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Management of War-Related Burn Injuries: Lessons Learned From Recent Ongoing Conflicts Providing Exceptional Care in Unusual Places

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Thermal injury is a sad but common and obligatory component of armed conflicts

LEBANON WAR(S)

BEIRUT PORT EXPLOSION

- Overall incidence of **burns in current military operations has nearly doubled during the past few years**

- **In modern warfare, 1 in 4 injuries is a burn**

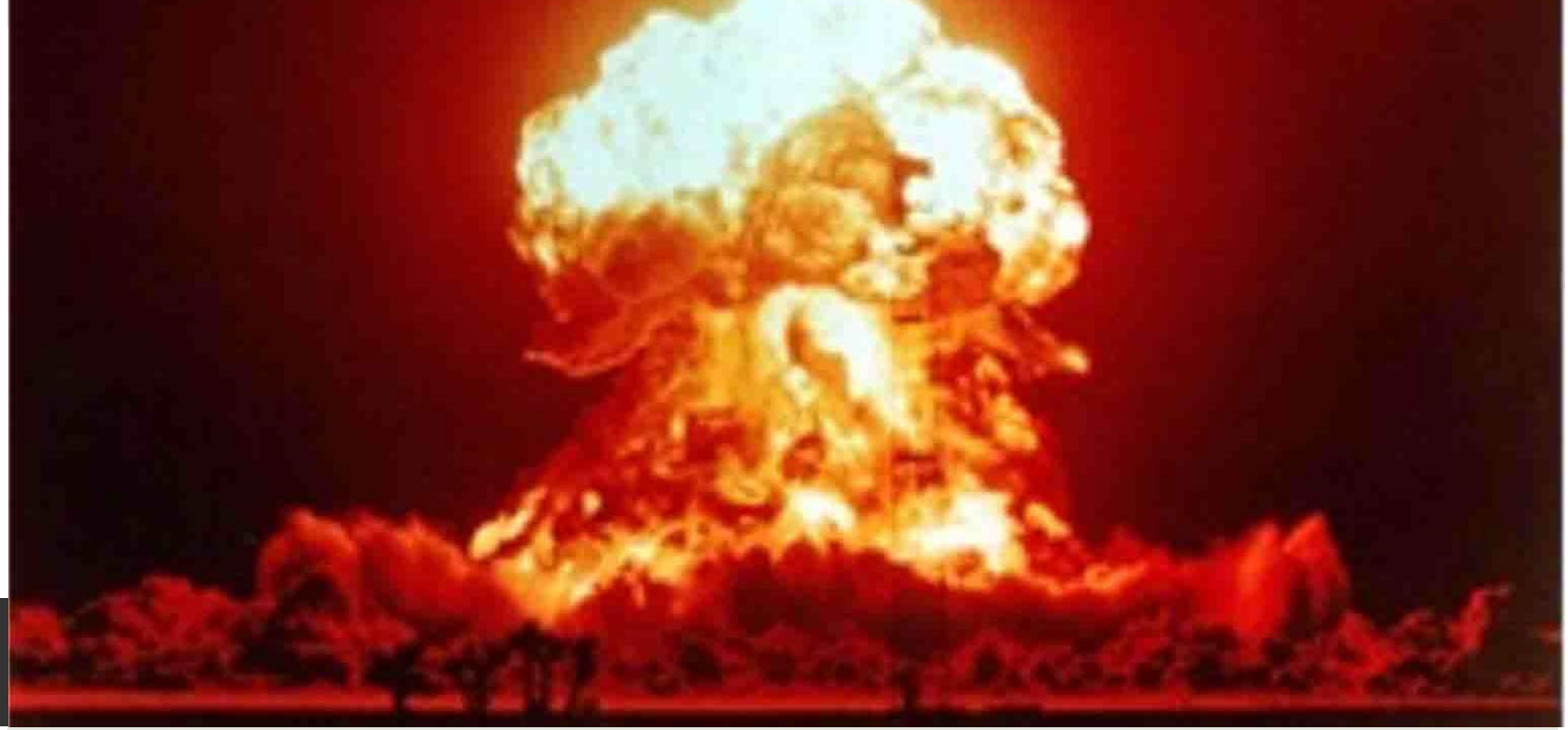
Warfare **burn injury** has been largely ignored in the past. It **was brought to the forefront of Army Medical Corps planning only at the end of World War II**

The concept of the dedicated burn unit is relatively new. It is a product of wartime and disaster experience

- **A large percentage of military burn injuries are accidental** and not directly attributable to the combat environment
- **In combat, burn injury accounts for 5% to 10%** of combat casualties
- **Nearly 20% are categorized as severe**

The provision of military burn care mirrors the civilian standards; however, **several aspects of treatment of war-related burn injuries are peculiar to the war situation itself** and to the specific conditions of each armed conflic

- The essence of the successful treatment of burn casualties is
  - **effective triage**
  - **timely diagnosis**
  - **accurate assessment of surgical priority**
  - **appropriate resuscitation**



In the recent conflicts, **many military injuries have been from explosions**, which generate high amounts of heat in a flame ball as well as blast overpressure and penetrating fragments.

