

Initial management of complex hand injuries in military or austere environments: how to defer and prepare for definitive repair?

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Abstract

Introduction The damage control orthopedics (DCO) concept is a sequential surgical management strategy indicated when ideal primary treatment is not possible or suitable. DCO principles are routinely applied to hand traumas in wartime practice, but could also be useful in a civilian setting when immediate specialized management cannot be carried out.

Methods The authors report three typical observations of soldiers treated for a complex hand trauma on the field by orthopedic surgeons from the French Military Health Service (FMHS). Application of the hand DCO concept is analyzed and discussed considering the literature and the FMHS experience.

Results With regards to treating the hand, DCO necessitates a meticulous debridement with precise wound assessment, the frequent use of a primary definitive internal fixation by K-wires, and the possibility of a temporary coverage. These simple and fast procedures help avoid infection and prepare the hand for secondary repair.

Conclusion Hand DCO can be applied by any surgeon in various situations: in association with polytrauma, complex injuries requiring multiple reconstructions, or delayed transfer to a specialized center.

Keywords Damage control surgery · Hand trauma · Military · Orthopedic surgery · Polytrauma

Introduction

Damage control orthopedics (DCO) is an emergency surgical tactic revolving around three stages and based on simple and fast initial procedures intended to stabilize the patient and defer definitive treatment. Initially described as a temporary external fixation of femur or pelvic fractures in unstable polytraumatized patients, this concept was extended to the management of complicated isolated limb traumas for which the ideal treatment cannot be provided at the initial phase [1–4]. DCO has now been used for several years in civilian and military surgical practice [5–9].

Wartime practice is characterized by almost systematic application of sequential DCO procedures, including for hand traumas. DCO applies simple but specific principles that help avoid early complications and facilitate secondary treatment. This tactic required in low resources settings and in the case of serious injury, is radically different from the ideal one step treatment recommended by hand surgeons since the 1970s [10–13]. However, we believe that these temporary procedures could be frequently applied in civilian practice, especially when early patient transfer to a specialized center is not possible.

Technical aspects of hand DCO are presented here through three typical observations of servicemen injured on various theatres of operations and managed by orthopedic surgeons from the French Military Health Service (FMHS). These observations are illustrative of the circumstances of hand DCO application.

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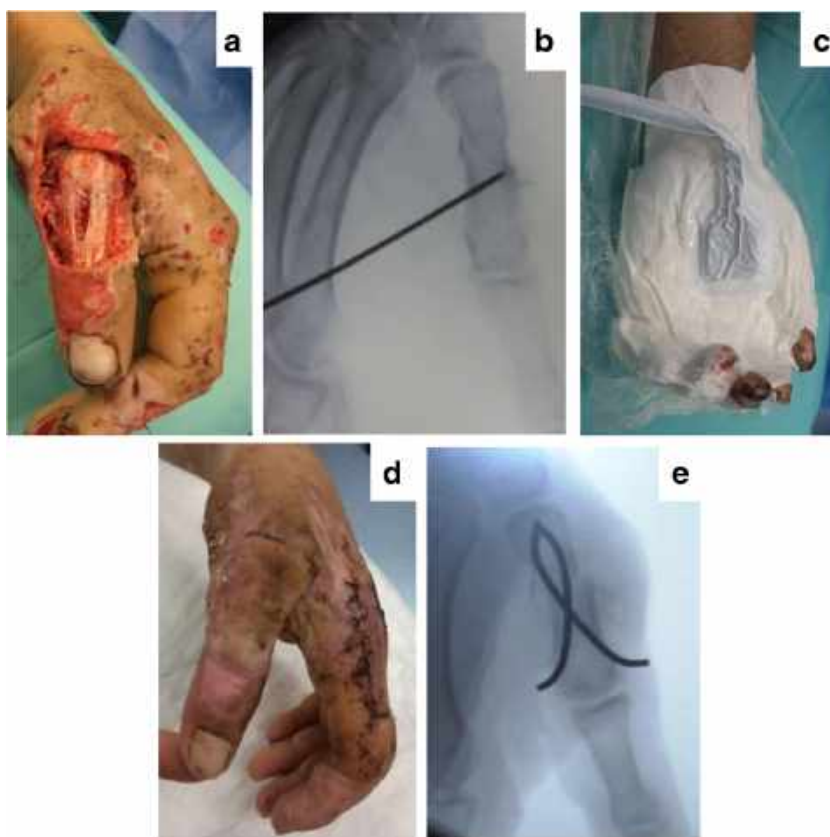
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Fig. 1 Sequential management of an open fracture of the first metacarpal bone in an unstable polytraumatized patient: debridement (a), temporary bone fixation (b), negative pressure dressing (c), flap coverage (d) and definitive bone fixation (e)



