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## Management of War Limb Injuries in the 21<sup>st</sup> Century

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### *Author's contribution*

*The sole author designed, analysed, interpreted and prepared the manuscript.*

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### ABSTRACT

**Background:** War trauma includes some of the most complex injury entities that require complex techniques, often in austere settings. After body armor use and advanced resuscitation and evacuation plans, limb injuries and salvage has increased. In this article, we review the recent war injured care, regarding limb injuries.

**Methods:** Retrospective literature search in PubMed was conducted for articles after 2010, regarding initial limb salvage and advanced reconstruction after evacuation. 43 published articles and manuals were included in the review, so that the latest protocols be interpreted.

**Results:** Protocols of war surgery and extremity injuries have changed in modern warfare, as high energy weapons often cause severe limb injuries affecting multiple tissues. Of utmost importance is the thorough debridement and staged reconstruction, after optimization of injured tissue condition. In priority series, vascular, bony, nerve and soft tissue injuries have to be addressed. Reconstruction techniques must be adapted to each injury.

**Conclusion:** As weapons evolve and war conduction changes, medical care must constantly evolve, too, in order to meet the standard of care required to achieve extremity salvage and good functionality.

*Keywords: Limb injury; extremity; war; trauma; tissue reconstruction; combat injury.*

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## ABBREVIATIONS

*EMT* : Emergency Medical Team  
*FST* : Forward Surgical Team (military)  
*IED* : Improvised Explosive Device  
*BMP* : Bone Morphogenetic Protein  
*MESS* : Mangled Extremity Severity Score  
*NPWT* : Negative Pressure Wound Therapy  
*TCCC* : (Tactical Combat Casualty Care): Set of prehospital trauma care guidelines customized for use on the battlefield  
*PTSD* : Post Traumatic Stress Disorder

## 1. INTRODUCTION

### 1.1 History

In the past centuries, soldiers rarely survived a battlefield injury. Nowadays most of them survive their injuries. It was in war that the best surgeons shone and the greatest advancements in surgical specialties were made, among mass casualties with complex injury patterns. The great 19th century Russian military surgeon, Nikolai Pirogov, is rumored to have called the war “an epidemic of trauma”.

The roots of modern war trauma care are traced back to Ambrose Pare in the 16<sup>th</sup> century [1]. The evolvments coincide with the introduction of gunpowder in wars, and the massive increase of war limb trauma. Until that time, wounds associated with limb fractures were treated with burnt oil to cauterize the microbes. Pare was the first who replaced oil with ointments, minimizing the iatrogenic trauma of the wound and reducing the infection rate. Moreover, he introduced the amputation through healthy flesh for the injuries considered to be infected, like open fractures after gunshot trauma. Almost two centuries later, Pierre Desault and his student, Dominique Jean Larrey introduced and evolved the debridement techniques for devitalized tissue. The Dutch military surgeon, Antonius Mathijssen was the first to immobilize fractures with Plaster of Paris (POP). Study of Physiology, Microbiology and significant improvements in anesthesia, diagnostics, and hospital environment, including also the discovery of radiographs, brought the war surgeons at the threshold of the 20<sup>th</sup> century.

### 1.2 Past Experience of the 20<sup>th</sup> Century

Historians often note a significant alteration of practice of medicine and standard of care throughout a war period. In the beginning of World War I, limb orthopedic trauma was not well understood, which led to high mortality and very

high infection and amputation rate for most of war limb injuries [2]. The well-known English orthopedic surgeon Jones introduced the traction splint of extremity injuries to realign the bone and surrounding soft tissue, reducing significantly the mortality of these injuries. Overall, awareness was risen regarding thorough debridement and adequate immobilization.

This was the standard of care during the interwar period, in the Spanish civil war, all the way until World War II. At that time the need for trained orthopedic surgeons emerged and intensive training programs were introduced in the competing countries. The external fixation proved to be a very useful tool in the hands of an experienced surgeon. Revolutionary was, of course, the introduction of penicillin, too.

With this experience, the medical stuff went on to the Korean War in the 50s and later to the Vietnam War. The introduction of body armor reduced fatal torso injuries and increased the survivors with severe limb injuries. In addition to the advanced surgical techniques and the evolution in vascular surgery, aerial transport and forward hospital units played a key role to the medical care of the injured soldiers. That is where the organization and articulation of medical treatment facilities begins [3].

