effective against these weapons that result in more severe injuries than general thermal combat related injuries. Thermobaric injuries predominantly cause third- and fourth-degree burns, with significant upper respiratory tract damage and barotrauma. Within the comprehensive landscape of thermal injuries in the current war in Ukraine, thermobaric burns constituted 3.1% of combat related injuries, predominantly manifesting as 31% to 90% TBSA third- and fourth-degree burns [11,18].

Motorized warfare has created also a subset of casualties with a different epidemiology from infantry soldier casualties. Use of tanks, armored vehicles, aircrafts, and battleships in conflicts since WW I, has increased the proportion of thermal injuries. 34% of all naval casualties during the Falklands War were thermal [6,8]. Combat injuries in armored divisions are reported to be thermal in 25% [17]. 70% of Israeli tank casualties during the 1973 War were burns. As much as the armored vehicle protects the crew from small- to medium-caliber ballistic weaponry and shrapnel, being a contained space, it may become a death trap. Armor-piercing anti-tank weapons cause sudden heat exposure inside the vehicle, resulting in major thermal injuries with high morbidity and mortality [7,8]. Furthermore, armored warfare casualties are

difficult to evacuate unless medical units are highly mobile and equipped with dedicated armored vehicles with all-terrain capabilities [7].

Homemade IEDs have been increasingly used in the ongoing Middle East conflict. When these devices detonate under a vehicle, an additional mechanism of severe burn injury occurs. Combustion of contents within the vehicle, such as fuel and ammunition, occurs, and fires within the vehicle often continue to burn for longer periods of time [15]. Increased incidence of combat-related burns was observed during the wars in Iraq and Afghanistan, due to increased use of IEDs [19].

Distribution of war-related burns among military service members is dependent on the protective nature of service uniforms and protective gears during combat operations. Despite active efforts to ensure optimal protection, the face and hands continue to be the least protected [3,4]. Unlike burns of civilian patients, deployment-related burns of military personnel are disproportionately distributed toward body areas not protected by armor. Since the Persian Gulf Wars, head and neck and extremity injuries have increased while injuries to the thorax and abdomen have been on the decline [17]. From 2001 through 2018, combat related burns of U.S. military involved the head and hands in 48% of all burns [12]. Though these burns make less than 20% TBSA and are largely survivable, they are usually mostly full thickness. Facial burns are highly associated with eye injury, traumatic brain injury, need for mechanical ventilation and intensive care unit admission, and are particularly devastating both functionally and aesthetically leading to significant morbidity and decreased quality of life [4,12,19].

Burns sustained in a combat zone are invariably associated with other severe and more complex injuries including multiple open soft tissue wounds sustained in a dirty environment; they can however be very distracting [3,4]. Presence of burn injury complicates management of associated traumatic injuries and vice versa [3]. A recent report about the current armed conflict in Gaza Strip revealed that most of the Israeli wounded soldiers that suffered from significant burns, had additional life-threatening injuries [14]. The burn injury itself, in most situations, is the least severe [3,4].

Collateral burn injuries to civilian populations and involvement of civilian surgeons

The toll of civilian deaths in current wars and conflicts has been building for decades. Civilian populations, particularly since World War II (WW II), have suffered most of the consequences of armed violence. In WW I, civilians accounted for 5-19% of all war-related deaths. In WW II, civilian mortality increased to 48-65 %. Since then, spread of asymmetric conflicts and urbanization of military operations has occurred, with more warfare at present being conducted in urban environments [7,8]. In contrast to traditional cross-border wars between opposing armies, warfare in the 21st century involves networks of state and non-state actors with various military and militia tactics and strategies constituting multidomain asymmetrical and hybrid operations in which the target of warfighting is not limited to the military [20].

Unfortunately, civilians are becoming major targets. They represent today the most at-risk population [3,21]. There has been an increase in civilian fatalities from 5% at the turn of the 19th century to more than 90% in the wars during 1990's. Increased explosive power of munitions used today are leading to high rates of injuries associated with blast and fire [8]. Civilians of all age groups and both sexes suffer from more serious wounds affecting the whole body than those seen in military personnel wearing protective gears, and account for more than 80-90% of those killed [3]. The rise in case load burden of civilian war trauma overwhelms most health systems and consumes a significant portion of available critical care capacity [3,22,23,24].

