Warfare Injuries : History, Triage, Transport and Field Hospital Setup in the Armed Forces

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Abstract

The treatment of war wounds has been an ancient art, constantly refined and adapted to reflect improvements in warfare strategies, weapons technology, transportation and damage control surgical practices. Throughout history, more soldiers died from disease than combat wounds, and misconceptions regarding the best timing and mode of treatment for injuries often resulted in more harm than good. Since the 19th century, mortality from war wounds steadily decreased as surgeons developed systems for rapidly moving the wounded from the battlefield to frontline hospitals. This article reviews the trends in military trauma management including triage, evacuation and field hospital setup in the Armed Forces.

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History : Medical Organisation

The need for surgical care of the injured during warfare is part of the story of civilization. The history of military trauma has changed with the evolution of newer weapons and wounding agents, more so in the 19th and 20th century. Pikoulis et al [1] reviewed wounds depicted in 'The Iliad', and determined that arrow and spear wounds carried high mortality rates, suggesting surgeons were unable to get to wounded soldiers during action, treating only the higher class or those who survived the battle.

The outstanding military surgeon of Napoleonic Wars, Baron Dominique Larrey, is regarded as the originator of military trauma care, and what would become known as triage [2]. He placed surgical teams near front lines and instituted specially designed horse-drawn "flying ambulances" in which the wounded rode, cared for by an early version of emergency medical technicians [3]. Care was prioritised 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. After Larrey's system was used during the Battle of Metz (1793), he was ordered to organize medical care for the entire French Army [2].

The Crimean War underscored the importance of methods used by Larrey decades earlier, particularly the importance of organized evacuation and surgical care close to the front lines. This war revealed a stark contrast between the battlefield care provided by the French, with their expert organization and system of light ambulances, and the poorly organized British Medical Services. Outrage over the poor treatment given to the British wounded led the British War Office to send a young nurse, Florence Nightingale (1820–1910), and a staff of 38 volunteers to the British barracks in Istanbul. Nikolai Pirogoff (1810–1881), who served in the Imperial Russian Army, brought skilled nurses into military hospitals and worked to modernize Russian medical equipment [4].

In the American Civil War, most physicians had no experience of battlefield trauma. Regimental surgeons were responsible for dressing wounds and patients were evacuated to division level hospitals. By the end of the war the main advance was a network of hospital trains, ships and general hospitals and an effective military corps with medical evacuation, hospitals and surgical specialists. Esmarch (1823-1908) remembered for his bandage, also contributed to the German medical system, specially the organization structure and rules for sorting dangerous wounds regardless of ranks [5].

The concept of triage (from the French trier - to sort out) was developed by French physicians in World War (WW) I [6]. But institution of a rationalized approach was yet to come. The unprecedented mass casualties of WW I with horrific wounds from machine guns and shell fragments created terrific strain on the British and French medical units. The advent of British casualty

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clearing station (CCS), which was approx 6-9 miles behind the front lines, was made possible with motorized transport. These CCS staffed by surgeons, anesthetists and nurses, were usually overwhelmed with casualties, compelling British surgeons to prioritise. The British manual listed the goal of triage as first conservation of manpower and secondly the interest of the wounded [7].

In the British Army, the medical Staff Corps was formed in 1885; the Army Hospital Corps in 1857 and these were amalgamated in 1898 to form the Royal Army Medical Corps. The history of Indian Medical Service dates back to 1612 on formation of East India Company. Military surgeons were first employed from 1745 onwards. The Bengal Medical Service was formed in 1764, Madras Medical Service in 1767 and Bombay Medical Service in 1779. These were combined into IMS in 1886. The British Indian Army native troops were looked after by Regimental doctors till 1916 when Garrison hospitals were formed initially. The Indian Army Medical Corps was formed by amalgamation of its constituents on 03 Apr 1943.

WW II saw more advances in medical organisation in both the British and United States Armies. The chain of evacuation began with combat medics or orderlies, with evac to Battle Aid Stations or Regimental Aid Posts. For additional treatment, patients were evacuated to Divisional clearing stations or Field Hospitals. Definitive care took place at military stations in the hinterland or overseas. During the Korean War, new Mobile Army Surgical Hospitals (MASH) was deployed under the leadership of the pioneering surgeon Michael Debakey to provide resuscitative surgical care within 10 miles of the front lines. Helicopter companies supported MASH, allowing treatment within 3 to 12 hrs of wounding [8]. Mortality from all wounds decreased to a low of 2.4% [9]. The MASH units, which grew from 60 beds to 200 beds in the Persian Gulf War, were found to be cumbersome and not mobile enough to keep pace with the advancing armour, hence a 20 person Forward Surgical Team was created along with a combat support hospital (CSH) which was a modular unit having 44 to 248 beds. This re-organisation was completed by 2003.