Parallel to the orthopedic and vascular techniques the weapons evolved as well, with high velocity weapons, new bullets creating cavities in the bones and mines, causing subtotal amputation injuries of the lower extremities emerging in the Vietnam War. The compartment relief and amputation techniques evolved during this war.

Sadly, wars continue to take place in various places on earth, like the Gulf War and other war conflicts in the Middle East and in many African countries in the 21<sup>st</sup> century. Medical advancements naturally continue to take place as long as war injures occur.

In this review, recent information is being presented, which concerns the forward medical units providing temporary care and the tertiary medical establishments which provide definitive care.

## 2. MATERIALS AND METHODS

We conducted a literature-based study in the PubMed Database after designing the literature database search strategies, limited to retrieve

literature after 2010. This included the following search terms: “extremity,” “trauma,” “injury,” “military,” “combat,” “limb” and “battlefield” in different combinations. For historical and technical background, articles published prior to 2010 were also reviewed if they described a historical perspective of currently utilized modalities. Because there are few large-volume studies on the repair of peripheral nerve lesions caused by gunshot wounds, we included two articles from 2008 and 2007. In this review we define the war limb injury as an injury affecting one or more of the following tissues, bone, vessels, nerves, skin and muscles, requiring definitive care after initial stabilization in a medical establishment from a surgical team; which is caused during wartime by military weapons, like rifles, mines etc. in or near the battlefield. During the study, we also conducted a bibliography search of the encountered articles. Besides the original studies, based on field surgical team’s experience, several recommendations and guides from humanitarian aid and military healthcare manuals were included as well. We included randomized controlled trials, non-randomized comparative studies, case series and case reports investigating adults with severe extremity trauma with available full text. After thorough literature review, the aim was to present the different tissues that can be injured in war limb injuries and their management principles, both in the field and in the hospital with simple and more advanced techniques.

### **3. DISCUSSION**

#### **3.1 Initial Treatment in the Field**

Implication of body armor and advanced protective equipment, as well as advancements in military weapons and use of heavy military weapons, mines and lately more often, especially in Middle East, in the so called from the western governments, “War of Terror”, improvised explosive devices (IED), has led to a vast increase of severe extremity injuries. More and more blast injuries occur in modern war settings [4]. Blast injuries incorporate multiple mechanisms of injury including penetrating fragmentary injury, blunt force trauma, flash burn, and overpressure wave damage [5].

In terms of field care, according to the TCCC Guidelines (Tactical Combat Casualty Care) the application of tourniquet is the gold standard, especially if an arterial injury is suspected.

However, some authors suggest not applying a tourniquet in absence of bleeding, as it can increase limb edema by impeding venous return, result to compartment syndrome, cause limb ischemia or even, if poorly used, increase the blood loss [6]. If there is vascular injury near the torso, it is suggested to press the wound directly and pack it with gauzes, and, if available, hemostatic gauzes, too. Constant advancements in this technology have ensured that every soldier in the field has a package to use in such an emergency. The latest products appear to successfully control hemorrhage most of the times [7]. Similar principle of acute care with hemostatic adjuncts is suggested for junctional wounds in the groin or axilla [8]. Secure intravenous or intraosseous access and antibiotics, analgesics and fluid administration as well as administration of tranexamic acid are also part of treatment in the field.

#### **3.2 Initial Surgical Treatment Principles**

During World War II there were introduced Forward Surgical Teams (FST), which were transported near the battlefield with supplies, capable to perform several major operations, in terms of damage control surgery principles, for a finite period of time [9]. The teams evolved in the past years, adapting to the needs of the modern warfare. Latest advancements in aeromedical transport, sophisticated evacuation techniques and new adequate equipment used in level II and level III Emergency Medical Teams (EMT) in war, has led to a quick, primarily lifesaving medical care of the injured in the field and the rapid transport to a medical unit. Those reasons contribute to the vast increase of limb injuries managed by those teams.

Infection control measures, like radical debridement, use of antibiotics and tetanus prophylaxis, and temporary fracture immobilization with external fixators, POP or specific traction splints trying to restore alignment, rotation and length of the injured extremity, are very often performed from these teams. Care should be taken though, as poor application of bone immobilization techniques is associated with very poor therapeutic results. Every wound in these settings is considered contaminated, which makes thorough irrigation with an antiseptic but non cytotoxic solution and careful debridement essential for the management. The effects of ballistic injury extend beyond the area of the wound, so that thorough wound exploration is of paramount

importance. Longitudinal incisions across the limb, adapting over flexor surface of joints, may reveal the true extent of the wound. High pressure lavage should be avoided as it is considered to disperse debris in the healthy tissue [10].