- **Explosive devices typically result in a greater number of injury sites and greater severity of injuries**
- Temperatures from the explosive gases can reach 3000°C (5432°F) and may result in fatal third-degree burns in victims close to the detonation

Burns sustained in a combat zone invariably are associated with multiple open soft tissue wounds sustained in a dirty environment

The burn injury itself being most often the less severe of other multiple injuries

The pattern of injury for military casualties is related to the **protective equipment worn at the time of exposure to the thermal energy**

The face and hands continue to be those areas least protected among military personnel

Chest, upper arm, and thigh burns are more common in civilians

As compared to civilian burns, more military burns have

-full-thickness injury

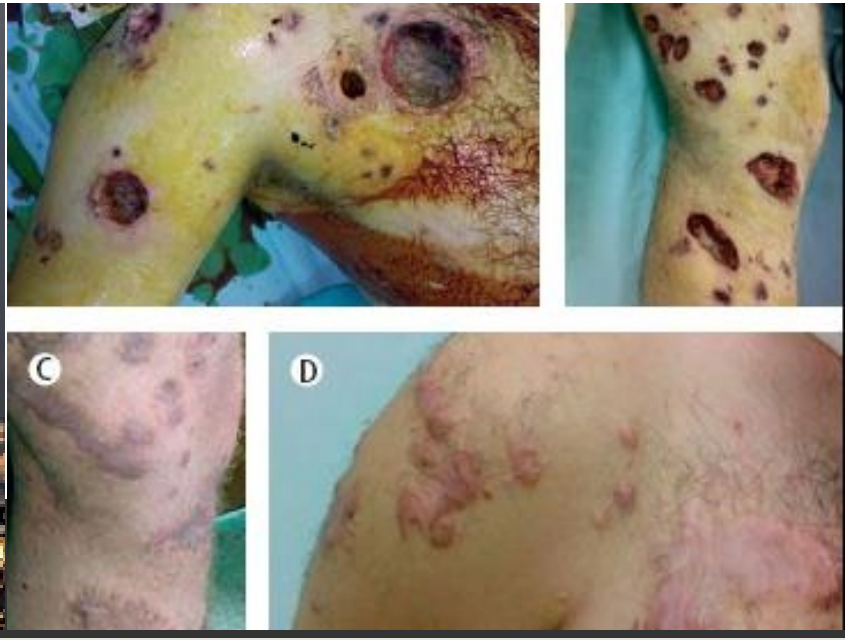
-inhalation injury

-associated injuries

CIVILIAN INJURIES DURING WARFARE

- **Civilians are becoming the major targets in modern-day conflicts**

- In World War I, civilians accounted for 5% to 19% of all war-related deaths
- In World War II, civilian mortality increased to 48%
- **Today, civilians account for more than 80% of those killed and wounded**



Many weapons used in present-day warfare contain **white phosphorus**. This element ignites on contact with air, and fragments of phosphorus will be scattered throughout any wounds caused by such weapons

When surgical treatment is available**, the wet wound can be irrigated with a freshly prepared solution of 1% copper sulfate**. This solution combines with phosphorus to form black copper sulfate, which impedes violent oxidati and identifies the particles that can be subsequently removed with forceps and placed in a dish filled with water.

Napalm is another intensely flammable agent in a liquid form, which will cling to the injured patient and cause serious and extensive burns.

Napalm burns are invariably of full thickness, with coagulation of muscles and other deep tissues

Nephrotoxicity is a serious complication, and the mortality may be high in proportion to the total body surface area involved.

A full-thickness napalm burn of only 10% of the body surface area may result in renal failure.

- **Care of military victims is usually well structured** and follows strict guidelines for first aid and evacuation to field hospitals by trained military personnel
- **Options available for civilian injury intervention in wartime are limited**. During war, 70% of all pre-hospital transport of civilian victims is done by lay public (friends and relatives of the victims) or other first responders

TRIAGE

Triage is an important aspect of military burn care to ensure that available medical care resources are matched to the severity of burn injury and the number of burn casualties

Triage decisions during mass casualty events or in austere settings where resources are limited can be difficult

With limited resources, burn care resources should be applied to that group of patients in which greatest benefit will be realized

- In a situation with resource restrictions or large numbers of casualties, hospital care can be delayed for those patients with burns of 20% or less TBSA
- Similarly, expectant care should be applied to those patients with burns exceeding 70% TBSA
- With even greater restriction of health care availability, the upper limit of the maximum treatment group should be reduced by stepwise decrements of 10% until the surgical workload matches available resources