War Wounds

The earliest account of wound management comes from Homer's epic poem the Iliad (circa 77 BCE) based on the Trojan War. The account depicts surgeons as skilled and professional physicians, who treated gruesome wounds. Hippocrates (460-477 BCE) wrote on wound care and management [10]. The belief in 'laudable pus' persisted for more than a millennium. By the 19th century, formation of pus was considered an inevitable consequence of surgery, and was often followed by death. The development of firearms resulted in gross tissue destruction, which led to pouring of oil in the wounds. Ambrose Pare', a French surgeon ran out of oil and substituted a salve of egg yolk and oil of rose, found it reduced inflammation and enhanced patient comfort [11]. By the time of the Crimean War, wound management saw the use of minie' ball in combat; these bullets struck the body with greater force shattering bone and soft tissue. These compound fractures led to serious consequences and mortality [12]. The British orthopaedic surgeon, Robert Jones applied the lessons from his medical family to great effect during WW I. Jones' uncle; Hugh Owen Thomas first described the use of braces and splints in fracture management [13]. In WW I the death rate from battlefield fractures of femur was approximately 80%, in response Jones introduced his uncle's splint to immobilize the legs in battlefield. Stretcher-bearers were blindfolded during training sessions for an application of splints in darkness. By 1915 the femur fracture mortality had reduced to approx 20%. The major change in the evaluation of wounds in WW II involved the timing of closure. Surgeons had learned the value of delayed primary closure to aid recovery and judging the clinical appearance of wounds led to better results [14].

Amputation had been performed since ancient times. Britain's John Hunter in line with his conservative approach advised against amputations in 18th century battlefields. In contrast France's Larrey used immediate intervention within 24 hours. He is credited with performing 200 amputations in a 24 - hour period during the battle of Borodino in 1812 [15]. The Crimean War was the first major conflict in which chloroform was widely used as an anaesthetic [16]. Ether was used on a limited scale by the US Army and by the Imperial Russian Army, but the inherent flammability made its utility in the battlefield questionable [17]. An additional innovation was the use of plaster of paris as a support for broken bones [18]. Although surgeons' were aware of flap techniques, circular amputations were preferred for better control of haemorrhage. Later surgeons' became adept in tying an artery.

Military surgeons were quick to adopt the use of radiographs after Roentgen discovered x-rays in 1895. This was first used by Italian physicians to locate bullets and by German and British during Greeco-Turkish War of 1897 [19]. During WW I, Antoine Depage realized that the approach of minimal wound exploration and primary closure was insufficient. He believed dead tissue led to infection and must be removed. Antisepsis was essential but could not replace debridement and removal of foreign body [20]. Allied surgeons began using delayed

closure, and the rate of major amputations decreased from 12% to just 1.7% [21]. By WW II surgeons were instructed to use the circular method of amputation and vaseline gauze was used for better healing [22]. Through the conflicts in Vietnam and Korea, US Army prohibited use of external fixation for bone injuries and functional casting was the official technique for long bone fractures [23]. A major innovation of fracture treatment came from Gerhard Kentscher who in late 1930s developed the practice of intra medullary nailing for long bones. Paul Brown pioneered the use of Kirschner wires to provide fixation for closed and open complex hand injuries [24]. Vascular surgery became routine in Korea and Vietnam reducing the amputation rates.

Current guidelines no longer call for amputation as in the past, but emphasize the need to preserve length. The patient undergoes thorough surgical debridement within two hours of injury and debridement every 48 to 72 hours. No viable tissues are removed and the level of soft tissue injury and not fracture, determines amputation level.

The nature of wounds in Iraq and Afghanistan has been transformed by IED's contributing to massive tissue damage and amputation. Tourniquets and advanced haemostatic dressings are also used in field. Placement of vascular shunts and combination of internal and external fixation is used in fractures. Free and rotational flaps are used to provide soft tissue cover along with vacuum assisted closure. Damage control resuscitation, stabilization of blood chemistry, prevention of hypothermia and permissive hypotension are important in addition to controlling bleeding, removing foreign bodies and fracture fixation for the recovery of a wounded soldier.

Blood transfusion

After Landsteiner described blood types [25], expanded transfusion offered the promise of preventing many fatalities caused by hemorrhagic shock. It also posed medical and logistic challenges to care providers. The British army began routine use of blood in combat in WW I. In 1916 surgeons performed direct transfusions in 19 casualties of which 15 died. Despite the inauspicious start, they routinely performed transfusions using syringe and cannula. The American surgeon Capt Robertson stockpiled blood in an icebox in 1917. In WW II, blood and plasma was in use more by the British. The Americans, after heavy losses in North Africa started using whole units of blood shipped from the mainland [26]. Type O blood was greatly preferred to eliminate the requirement of trained technicians. All armies provided forward units with blood and blood components with the medical units.