For more complex extremity trauma, with concomitant arterial injury, primary vascular repair and application of temporary vascular shunts appear to be equal regarding limb salvage, with the latter having the advantage of minimizing the initial surgical time [11], and being the therapy of choice in concomitant unstable bony injuries. Transport for definitive care is, of course mandatory. Definitive vascular repair in austere settings, however, seems to be relative successful and should be encouraged when possible [12]. Some authors suggest that both procedures, performed in a selected group of patients can be effective in avoiding amputation up to 70% [13].

Many of those injuries present with a concomitant compartment syndrome, so fasciotomy is also very often performed. When lower leg fasciotomy is performed, all four compartments have to be released, either through one or two incisions. Regarding the upper limb, carpal tunnel is released, hand compartments as well [10]. All wounds and incisions are left open and are covered with fluffed sterile gauzes until second look [6]. Other materials like synthetic skin replacement for temporary wound dressings can also be applied. If soft tissue and bony defects are extended, reconstructive techniques, like cement spacers according to Masquelet technique or cover with local flaps, can sometimes be used [14,15]. Free tissue transfer can be used only to a limited extent in such settings. Pedicled flaps, however, have been used with success from orthopedic surgeons in FSTs and should be integral part of their training, prior deployment. [16]. The overall treatment is focused on functional restoration rather than on cosmetic aspects.

The main strategy of those teams in order is saving the life, saving the limb and retaining function. So sometimes primary amputation becomes obligatory especially for blast injuries, complex fractures with no limb functionality remained or arterial injury with massive blood loss, resulting to an unstable patient. Amputation mostly concerns lower extremity and an often cause is popliteal artery injury [12]. It is

suggested that amputation is a part of initial debridement, when limb salvage is not a possibility, in order to maximize the use of the operating table and avoid complications.

There are several factors, like unstable environment, training and experience of the surgeon, availability of resources, likelihood of complications like infection and ischemia and remaining limb functionality that play a role in decision making. The most decisive factor appears to be the experience of the surgeon. Sometimes, when many casualties emerge in the medical establishment, the surgical team has to do "the best for the most" and not "everything for everyone" [17]. Especially for blasted limbs with severe bony and soft tissue injuries with accompanying arterial injury, amputation should be considered sometimes without limb salvage tries, as it has been shown that these injuries often lead to secondary amputation [18]. The MESS (Mangled Extremity Severity Score) seems to be useful, though by some authors controversial, regarding the decision making [19,20]. According to Dickens et al. [21] for calcaneal injuries, the blast mechanism of injury, location of wound plantar, larger open wound size in cm<sup>2</sup>, and escalating Gustillo and Anderson classification types were predictive of eventual amputation.

Guillotine amputations are no longer recommended [17]. The amputation should be performed proximal enough in healthy tissues so that primary closure of the stump is possible. The wound can also be left open, be reevaluated and closed after 4-5 days, especially in case of severely contaminated injuries [20].

In their follow up, soldiers that underwent an amputation had statistically significant lower pain and higher level of activity than the limb salvage patients, indicating that amputation is not always the worst therapeutic option. Also, with an amputation we can spare the patient a long time in hospitals undergoing several procedures such as revascularization, bone graft/bone transport, local/free flap coverage or repair of a major nerve injury. Regarding lower extremity injuries, it has been shown that military members having undergone an amputation were more likely to engage in sports and leisure activities and less likely to suffer from depression, posttraumatic stress disorder (PTSD) and chronic pain [22]. Regarding the upper extremity, there were not found any statistically

important differences among those two groups [23].

### **3.3 Definitive Surgical Treatment Principles**

War trauma, in contrast to civilian trauma, is considered to be massively contaminated, so that a primary reconstructive procedure often fails. After abovementioned measures and acute healing phase, secondary treatment in tertiary hospital follows [14]. The surgical team is confronted with these complex injuries and has now the difficult task of restoring the extremity, often with several procedures. If available, several specialists are required, mainly orthopedic and plastic surgeons.