IMMEDIATE RESUSCITATION AND INITIAL BURN CARE IN A COMBAT ZONE

- Initial management of the burn casualty in the combat zone requires
  - **a strategy of rapid assessment**
  - **airway protection**
  - **appropriate resuscitation**
  - **a thorough examination for associated injuries common to the battlefield casualty**

- To prevent organ failure and death, **appropriate volume replacement in the burn patient can be very challenging**
- Exposure before evacuation and prolonged transport in helicopters without **complete temperature regulation is another complicating factor**

- Fear of under-resuscitation seems to be the predominant concern in the early management of the burn soldiers
- **Over-resuscitation manifested by fluid infusion volumes well in excess of the Parkland formula seems to be the norm and must be avoided**

Burn patient after a decompression laparotomy **for abdominal compartment syndrome** (ACS)

J Emerg Trauma Shock. 2011 Jan-Mar; 4(1): 109–113. **A primer on burn resuscitation** Ferdinand K Bacomo and Kevin K Chung

- A resuscitation volume greater than 237 cc/kg over the course of 12 h (or **16 L during a 12-h period** in a 70-kg man) appears to be the threshold for the development of Abdominal Compartment Syndrome

- Ivy Index (**24 h cumulative resuscitation volumes) exceeding 250 mL/kg** is a well acknowledged independent predictor of mortality

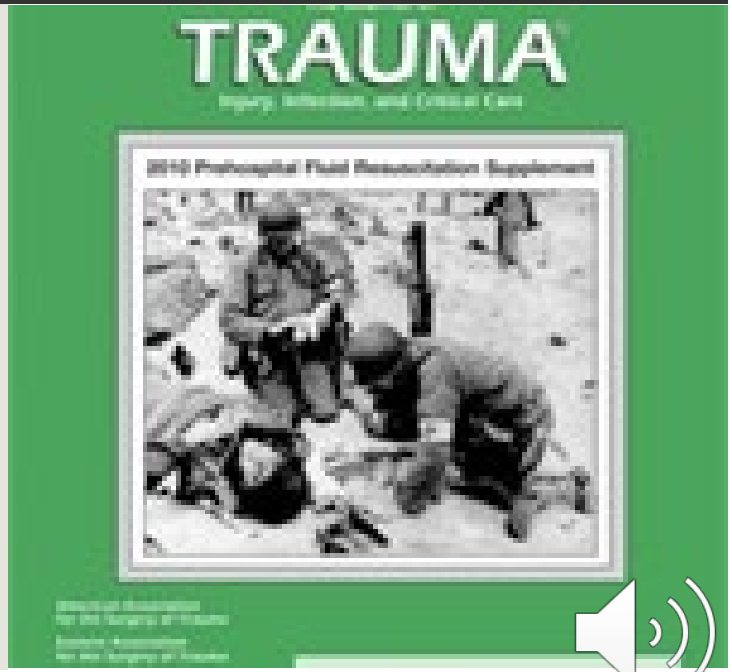
- In an effort to simplify the derivation of the initial fluid rate **the RULE of 10** was developed by the US Army Institute of Surgical Research

The Journal of Trauma: Injury, Infection, and Critical Care
Issue: Volume 69(1) Supplement, July 2010, pp S49-S54

1. Estimate burn size to the nearest 10

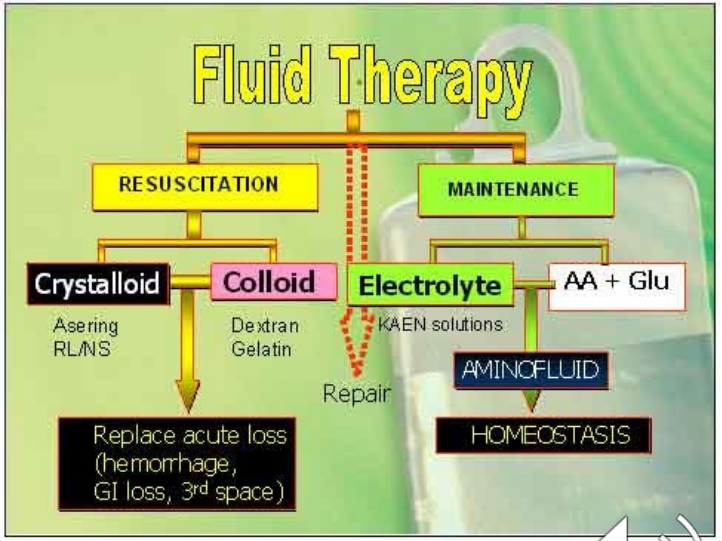
2. %TBSA × 10 = initial fluid rate in mL/hr (for adult patients weighing 40 kg to 80 kg)