Numerous civilians including women and children were wounded during the Iran-Iraq war due to conventional missiles, landmines, and even unconventional sulfur mustard chemical missiles causing severe burns. Unfortunately, children and adolescents bear the heaviest burden; in fact, more children are wounded in recent wars than military service members [20,25,26]. A large portion of casualties admitted to U.S. military hospitals on the battlefield in Iraq consisted of children, of whom 13% had burns [27]. A descriptive study based on an injury registry maintained for Palestinian victims treated in hospital facilities in Gaza Strip in 2014, reported an overall number of injuries of 6.4 per 1000 population, with male predominance. Almost half of the injured victims were 20–39 years of age, followed by children and adolescents < 20 years. Most injuries were secondary to blasts and explosions. Multiple body shrapnel wounds and burns were most frequent (39.3%) involving primarily the upper body. 3.3% required skin grafting and specialized burn management [1]. Among civilian casualties admitted to ICU in the Gaza Strip, burns were associated with a higher mortality rate [3,22,23].

As required by international conventions, care of civilian victims should theoretically be provided by armed forces who are committed to caring impartially for casualties, without regard to national or combatant status. Care of enemy prisoners of war and local civilians has been part of overseas U.S. and NATO military operations. Civilian population frequently represents 60-80% of all injured casualties admitted to military combat support facilities where complete resuscitative and hospital care can be provided [3]. It must be noted though, that military surgeons deployed to the war zone are familiar with combatant injuries; they are however frequently challenged by non-familiar multiple injuries to non-body-armour wearing casualties with potential co-morbid conditions. 30% of U.S. surgeons deployed to Iraq and Afghanistan had to perform procedures they had not done before [28].

Civilian victims in current conflicts are mostly managed by the non-military health care system, and almost all pre-hospital transport of civilian victims is done by friends and relatives or other first responders [3]. Activity of civilian physicians in civil society does not always match the progress of the war [9]. Though these physicians may have limited experience with complex blast and ballistic injuries complicated by additional thermal wounds [28], they become actively involved in taking care of the wounded as was the case with the 2023-2024 war in Lebanon. Once mass casualty occurs, war enters civilian hospitals. The challenge would be whether civilian surgeons can shift from sophisticated elective work they are used to perform, to health care delivery under the stress of an ongoing armed conflict and massive influx of severely wounded victims, that necessitates rapidity of good primary care and speed of delivering surgical procedures. As surgical capacity fails, debridements and subsequent definitive treatments become delayed. Contamination progresses to infection and morbidity ensues [20,29].

Fig. 1: Typical hand injuries secondary to the 2024 pager attack on Lebanon

Fig. 2: facial wounds with ocular injury

With more than 250 wounded transferred to our hospital in Beirut within a couple of hours following the 2024 pager attack in Lebanon, all having injuries to their hands and face necessitating interventions by the same Plastic and Reconstructive surgical team and requiring the same consumables (fig. 1 and 2), stringent managing of surgical manpower hours and supplies in addition to speed and efficiency, become a determining factor. Whether complex reconstruction needs to be done acutely or delayed without deterioration of the outcome is not an issue under these circumstances. Despite capabilities to deliver advanced complex reconstruction, it is better with an ongoing conflict and no available long-term rehabilitation support, to deliver quality but simple care to achieve stable wound healing [29].

Treatment options available to civilian casualties are unfortunately limited. Civilians are particularly vulnerable to infection by antimicrobial resistant bacteria due to several factors including overuse or misuse of antibiotics without sufficient microbiological guidance due to degradation of diagnostic capabilities, inadequate water supply, overcrowding in displacement settings, poor sanitation and hygiene, and limited access to healthcare [30]. Furthermore, their access to facilities for more definitive surgical care outside the combat zone or to specialized burn centers where the most definitive rehabilitative and tertiary care can be delivered, is extremely limited, if not impossible [3]. In Iraq, out of numerous burned children admitted to U.S. Army Combat Support Hospital (CSH), few, funded by charitable organizations, could be transferred to specialized burn centers abroad for acute and reconstructive burn surgery [27].