#### **3.3.1 Bone reconstruction**

It is forbidden to try to stabilize a fracture with plates and screws during primary care in the battlefield, as foreign material has a high risk of infection. Moreover, most of those injuries are accompanied by soft tissue defects, which also forbids the use of these materials. So, patients are admitted to tertiary hospitals with external fixators or skeletal traction. There, with the appropriate expertise and equipment, where also the soft tissue cover can be ensured, definitive treatment procedures can be performed with safety.

In the Afghanistan war, the soldiers of NATO, were often attacked from the locals with improvised explosive devices (IEDs), and new injury patterns occurred, including multiple extremity injuries, high bilateral transfemoral amputations, amputated or mangled upper extremities, open pelvis fractures, and injury to the perineal and/or genital regions [24]. That way, and because of limited tissue availability for flap coverage, the traditional orthopedic reconstruction techniques had to be optimized to comport with these complex trauma entities. Although the surgical techniques and the equipment evolved, it failed to be depicted in higher union rates, mainly because of the parallel involvement of weapons and complex injury patterns [25].

These complex injuries accompanied of soft-tissue loss, reduced local vascularity, regional scarring and secondary infections pose a challenge regarding bone regeneration and reconstruction techniques. For defects smaller than 4 cm, osteoinducting factors, such as BMP-

2 and other factors can be used with success [26]. For larger segmental defects, the Masquelet technique can be applied, with initial positioning of a cement spacer, sometimes enhanced with antibiotics. This way, a highly vascularized pseudomembrane with osteoconductive properties is built. In the next stage, bone grafting or bone transport can be performed to bridge the defect [27]. For even larger defects, vascularized iliac crest or vascularized fibula can be used. Combinations of those techniques, as well as novel adjuncts, like segmental bone transport over nail, bone grafting from femur via reamer etc. can be applied with safety as well.

#### **3.3.2 Vascular reconstruction**

High energy limb injuries with concomitant vascular injury and subsequent inflammatory response, which can last up to five days, are at high risk of amputation [19]. Such complex vascular injuries with compromised limb perfusion have to be addressed into few hours, 6 according to most authors. Several factors, other than solely time of injury and beginning of ischemia, appear to be correlated to functional recovery of the limb and avoidance of amputation. Among them are segmental arterial injury, skeletal trauma and fasciotomy [28]. This is one of the procedures a forward surgical team shall perform.

Regarding treatment strategies, there are two main acceptable options. Firstly, shunt placement in a forward medical unit followed by definitive treatment, and secondly definitive care from the FST or in an, at least role 3, medical establishment. Staged femoropopliteal injury care is associated with similar limb salvage to initial definitive management. Early thrombosis rates can be higher, likely because of shunt failure, but this does not lead to increased limb amputation rates [29].

Serious limb vascular injuries exhibit “absolute signs” in clinical examination like absent pulses, ischemia, active bleeding, and pulsatile hematomas. Immediate vascular surgical procedure is indicated. Other diagnostic adjuncts like ultrasound, Doppler, angiography, when available and time permits, or even single frame arteriography can be used, as well [19].

Compartment syndrome can occur due to the initial ischemic insult and the latter reperfusion injury, and complications could be lessened by fasciotomy as mentioned above [30].

Lastly, regarding venous injuries, war surgeons used to simply ligate them. That way thrombotic phlebitis and pulmonary embolism could occur. Nowadays it is considered that venous repair can alleviate limb edema, improve long-term arterial patency and contributes to reduced amputation rates, so that attempts to repair the veins are officially recommended, with ligation being left for life-threatening venous injuries [19].

### 3.3.3 Nerve reconstruction

Many factors like the type of the peripheral nerve, the injury level (proximal or distal), associated injuries like soft tissue and vascular injuries and fractures, electrophysiological findings, operation time, intraoperative findings, surgical techniques and repair techniques like neurolysis, direct nerve suture or nerve grafting, graft length, and postoperative physical rehabilitation have prognostic value for peripheral nerve lesions due to gunshot wounds [31].

The more distal the nerve, the better and quicker the recovery [32]. Also nerves that can be repaired with neurolysis have better results than sites where nerve grafting is necessary. Moreover, particular nerves seem to recover better than others, with better results being demonstrated for femoral, tibial and median nerves and worse recovery occurring for popliteal and ulnar nerves and brachial plexus [31]. It has been proposed that, because the ulnar nerve is both sensory and motoric nerve, its reconstruction is more difficult.