Observations

Case 1 (Fig. 1)

A 25-year-old Afghan policeman suffered a dismounted complex blast injury from a terrorist attack by an improvised explosive device. After life-saving procedures were performed in a forward surgical unit, he was admitted in a borderline condition with a bilateral above knee amputation and multiple wounds to the two upper extremities from shrapnel. His left hand had an open fracture of the first metacarpal bone (M1) with an underlying soft-tissue defect.

Initial management of the left-hand consisted of meticulous debridement and irrigation, temporary fracture stabilization by intermetacarpal pinning, and application of a dressing using negative pressure wound therapy (NPWT). After 6 days of intensive care, his general condition improved and allowed for definitive treatment: iterative debridement, intramedullary pinning of M1, and coverage by a kite flap harvested from the index finger. No complications occurred and bone union was achieved 6 weeks later.

Case 2 (Fig. 2)

A 20-year-old French artilleryman deployed in Afghanistan experienced a blast trauma of his right (dominant) thumb

while he was using a mortar. Examination revealed a total finger tip amputation without fracture. There was no possibility for early medical evacuation (MEDEVAC) to France.

In this situation, primary treatment included marginal debridement and temporary coverage by semi-full-thickness skin grafting after freshening of the volar aspect of the exposed phalanx. MEDEVAC was possible on day 4 and the patient was transferred to a specialized unit. The skin graft was removed and definitive coverage was achieved by a sensitized pedicled flap. There were no complications. At the last follow-up, more than 3 years later, the cosmetic aspect and sensitive recovery were satisfactory.

Case 3

A 22-year-old French legionnaire sustained a trauma of his left hand using a bayonet in Chad. Clinical examination showed a deep volar wound of the fourth intermetacarpal space with sensory deficits of the fourth and little finger. There were no microsurgical means in the forward surgical unit and no possibility for early MEDEVAC.

Debridement and exploration of the wound were carried out as an emergency. A complete sectioning of the fourth common digital nerve and artery was noticed, as well as a laceration of the fourth flexor tendons sheath (without any tendon lesion) and volar capsule of the fifth metacarpophalangeal joint. A copious

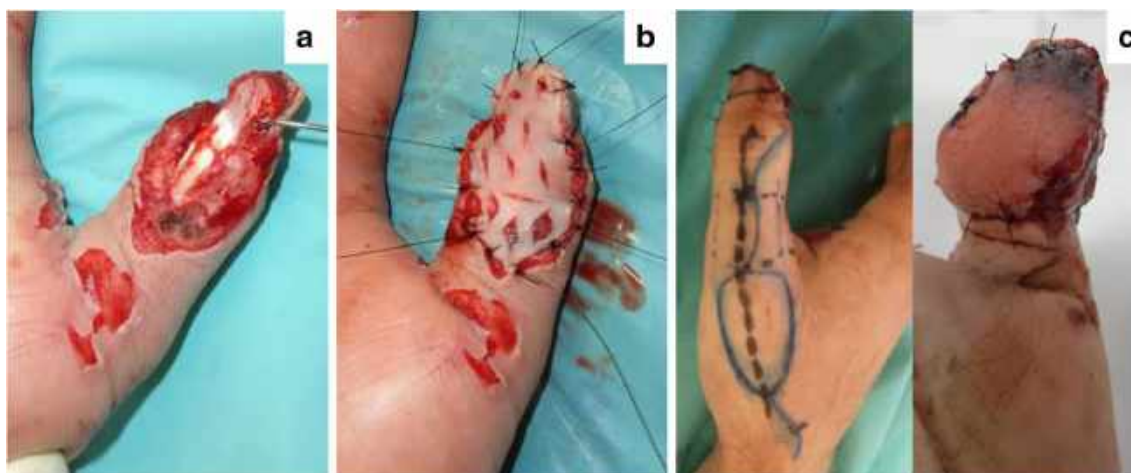


Fig. 2 Sequential management of a thumb fingertip amputation by a blast: debridement (a), temporary coverage by skin grafting (b) and definitive flap coverage (c)