Terror attacks and burn injuries

Urban terrorism has been called the scourge of the 21st century, striking with explosives and suicide bombings at unexpected times and places, oftentimes causing a high number of civilian multidimensional injuries with penetrating trauma, blast injury, and burns that are unusual in civilian practice [28,31]. Treatment of victims of terrorist attacks is a difficult and pressing concern. Many have more severe injures compared with other trauma victims; a large proportion require intensive care. One important denominator of these attacks is the chaos and overwhelming pressure they create for prehospital emergency caregivers and hospital medical teams that become confronted with a massive influx of war-like multiple casualties overwhelming local hospital structures and care teams, and creating a situation in which certain victims cannot be treated, or, at least, not treated the same as one injured patient admitted alone to an emergency service[3,20,32,33,34,35].

Victims of a mass casualty event have a mortality risk 2.75 times higher than that of a single injured patient managed in an individual setting. Treatment of wounded patients in this context necessitates application of codified damage control and proven principles similar to those practiced by military health care teams deployed to war zones [35]. Comparing terror-related burn patients to terror patients with no associated burns and non-terror related burn patients, 87.2% of burn/terror patients suffer other accompanying injuries, while only 10.4% of burn/no-terror patients had other injuries. Though mortality rates in terror-attack injuries are not affected by burns, burn/terror patients have significantly higher injury severity score, more complex presentation, increased length of hospital stay and a higher ICU admissions rate [32].

Burns are at present a common form of injury among terror-attack victims and contribute about 9% of all terror

related trauma [3]. However, burn centres are never the first responders in terrorist attacks [33]. Several potential barriers to the provision of optimal care following a burn disaster situation, even in the most advanced setups, hinder adequate management of burn patients. In addition to lack of adequate systems to facilitate either primary or secondary triage, failure of communication systems not only hinders sharing of information between responders in the field but also prevents effective coordination and planning by and among hospital receiving units for referral of victims to available burn care facilities capable of managing simultaneously a large number of burn victims [3]. Following three terrorist attacks in Indonesia including the 2002 Bali bombing, 2003 Jakarta Marriott bombing, and 2005 Bali bombing, burn-patients were transferred to Singapore General Hospital Burns Centre. Despite being well equipped, main problems faced while caring for victims were those of manpower, lack of bed space, shortage of blood products, and lack of cadaver skin used as skin substitute to cover wounds following massive early excision [33].

Challenges of burn care during ongoing armed conflict

Reports quoting "Red Cross statistics for limited conflict" indicate that only 2% of victims suffer from burns [17]. Though not predominant and not the most common injury seen, even in high level combat settings, burns nevertheless require specialized care. They are generally one of the most complex forms of trauma and resource intensive to treat, and are associated with high levels of physical and psychological morbidity. Unfortunately, most deployed healthcare teams in conflict zones have little or no burn care experience [4,5].

Caring for burn victims in a situation of an ongoing war is particular and faces unique challenges [9]. The burn incident scene is frequently chaotic and fraught with hazards, especially in case of large numbers of military and civilian casualties. Potential risks may also still be present, such as enemy fire, explosives, or toxic smoke from burning sources [5]. Moreover, in addition to resource scarcity and need for quick adaptability, some conflicts are characterized by destruction of infrastructure and significant population displacement [22,36,37]. Extensive damage, with over 1000 medical facilities destroyed followed the 2022 Russian invasion of Ukraine, severely disrupting the health care system and exacerbating the trauma care crisis [38].

Regrettably, ability of any one nation to greatly expand burn capacity in times of crisis is limited [13]. Many if not most victims with burns are admitted and cared for in non-specialized facilities. It is estimated that during an armed conflict, burns-related procedures in non-specialised operating theatres may account for 11% of the workload [5]. Civilian trauma centers and other non-burn specialized centers that could potentially take care of severely burned patients, are however, rarely prepared to absorb some of the war related burn burden due to lack of proper training and expertise [13].

As early as 1916, the Russian surgeon Vladimir Oppel presented the uniform doctrine of treatment and evacuation system of combat related injuries based on principles described by Pirogov [7]. Butler [39] described years later stages of care for use in the special operations forces, which serve as a framework for tactical management of battlefield casualties, including care under fire, care rendered when the casualty is no longer under effective hostile fire, and combat care evacuation. He subsequently described Tactical Combat Casualty Care (TCCC), a set of evidence-based, best-practice prehospital trauma care guidelines customized for use on the battlefield [17]. Unfortunately, specific guidelines for acute burn injury management are still lacking.

