

Recent advance

Combat-related upper extremity injuries: Surgical management specificities on the theatres of operations

*Traumatismes de guerre du membre supérieur :
spécificités du traitement chirurgical sur les théâtres d'opérations*

L. Mathieu^{a,*}, A. Bertani^a, C. Gaillard^b, P. Chaudier^a, D. Ollat^c, B. Bauer^d, S. Rigal^d

^a Department of Orthopaedic and Trauma Surgery, Desgenettes Military Hospital, 108, boulevard Pinel, 69275 Lyon cedex 03, France

^b Department of Orthopaedic and Trauma Surgery, Saint-Anne Military Hospital, 2, boulevard Saint-Anne, 83800 Toulon cedex 09, France

^c Department of Orthopaedic and Trauma Surgery, Bégin Military Hospital, 69, avenue de Paris, 94160 Saint-Mandé, France

^d Department of Orthopaedic and Trauma Surgery, Percy Military Hospital, 101, avenue Henri-Barbusse, 92140 Clamart, France

Received 1 December 2013; received in revised form 11 February 2014; accepted 23 February 2014

Available online 18 April 2014

Abstract

This review presents the current surgical management of combat-related upper extremity injuries during the acute phase. The strategy consists of saving the life, saving the limb and retaining function. Surgical tactics are based on damage control orthopaedics techniques of haemorrhage control, wound debridement, and temporary bone stabilization prior to evacuation out of the combat zone. Features of the definitive management of local casualties in battlefield medical facilities are also discussed. In this situation, reconstructive procedures have to take into account the limited resources and operational constraints.

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Keywords: Upper extremity; Hand; Trauma; War surgery; Damage control Orthopaedic

Résumé

Cette mise au point présente les principes actuels de la prise en charge chirurgicale des traumatismes du membre supérieur de guerre à la phase initiale. La stratégie consiste à sauver la vie, sauver le membre et préserver la fonction. Les tactiques chirurgicales reposent sur des techniques de *damage control* orthopédique, basées sur le contrôle de l'hémorragie, la décontamination des plaies et la stabilisation provisoire des fractures, avant l'évacuation des blessés vers la métropole. Les particularités du traitement définitif des blessés locaux dans les structures chirurgicales de l'avant sont également développées. Dans ce contexte, les techniques de reconstruction employées doivent tenir compte des moyens techniques disponibles et des impératifs opérationnels.

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Mots clés : Membre supérieur ; Main ; Traumatisme ; Chirurgie de guerre ; *Damage control* orthopédique

1. Introduction

Guidelines for management of gunshot wounds and blast injuries of the hand and upper extremity have been widely

described [1–7]. Although war-type wounds can be encountered in civilian practice, surgeons in combat situation have to treat highly contaminated wounds with specific constraints due to associated injuries, delayed management and limited resources [3,6]. In current asymmetric conflicts, the use of Improvised Explosive Devices (IEDs) often causes devastating blast injuries that combine multiple high-energy fractures, traumatic

* Corresponding author.

E-mail address: laurent.mathieu69@yahoo.fr (L. Mathieu).

amputations and extensive soft-tissue defects. A sequential management approach based on damage control surgery principles is always required. Life and limb-salvage procedures are provided in battlefield Medical Treatment Facilities (MTFs) prior to intercontinental medical evacuation to military trauma centres where definitive treatment is provided [8,9].

Despite numerous publications about modern war Damage Control Orthopaedics (DCO), details of the primary care for hand and upper extremity injuries are rarely described in published studies [9]. Conversely, principles for secondary reconstruction have been recently defined – they are nearly the same as those used in civilian practice [4,10–12]. However, definitive treatment is also performed within the combat zone for local resident patients [13]. Due to the lack of hand and plastic surgeons in local hospitals or forward MTFs, reconstructive procedures are mostly performed by orthopaedic surgeons with limited microsurgery training.

The main purpose of this article is to describe how DCO procedures apply to managing hand and upper extremity injuries on the battlefield. Possibilities for reconstruction procedures on local residents without performing complex microvascular surgery are also detailed.

2. Levels of medical care on the battlefield

Various levels of medical care with sequential management have been developed to ensure that injured military personnel receive the best possible medical care [2].

Level 1 care is performed by the wounded soldier's immediate combat colleagues, then by paramedics or an emergency medical team. The first objective is to stop the bleeding by applying pressure dressings, tactical tourniquets or local haemostatic agents into the wound. When junctional bleeding in the axillary area cannot be controlled by a regular limb tourniquet, the Combat Ready Clamp[®] (Combat Medical Systems, Fayetteville, NC) can be used by prehospital providers to continuously compress the subclavian artery (Fig. 1) [14].



Fig. 1. Use of the Combat Ready Clamp[®] to stop axillary bleeding by external compression of the subclavian artery.

Once the bleeding has been controlled, physicians establish the airway, replace fluids, insert a chest tube, and then reduce and splint fractures [2].

Level 2 MTFs are represented by Forward Surgical Teams (FSTs). These small surgical units (including two general surgeons) are located in close proximity to the battlefield in order to provide resuscitative measures and perform life-saving and limb-saving surgical procedures (Fig. 2). Treatment is limited to basic surgical procedures before rapid tactical medical evacuation by helicopter to higher levels of care for further procedures [2]. For upper extremity injuries, damage control procedures may include wound debridement and irrigation, bone stabilization by splint or external fixation, temporary revascularization by shunt, and fasciotomy [15].

Level 3 corresponds to Combat Support Hospitals (CSHs) which are the highest level of care within the battlefield (Fig. 2). Resources at level 3 facilities consist of a multidisciplinary surgical team, including one or two orthopaedic surgeons, intraoperative fluoroscopy, a blood bank and an intensive care unit. Damage control procedures are completed in order to stabilize the wounded patient for strategic medical evacuation by plane to definitive care facilities outside the combat zone. Furthermore, definitive musculoskeletal procedures and reconstruction can be provided at this level for local residents but have to take into account the limited resources and operational constraints [16,17].

In the French Army Medical Service, Level 4 is defined as metropolitan military hospitals where definitive surgical treatment, limb reconstruction and rehabilitation are provided with access to state-of-the-art resources [2]. The function of these Level 4 facilities is beyond the scope of this article.

3. Life and limb-salvage (Level 2 and 3 facilities)

3.1. Haemorrhage control

The first priority is to stop the bleeding by identifying and controlling any injured blood vessel. This can easily be performed using a pneumatic tourniquet above the elbow, but proximal brachial artery injuries require control by clamp at the axillary level through a deltopectoral or transpectoral approach (Fig. 3). In this case the field tourniquet is included in the sterile draping and removed once vascular control has been achieved [16]. Otherwise, salvage amputation should be considered in unstable or borderline patients with a mangled, hemorrhagic upper extremity [18].

3.2. Wound decontamination

All wounds are explored and debrided with the dual purpose of removing gross contamination, dead tissue or foreign bodies, and decompressing the wounded area. When possible, debridement should be accomplished with a tourniquet in place to limit blood loss and aid with wound exploration [3,10]. In heavily contaminated and multiple wounds due to IEDs, marginal debridement is recommended: all the necrotic tissues are removed, but potentially viable tissue is retained and

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