irrigation of the injured sheath and joint was performed prior to a loose skin closure with drainage. Three days later the patient was evacuated to a French military hospital, and microsurgical repair of the transected nerve was achieved. The adjacent transected artery was not repaired because of extensive thrombosis and perfect digital perfusion. There was no infection and sensory recovery was in process at the last follow-up.

Discussion

Is DCO applicable at the hand level?

DCO is a sequential treatment based on an initial phase of control of hemorrhages, wound decontamination and temporary stabilization of long bones and pelvic fractures by external fixation [1–9]. Rigal et al. [6] recently specified the DCO application circumstances and distinguished four situations:

- Unstable polytraumatized patients to limit a “second hit”;
- Isolated but severely injured extremities as a result of vascular trauma, soft-tissue lesions, or multi-focal fractures;
- Limited resources, especially a lack of surgical skills;
- Massive casualties.

These situations are encountered daily in the field by military practitioners. DCO procedures have served as a basis for treatment of traumas of wartime limbs for many years, including hand traumas [14, 15]. Jabaley et al. [12] laid the basis for the application of DCO procedures to hand traumas during the Vietnam War. The main objective at the hand level is to prevent infection and prepare for secondary repair by a detailed wound exploration. The observations reported here illustrate the three principle indications of hand DCO. In case 1, the unstable general condition of the patient did not allow for an ideal treatment with primary soft-tissue coverage by a flap.

Case 2 corresponded to an isolated hand injury, the management of which required the expertise of a specialist. In case 3, the DCO application was imposed by the absence of microsurgical means.

These situations are not specific to military practice, and may be encountered in civilian practice when patient transfer to a hand surgical unit must be delayed. DCO applies to polytraumatized patients in whom life-saving procedures and intensive care take priority in the first weeks [16]. Treatment of hand injuries in these patients may be carried out only after improvement of their general condition. Delayed management may also be related to transfer difficulties from an isolated facility, especially in developing countries where access to hand specialists is limited. In these situations, it is particularly important that the surgeon responsible for the initial management perform simple DCO procedures to preserve hand function.

Specificities of hand DCO

Control of hemorrhage

If hemorrhage control is the first priority in a DCO procedure, it is seldom an issue at the hand level. Compressive dressings are usually sufficient to stop the bleeding prior to surgical management.

Debridement & irrigation

Prevention of infection is the second DCO priority [17, 18]. All hand wounds must be explored and debrided in respect of volar or dorsal approaches, and with a tourniquet in place to facilitate wound assessment. In the context of a DCO procedure, marginal debridement is recommended: all the necrotic tissues are removed, but potentially viable tissue is retained and excessive skin excision is avoided. Iterative and radical

debridement will be the first step of definitive treatment. At the volar aspect, nerves and blood vessels must be identified and protected constantly. Flexor tendons sheath lacerations are managed by limited excision with preservation of pulleys. Because no primary tendon repair will be performed, tendon stumps should be preserved or minimally debrided to remove gross contamination. Unless they have been extruded from the body or severely contaminated, hand bone fragments should be left in place. Even in highly complex digital injuries no primary amputation should be performed unless devascularization is evident because any revascularization is impossible in this context. During definitive treatment, a non-functional finger may be secondarily used for reconstruction of adjacent fingers according to the “finger bank” principle described by Foucher et al. [19].

Wound decontamination also requires copious irrigation by a saline solution, especially in cases of tendon sheath and capsular joint lacerations [20–22]. Broader spectrum antibiotic coverage may be considered in patients who have a highly-contaminated wound, and tetanus toxoid injection discussed according to their immunization status.