Infection and Antibiotics

Physicians throughout the 18th and 19th century continued to experiment with various compounds like nitrate, alcohol solution etc to prevent the spread of infection. Earlier surgeons operated with bare hands till the introduction of gloves. In WW I wounds were irrigated with Carrel and Dakin's solution, this however fell into disfavour after the war. The equine anti-tetanus toxin discovered in 1890 was distributed in large scale by 1914 decreasing the cases of tetanus [27]. In WW II sulpha powder was initially used in wounds but fell out of practice by 1944. Penicillin was first administered to US troops in 1942, later large-scale military use was instituted. Constant progress has been made in newer antibiotics, leading to decrease in deaths due to infections. Most recent guidelines for war wounds include use of culture, administration of antibiotics within 3 hours of wounding, use of low-pressure lavage and termination of antibiotics within 24 to 72 hours. Wartime physicians experiment and experience has had an undeniable impact in civilian practice [28].

Triage

Modern combat casualty evacuation has become so immediate and efficient that it can result in a mass casualty situation at Forward Surgical centre of Field or Border static hospitals. 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, equipment, supplies, personnel, and evacuation capabilities). Triage occurs at every level of care, starting with buddy and medic care, extending through the OT, the ICU, and the evacuation chain.

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.

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.

Priority I (Red disc) : This group includes those soldiers requiring lifesaving surgery and resuscitation.

It is anticipated that 10-20% 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 BP < 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 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 (eg, stabilizing 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 disc) : These casualties have relatively minor injuries (eg, 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), in which any treatment would be of no use as these casualties are usually beyond salvage.

Evacuation and Levels of care

Military doctrine provides an integrated health support system, for triage, evacuation and treatment of the injured soldiers. In Armed Forces there are 5 levels of care, previously referred as echelons of care by NATO and US doctrine.

Level 1 care is by self or buddy or at the RAP level.

Level 2 care is at Forward Surgical Centre or FSC of the Field hospital. Here life and limb saving surgery is done.

Level 3 is the highest care in the combat setting for the US forces, while in Indian set-up it would mean treatment at a large General or Zonal hospital.

Level 4 is treatment outside combat zone for US forces while in India it would be Command Hospitals.

Level 5 is the highest care in civil or military setup [29].

These levels are not to be confused with the American College of Surgeons designated civilian trauma centres where level 1 is the highest and the best facility and level 5 the least [30].

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.

Conclusion

Throughout modern warfare, medical care has been reorganized to fit exigencies of time and needs of the wounded. Although the tools and skills available today are more advanced than those possessed by Larrey, the mission remains the same. Combat trauma, unlike civilian trauma is characterized by a carefully planned and choreographed staged continuum of care. Blast injuries are the future order of battle with IED's leading to comminution, contamination, mutilation and amputation as a frequent theme. Additional study in military and civilian settings is needed to refine protocols for antibiotic prophylaxis, combat damage control resuscitation and surgery on the battlefield followed by definitive treatment at higher levels of care. Another ongoing challenge is the need to develop the Joint Theatre Trauma Registry in our set-up.

Conflict of Interest

None identified

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Journal Scan

Cho SD, Kiraly LN, Flaherty SF, Herzig DO, Lu KC, Schreiber MA. Management of colonic injuries in the combat theater. Dis Colon Rectum 2010; 53: 728-34.

Combat injuries are more often associated with blast, penetrating, and high energy mechanism than civilian trauma, generating controversy about the management of combat colonic injury. Despite implementation of mandatory colostomy in World War II, recent civilian data suggest that primary repair without diversion is safe and feasible. This study conducted at Oregon Health and Science University, Portland, seeks to determine whether management strategy affects early complications. The records from the combat theater (downrange) and tertiary referral centre in Germany were retrospectively reviewed from 2005 to 2006. Patient characteristics, management strategy, treatment course and early complications were recorded. Comparison groups by management strategy were primary repair, diversion and damage control. A total of 133 patients sustained colonic injuries from penetrating (71%), blunt (5%) and blast (23%) mechanisms. Average injury severity score was 21 and length of stay in the referral center was 7.1 days. Injury distribution was 21% ascending, 21% descending, 15% transverse, 27% sigmoid, and 25% rectum. Downrange complications for primary repair, initial ostomy and damage control groups were 14%, 15% and 30%, respectively. On discharge from the centre, 62% of patients had undergone a diversion. The complication rate was 18% overall and was unrelated to management strategy ($p = 0.16$). Multivariate analysis did not identify independent predictors of complications. The authors concluded that the early complications were similar by mechanism, anatomic location, severity of injury, and management strategy. Good surgical judgement allows for low morbidity and supports primary repair in selected cases. Damage control surgery is effective in multinational theater of operations.

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