Primary repair of these injuries is contraindicated because it is impossible to determine the exact proximal and distal extent of nerve injury. Recent research suggests that early surgical repair, though, appears to have superior results compared to repair several months after nerve injury in terms of pain treatment and in improving motoric and sensitivity, [33] with consensus for repair being set within 6 months, after injury [32]. Long term follow-up is of utmost importance in order to evaluate the need for further surgical procedures, for example in case of distal decompressive surgery in anatomical tunnels [33].

### 3.3.4 Soft tissue reconstruction

In a tertiary hospital a negative pressure wound therapy (NPWT) can also be applied, as temporary cover, with good results regarding wound healing [34]. Purpose of this is to promote

the formation of healthy granulated tissue and prepare the injured site for coverage.

Use of the classic ladder of soft tissue reconstruction in decision making, which emphasizes using the simplest coverage technique while ensuring the optimal overall outcome (i.e., primary closure before skin graft, skin graft before tissue transfer, pedicle flaps before free flaps) seems to have the better results regarding limb salvage and overall morbidity [35,36]. Despite that, a case by case therapy option should be considered, as all the techniques have several advantages and disadvantages [37]. For example, free flaps will be taken from an uninjured region, with no debris, contamination and microvascular compromise, whereas they have a greater risk of failure because of the vascular anastomosis [36]. Muscle flaps, although technically demanding and associated with greater morbidity of donor site, appear to have antimicrobial properties and promote faster bone healing [36].

Due to the broad use of explosive munition, modern war trauma is high energy, resulting in massive local soft tissue loss and military reconstructing teams often have to combine local and free tissue transfer techniques to reconstruct the limb. Flap coverage can be achieved with different kinds of flaps, free or pedicled flaps, fasciocutaneous or myocutaneous. Latissimus dorsi, groin, gastrocnemius and sural flaps are some of them having been used with success [15]. Free flap coverage requires adequate infrastructure and major treatment facilities. When performed under those conditions, the success rate and limb salvage rates are over 90% [35]. High platelet counts, and previous antifibrinolytic use have not been associated with greater failure rates [36].

Regarding timing of coverage, it was recommended that early coverage is important for better results [38]. Nowadays, regarding blast or explosive injuries, definitive flap coverage should be performed in a clean field in an otherwise stable patient to achieve successful tissue transfer. That is very often not possible until the subacute period, seven days or more after injury, and sometimes even several weeks after trauma. This method has not been related to higher infection or failure rates [5].

Very often surgeons confront patients having suffered burns of variable severity and extent. Escharotomy for circumferential burns, tangential

excision of burnt tissue and paraffin gauze dressings for several days have to be applied initially. It is recommended that extended burns be covered in several procedures with no more than 10% covered in each procedure. Attention should be given to analgetic and fluid therapy to those patients, as it is shown that most of the time their needs are underestimated [15]. These treatment options require compliance of the patient and regular controls, often on outpatient basis, in order to be successful.

### 3.3.5 Amputation

Amputation rates have been reduced in recent times. A reason of course is the better medical care and advanced evacuation plans that allow fast definitive care of the wounded. Another reason can be the implementation of the Ottawa treaty that prohibits APM (Antipersonnel Mines), reducing traumatic amputations. Patients admitted because of APM Injury had significantly higher chance of amputation in a Columbian hospital [20]. Moreover, blast-injured extremities have in total extremely high rates of secondary amputation [18]. Limb salvage rates in resource scarce settings, on the other hand, have not changed [39], which underscores the importance of adequate equipment and rapid evacuation plans in order to achieve limb salvage. In the austere environment, the indications for amputation are not the same compared with daily practice, since amputation is sometimes performed as a lifesaving procedure, stopping catastrophic hemorrhage [17].

Sometimes surgeons treat local population, as well, because the local medical infrastructure is destroyed. In the initial decision making, patient's setting should be considered as well. Can patients afford the several procedures and possible revisions that may be needed in order to save the limb? Is he compliant? Could he be supported and taken care of during the long healing period? Are the hygienic conditions such that could allow proper care of the wounds? Answers to these questions may cause the surgeon to lean towards an amputation in the initial phase.

Chronic pain, osteomyelitis, and soft tissue infections are some of the causes that can lead to a delayed amputation. Patient having sustained injuries from IEDs are at greater risk. These findings emphasize the need for long-term follow up of severe limb war injuries [40]. As mentioned before, amputation does not seem to

affect the psychosocial health of the patients and should be taken into consideration at any time, if medical indications exist [23,22].