Injury assessment

Wound exploration is carried out together with debridement. In order to facilitate secondary repair it is crucial to perform a complete exploration of the wound and to register precisely the injury assessment into the operative report. Pictures taken at the arrival of the patient and after debridement can be useful for the specialized surgeon in some circumstances, and can be of interest in case of a later forensic problem.

Fractures stabilization

Temporary fixation of hand fractures can be achieved by splinting or pinning. However, since Kirschner-wires fixation is fast and can deal with nearly all types of metacarpal and phalangeal fractures, primary pinning is often the definitive fixation at the hand level. Even metacarpal fractures with bone loss can be treated by intermetacarpal or “bayonet-like” pinning. Alternatively, a small external fixator should be considered for maintaining phalangeal length if a bone gap exists, or for spanning fixation of complex metacarpophalangeal and proximal interphalangeal fractures [14, 23–25].

Tendons injuries

Because their surgical treatment is challenging, several authors recommend that flexor tendons should not be repaired by a non-specialized surgeon in wartime practice, except if evacuation must be delayed [12]. Thus, while simple extensor tendons lacerations may be sutured immediately, flexor tendons repair should not be performed during a hand DCO

procedure. Secondary repair can be easily performed by a specialist within 7 days after injury. The same management seems to be suitable for complex extensor tendon lacerations with loss of substance.

During the initial phase, the treatment should be limited to tendon sheath irrigation and prevention of flexor tendon retraction. If the tendon stumps are easily found (mostly at the palm level) a temporary mattress suture can be performed to prevent retraction. If the proximal stump is not visible (often at the digit level) a proximal-to-distal massage of the digit may permit milking the tendon end into the wound [26]. Conversely, if the retracted stump is not easily accessible, we believe that retrieving methods should be avoided to prevent further damage to the tendon sheath. This procedure will be done secondarily during tendon repair.

Nerves and vessels injuries

In cases of nerve laceration, a temporary loose suture of the ends prevents retraction and assists with further repair [25]. Otherwise, nerve ends can be fixed to surrounding structures that will not retract (fascias for example) with non-absorbable threads that will be used as landmarks by the surgeon performing the secondary repair. This method is useful at wrist and palm level, but may be not suitable distally to avoid additional injury to digital collateral nerves for which retraction is moderate.

As previously mentioned, devascularized injuries such as a mangled finger or ring finger injury pose insurmountable problems in an austere environment and require amputation in the proceedings of DCO. This amputation should be done as distal as possible, and the stump left opened or closed loosely to avoid infection. Definitive level of amputation and closure will be performed secondarily by the hand specialist. Other than these situations, vessels injuries require meticulous hemostasis by ligature or bipolar electrocautery to prevent hematoma formation. Arterial secondary repair is indeed strongly jeopardized by extensive thrombosis.

Skin closure or temporary coverage

When possible, a loose skin closure is performed using a fine monofilament suture, with or without drainage. In cases of soft-tissue defects, underlying tendons, joints or fractures are exposed to desiccation and infection [27]. Considering that definitive adequate coverage will not be possible for several days, we believe that a temporary coverage should be contemplated [28–30]. Various methods can be used in this indication: abdominal pocketing of the hand for large defects, full thickness skin-grafting (as seen in case 2), or preservation of a skin flap of questionable viability that will be removed later but will act as a “biological dressing” before the onset of necrosis. The later method is at risk of infection if the

definitive coverage has to be delayed by more than 3 to 4 days. As a last resort, NWPT (as seen in case 1) or simple wet dressings should also be considered, but are poorly suited to tendon and nerve exposure [25].

Conclusion

The DCO tactic is now routinely applied in both military and civilian settings to manage unstable polytraumatized patients, complex extremity injuries, or deal with limited available resources. This concept is also applicable to hand injuries when the ideal treatment in specialized centers is not feasible. Hand DCO is based on simple and fast temporary procedures achievable by any orthopedic surgeon, with the purpose to avoid infection and prepare for secondary repair for optimal functional outcomes.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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Ethical approval This article does not contain any studies with human participants or animals performed by any of the authors.

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