3. For every 10 kg above 80 kg, increase the rate by 100 mL/hr.



The choice of fluids in burn resuscitation remains, however, controversial

Small studies have demonstrated great potential in limiting the amount of fluid required for resuscitation by **using plasma, hypertonic saline, and high-dose vitamin C during the initial burn resuscitation**



- These **adjuncts, may prove to be logistically useful**
- They may be an excellent solution to the packing constraints imposed by the battlefield **reducing the weight of intravenous fluids transported while maintaining the ability to replace lost volume in injured soldiers**

- **Oral hydration solutions may be lifesaving in conditions where intravenous therapy is logistically impossible**. It could be considered in special operations warfare or mass casualties when no alternatives exist4 especially in patients with low TBSA injuries

LONG-RANGE EVACUATION AND TRANSPORT

- In burn patients, **evacuation presents a unique problem** because it usually takes place during the resuscitation phase

- **The evacuation of injured personnel has evolved with each new conflict,**




- **Casualties are initially treated by military medics or corpsmen closest to the point of injury**. Initial treatment is focused on the priorities of airway protection, hemorrhage control, and initiation of volume resuscitation

- **The wounded are then rapidly evacuated to the next higher level of care** where the patient can be further assessed and stabilized in preparation for transport back to a burn center as safely and expeditiously as possible to facilitate early excision and grafting, minimize ventilatory days, and institute rehabilitation therapy

- **Level I provides care as close as possible to the time of injury** and consists of immediate stabilization and evacuation to an initial aid station
- **Level II offers short-term holding capacity** and initial resuscitation
- **Level III**, such as the Army's CSH (combat support hospital), the Air Force Theater Hospital, and the Navy's hospital ship, **provides complete resuscitative and hospital care**. Assets at this level of care include a myriad of surgical specialties and support and are equivalent to a well-staffed community hospital.

- Care provided at **level IV** during the Iraqi conflict is delivered at a Regional Medical Center in Germany, rendering **more definitive surgical care outside the combat zone**

- **Level V care is the most definitive rehabilitative and tertiary level of care** and is provided in military and Veterans Affairs medical centers located in the United States

TERROR-RELATED BURN INJURIES

- **Today a larger proportion of attacks are performed by suicide bombers** equipped with explosives inevitably resulting in a combination of blast injuries, penetrating injuries, and thermal injuries

- The creation of **new explosives** with the addition of common items such as fuel, cooking gas cylinders, and other volatile materials in terrorists' bombs has further **increased the severity of burns caused by terrorist attacks** in the last few decades

Terrorist attacks are usually perpetrated in highly populated areas and therefore **near medical centers**, which **makes evacuation of victims a l complex operation**

Among **terror attack patients with burns, mortality is almost double** that of patients who have burns not related to a terror attack

CARING FOR HOST NATION MILITARY AND CIVILIAN BURN VICTIMS

Modern warfare is often fought in an urban environment. Events resulting in thermal injuries are not isolated to military personnel. Civilians are even more at risk. **Collateral damage to civilian populations is usually large**

This population frequently represents **60% to 80% of all injured casualties admitted to level III facilities** and receives burn treatment damage control surgery and definitive therapy at military facilities without evacuation to higher levels of care

- Hence, **level III facilities intended to provide short-term care and stabilization of combat burn casualties before rapid evacuation are usually confronted with caring as well of local victims who cannot be evacuated abroad and should be capable of providing levels IV and V long-term care for burn victims**

- Unfortunately **this is frequently not possible** in the absence of burn-trained occupational therapists, physical therapists, nurses, and other team members. Facilities for bathing patients usually are also lacking

CONCLUSION

- War creates substantial humanitarian needs not only by generating casualties but also by disrupting local medical systems
- Historically, major wars helped changing medical treatment protocols and even define new subspecialty surgical fields.

- During the American Civil War physicians perfected limb amputation skills
- During World War I surgeons established principles for cranio-facial injuries, which later defined the subspecialty of craniofacial surgery
- During World War II, treatment protocols for hand burns were established
- During the Vietnam War, surgeons perfected the repair of major vascular injuries, which helped establish the field of vascular surgery
- Abdominal compartment syndrome became appreciated after the Iraq war

We are still learning lessons from the injuries from ongoing conflict

- Paradigm shift from the application of unlimited resources to the allocation of care, with limited resources, for the greatest good for the greatest number of patients
- Training and preparation are essential to remain effective during crises
- Disaster triage and crisis management represent a tactical art that incorporates clinical skills, didactic information, communication ability, leadership, and decision making

- Planning, rehearsing, and exercising various scenarios encourage the flexibility, adaptability, and innovation required in combat situations as well as in disaster settings
- In addition to practicing established concepts from previous military conflicts, new technology for the advancement of trauma care must be continuously applied to help bring order to the chaos of overwhelming catastrophic events

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