However, regardless of the specific injury, it is important to note that in the context of an ongoing combat mission, executing the mission and providing optimal care for the casualty may be in direct conflict [17]; implementing TCCC guidelines may not be straightforward. Nevertheless, under combat conditions, assessment of burn injuries should follow basic principles of Advanced Trauma and Burn Life Support [4,38] while optimizing burn care despite the austere environment and inadequate local resources. In extreme circumstances, 'minimal acceptable care' with the selective treatment of burn patients is the rule [3,33]. Nevertheless, severely burned soldiers should receive a treatment that is, in its outcome, equivalent to medical standards [3,40].

Unlike civilian practice with available optimum resources, triage for sorting out casualties by priority based on injury severity, though difficult to make in austere settings, is a fundamental and important aspect of burn care during ongoing armed conflicts. Decisions can include withholding care for severely wounded patients who, under normal circumstances, would have been aggressively supported [3,4] . When the ratio between resources and injured individuals is low in a situation with resource

restrictions or large numbers of casualties, it is essential to maximize available resources for those who will benefit most [3,33]. Hospital care can be delayed for those patients with burns of 20% TBSA or less. Similarly, expectant care should be applied to those with burns exceeding 70% TBSA. Available care facilities and resources should be applied to burns from 20-70% TBSA. With greater restriction of health care availability, the upper limit of maximum treatment group should be reduced by stepwise decrements of 10% until the surgical workload matches available resources [3].

With high risk for inhalation injuries related to missile attacks and explosions, technical and instrumental preparedness for rapid intubation and adequate management are required. This is a limiting factor on the field; it increases the need for intubation sets, and staff with adequate skills for rapid intubation and intensive care [7]. Nevertheless, maintaining on the scene airway and circulation is of paramount importance. Patients with severe facial burns with or without evidence of immediate or impeding airway compromise, or requiring large volume resuscitation should be intubated and fluid resuscitation initiated without delay [4].

Resuscitation of burn victims in a war zone can be challenging, even for providers experienced in burn care. It must not hinder or delay rapid evacuation; it can be initiated during transport [37]. Nevertheless, appropriate volume replacement can be problematic. Adequate fluid resuscitation in a combat zone in the first 24 to 48 hours may not be smoothly administered. It presents a logistic nightmare for combat medics [3,8]. In case three soldiers suffer a 50% TBSA injury and evacuation is delayed for 8 hours, a total of 24 L of fluid would be needed, a volume more than what is usually carried by a typical platoon of soldiers. Reducing early fluid requirements with use of efficient volume expanders such as colloids or hyperosmotic saline solutions, though controversial, would probably be more convenient in such situations [8].

Often providers who evaluate and treat burn victims in the first echelons of care in combat have minimal training in resuscitation and care of burn victims [37]. A retrospective chart review of U.S. casualties with >20% TBSA thermal burns, transported from the site of injury to the CSH in Baghdad between 2006 and 2009, demonstrated that 58.3% of casualties did not receive prehospital fluid resuscitation. Prehospital vascular access was obtained in 24 casualties (50%); 20 of them received fluid resuscitation with nearly all receiving volumes in excess of guidelines established by the American Burn Association and those recommended by the Committee for TCCC. They all had longer transport times than those who did not receive fluids prior to arrival at the CSH. There was however a higher incidence of acute kidney injury in the group that did not receive prehospital fluids (47.4% vs. 26.7%)[37].

Adequate fluid administration while simultaneously avoiding potentially devastating complications associated with high-volume crystalloid overload is a real concern [3]. "Resuscitation morbidity" is a constellation of complications that may include abdominal compartment syndrome (ACS), airway obstruction, extremity compartment syndromes (ACS), and pulmonary edema. A resuscitation volume greater than 237 mL/kg during 12 hours (or 16 L during a 12-h period in a 70-kg man) appears to be the threshold for development of ACS [3,37].

For providers treating multiple casualties at once in a hostile environment, calculation of the modified Brooke or Parkland formula may be unrealistic prior to beginning fluid resuscitation in the prehospital setting. The Rule of 10, a simplified and safe calculation of initial fluid rate was developed and implemented by the U.S. TCCC guidelines to guide prehospital providers. To estimate the initial fluid rate in milliliters per hour, burn size is estimated to the nearest 10% TBSA. For patients weighing 40 to 80 kg, burn size is then multiplied by 10. The rate is increased by 100 mL/hour for every 10 kg above 80 kg [37].