### 3.3.6 Prosthetic limbs

This issue exceeds the purpose of this review, so only brief reference will be made. Knee systems are maybe the more complex, because they must allow smooth, controlled motion when walking, provide reliable support when standing and permit movement for sitting and kneeling. Several prostheses, monoaxial, polycentric, with manual or weight activated locking system, pneumatic or hydraulic, with constant or variable friction control are in the market. Recently there has been research regarding bionic, or microprocessor controlled knees, which appear to have promising results, yet being very expensive [41]. As advanced as the technology seems today compared to the earliest designs of the 1600s, one can only imagine the developments that will eventually result as researchers further explore the potential of mechanical, hydraulic, computerized and "bionic," or neuroprosthetic, technology.

## 4. CONCLUSION

This literature review aims to summarize the gathered knowledge from the battlefield regarding the management of war limb injuries. The experience of the different battlefields, combined with the general principles of contaminated surgery, is being put together and constitutes the above written recapitulation of various injury patterns and their management. Of this review, several recommendations regarding the training of war surgeons can be cited below.

## 5. RECOMMENDATIONS AND FUTURE DIRECTIONS

War settings require well trained surgeons who can cope with the aforementioned complex injury patterns regarding extremity injuries in battlefield hospitals, but also in tertiary medical settings, providing expert definitive treatment. Low-resource settings require ethical and medical compromises. Surgeons often must take care of the local population as well. A teaching program for surgeons, prior deployment, with aim to teach surgery in an austere environment for ethical, moral reasons and efficiency purposes could be really useful. Included could be different surgical specialized skills, principles of surgery adapted to the logistic and social context and basic steps

of emergency surgery in this context. Constant experience, research and innovation makes renewal of these protocols of paramount importance, in order to achieve up to date and evidence-based care of the injured in war settings.

The surgical teams should also be aware of systemic consequences of trauma and organ failures like kidney failure, associated with rhabdomyolysis after severe muscular limb trauma, which is associated with increased mortality, [42] and pulmonary embolism associated with fractures and immobilization, as well as coagulopathy and sepsis. Therapy should be initiated immediately on site.

Medical care of the injured though does not end with the wound suture. Veterans' health care and rehabilitation services face an expensive commitment of years of work ahead to assist veterans in their adjustment to these disfiguring and life-changing wounds of war and deserve investment as well as evidence based approaches to ensure the best possible outcomes [43].

#### CONSENT

It is not applicable.

#### ETHICAL APPROVAL

It is not applicable.

#### COMPETING INTERESTS

Author has declared that no competing interests exist.

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## APPENDIX

Organization of medical support among NATO Forces (3):

"Echelons" for land or air forces or "Roles" for maritime forces are defined on the basis of capabilities and resources and are stratified in four tiers of medical support. The treatment capability of each role/echelon is intrinsic at the higher level, e.g. a role 3 facility will have the ability to carry out role 2 functions. Each level of support has the responsibility to resupply and otherwise support the levels below them.

Role/Echelon 1 medical support is integral to a small unit, and provides first aid, immediate lifesaving measures, and triage.

Role/Echelon 2 support is normally provided at larger unit level, usually of Brigade or larger size, though it may be provided farther forward, depending upon the operational requirements. In general, it will be prepared to provide evacuation from Role/Echelon 1 facilities, triage and resuscitation, treatment and holding of patients until they can be returned to duty or evacuated, and emergency dental treatment. Certain operations may require their augmentation with the capabilities to perform emergency surgery and essential post-operative management. In this case, they will be often referred to as Role 2+.

Role/Echelon 3 support is normally provided at Division level and above. It includes additional capabilities, including specialist diagnostic resources, specialist surgical and medical capabilities, preventive medicine, food inspection, dentistry, and operational stress management teams when not provided at level 2. Classically, this support will be provided by field hospitals of various types.

Role/Echelon 4 medical support provides definitive care of patients for whom the treatment required is longer than the theatre evacuation policy or for whom the capabilities usually found at role/echelon 3 are inadequate. This would normally comprise specialist surgical and medical procedures, reconstruction, rehabilitation, and convalescence. This level of care is usually highly specialized, time consuming, and normally provided in the country of origin. Under unusual circumstances, this level of care may be established in a theatre of operations.

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