Wounds sustained under unique battlefield conditions are invariably contaminated. There is also growing evidence linking armed conflicts and forced displacement to emergence of antimicrobial resistant bacteria [29,30]. Factors such as injuries from high-energy ballistic weapons, wound type and severity, presence of embedded foreign material or fragments such as clothing, dirt, and debris, increase the risk of wound contamination by unusual bacteria existing in the battle field environment, and nosocomial pathogens at treatment facilities, especially multidrug-resistant pathogens [3,19]. Furthermore, despite fast triage and evacuation, initiation of antimicrobial therapy and burn surgical care are most likely to be delayed which increases the burden of postburn infections[3].

Ability of combat medics or civilian first responders to provide burn topical antimicrobial protection at or near the point of wounding after proper cleansing and adequate debridement is limited. Traditional methods for prophylaxis and treatment of wound infections, such as dressing soaks and burn cream application, are time and

resource consuming. Moreover, effective topical ointments are too cumbersome to be carried and used in the field and are effective only after proper cleansing and debridement. The ideal agent that will be light and easily transported, reconstitutable with available water, resistant to extremes of environmental conditions, and simple enough to use is yet to be developed [3].

Rapid evacuation and transport of soldiers injured thousands of miles away from definitive care facilities to the higher level of care is of paramount importance [3,37]. Shortening transport period substantially reduces mortality that is directly proportional to the time that elapses from the moment of injury to the moment of specialist treatment [17]. Fatal outcome of mechanized and armor warfare injuries may be as high as 50% in the first 24 h without proper medical care. One of the main reasons for the high Russian military fatalities in Chechnya was inadequate evacuation support in face of increased armored warfare head and neck and extremities injuries. U.S. success in lowering fatalities of war casualties in Iraq was due to effective medical evacuation ability. With efficient and properly functioning rescue and evacuation system, as many as 98% of soldiers who are not immediately killed in action can be saved [17].

Evacuation of combat casualties off the battlefield is invariably complex and sometimes lengthy. U.S. armed forces have set the most elaborate and orderly evacuation and treatment system for overseas military operations based on five levels of care delivery including level I emergency care as close as possible to the location and time of injury; level II facility with short-term holding capacity; level III CSHs that can provide complete resuscitative and hospital care before being transferred to level IV facility for more definitive surgical care outside the combat zone then final transfer to definitive level V facility for most definitive rehabilitative and tertiary level of care [3]. Nevertheless, very often, evacuation to advanced care facilities under challenging conditions may not be straightforward [36]. Infrastructure may not be available and orderly evacuation may be severely hindered and likely to be delayed, creating a requirement for prolonged field care [13,22]. Furthermore, hypothermia secondary to exposure before evacuation and prolonged transport without complete temperature regulation is a particular threat to injured patients and another complicating factor [3,37,41].

In resource-poor environments, burn care standards of state-of-the-art civilian burn centers are unattainable[36]. Caring for combat casualties has also the potential to strain a facility's ability to provide ideal infection prophylaxis and treatment using in-theater assets [3]. Thus, to optimize survival, burn care in war-torn, resource-poor environments, requires departure from conventional burn management standards and strategies. Early excision and grafting, may prove impractical resulting in resource depletion [36]. Health care providers in suboptimal circumstances and settings must balance competing priorities of caring for troops, prisoners, and civilians, while preparing for potential changes in battlefield conditions that necessitate rapid clearing of beds for new combat casualties. Guidelines for practical burn patient management in such austere environments, must focus on conserving critical resources and maximizing survival while minimizing need for intensive care. This approach may enable more sustainable care for large numbers of patients, even with limited medical supplies and personnel [36].

Conclusion

Military burns have a broad effect that ranges from individual patients to the overall status of military operations. From planning to execution, providing critical care services in austere war environment is very demanding. War injuries present enormous challenges to the entire medical system as a result of their severity combined with the great distance required for patients' transport to definitive care. Management of combat casualties with severe burns and associated traumatic injuries requires a coordinated interaction of surgical, critical care, and evacuation assets.

Though overall survival of combat-related injuries has been steadily improving, serious and significant obstacles to state-of-the-art burn management during ongoing military conflicts still persist, and each conflict presents with its own specificities and challenges. Armed conflicts have served however as a drive for advancement in medical and surgical care over the last 100 years resulting in substantial progress in management of burns and inhalation injuries. Military experience has increased our understanding of burns pathophysiology, and has enabled provision at present of appropriate care to large numbers of combat and civilian casualties with burns.

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