The management of soft tissue injuries and compartment syndrome

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Abstract

A sound knowledge of soft tissue injury and acute compartment syndrome in traumatized patients is essential for surgical practice. Safe and efficient treatment in the acute setting according to existing national guidelines ensures best practice. An understanding and discussion of the management and reconstructive options for soft tissue injury and acute compartments syndrome is discussed here.

Keywords Compartment syndrome; flaps; grafts; soft tissue injury

Soft tissue injury

Soft tissue injury can result from a wide variety of mechanisms including penetrating injuries, laceration and impalement type injuries, crush injuries and burst injuries. The mechanism of injury is an indicator of the possible deeper structural injury. For example glass lacerations often result in division of tendons and nerves whereas crush-type injuries often cause significant swelling, most notably of the muscle. Sensory disturbance is more likely due to a neuropraxia from contusion of the nerve rather than complete division.

No matter what the mechanism of injury, it is important to have a logical, sequential approach to trauma patients. The joint British Association of Plastic, Reconstructive and Aesthetic Surgeons (BAPRAS) and British Orthopaedic Association Standards for Trauma (BOAST) guidelines for management of lower limb fractures provide a framework from which we can base management of all traumatic soft tissue injuries.

Management in the emergency department

As with all trauma it is important to have an Advanced Trauma and Life Support (ATLS) approach to the patient.

Primary survey and concomitant resuscitation

- **Airway** (with C-spine control).
- **Breathing & Ventilation** — apply high flow oxygen and examine for coexisting chest injuries. Pulse oximetry and ABGs may also be performed at this point.
- **Circulation** — heart rate, blood pressure and control of any source of haemorrhage — this can be with the application of direct pressure, either digital or through the application of a pressure dressing, or if necessary a tourniquet. Obtain IV access and commence fluid resuscitation.
- **Disability** — assess and document the patients neurological status using the Glasgow Coma Scale.
- **Exposure** with Environmental control — exposure of the entire patient with temperature control.

Secondary survey

- Thorough sequential examination of the patient to identify all injuries with full neurological examination.
- AMPLE History (Allergies, Medications, Past Medical History, Last Meal, Events i.e. history of the injury).

Examination of the affected limb

Ideally this should be a joint assessment by plastic and orthopaedic surgeons.

Examine and document the neurovascular status of the limb:

- Check the posterior tibial and dorsalis pedis pulse (or appropriate distal artery depending on the location of injury) as well as capillary refill time.
- Examine and document sensation — comparison with the contralateral side is useful.
- Assess motor function, this will be difficult secondary to pain, but should be performed where able.
- Remove gross contaminants, examine, photograph and cover the wound with moist saline dressings and adhesive film (attempts at debridement or irrigation of the wound are not appropriate). It may be possible to comment on the type and size of wound (i.e. burst laceration, puncture wound etc., however the exact defect cannot be accurately predicted until after debridement in theatre).
- Reduce any co-existing fracture and splint the limb.
- Repeat the neurovascular examination following any manipulation of the limb.
- Obtain X-rays of the limb with two orthogonal views including the joint above and below.
- Administer IV antibiotics (co-amoxiclav or clindamycin) and tetanus prophylaxis if appropriate.

The BAPRAS/BOAST guidelines recommend that these injuries are explored on the next available trauma list by a senior orthopaedic and a senior plastic surgeon within normal working hours, with the following exceptions which warrant immediate exploration of the wound:

- devascularized limb
- compartment syndrome (see following section)
- gross contamination (marine, agricultural or sewage contamination)
- polytrauma.

As stated above, although these guidelines are specific to lower limb injuries, they provide a useful framework for the management of all open fractures and significant soft tissue injuries.

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Management in theatre

The limb is initially given a 'social clean,' (washed with a soapy solution) before being 'prepped and draped' for surgery. In a devascularized limb the priority is to restore blood flow as soon as possible. This is often done with vascular shunts prior to definitive vessel repair and should take priority over any bony fixation. Following this all devitalized bone and soft tissues are debrided. This may be performed using a tourniquet to limit blood loss although bone debridement is frequently performed without tourniquet control to identify bleeding, and thus vascularized, bone ends. Soft tissue debridement may be completed after skeletal stabilization although all debris must be removed before stabilization as well as any soft tissues that require debridement that will become obscured after bone stabilization. After thorough debridement and stabilization, the defect can be accurately examined. Things to specifically look for are:

- Size of the defect and associated 'zone of injury' which may extend beyond the wound edges.
- Base of the wound (fat, muscle, paratenon, fascia, exposed tendon or bone/fracture).
- Any associated degloving injury (this may have been debrided, but in specialist areas such as the sole of foot or volar surface of the hand it is often left to 'declare itself' over a period of 48 hours).
- Macroscopic appearance of arteries within the defect.
- Injury to nerves or tendons within the defect. Whilst devitalized tissue is debrided, generally a more conservative approach is adopted for major nerves that are integral to limb function and these are preserved if possible.

It may be possible to repair any damaged structures and close the defect primarily at this stage. However, frequently a more complicated reconstruction is required and if necessary the defect can be temporized with a negative pressure dressing which conveniently seals the wound and reconstruction of the injury can be planned.

Reconstruction of soft tissue defects

As well as the details of the wound and associated structural injuries, as described above, a full history of the patient and injury is required:

- History of the trauma and mechanism of injury — this is very important in appreciating the probable zone of trauma and extent of injury as well as likely contamination.
- Pre-morbid function, including occupation, significant hobbies etc. which may contribute to planning the desired outcome for reconstruction.
- Co-morbidities including pre-existing diagnosis of vascular disease, ischaemic heart disease, diabetes, poor lung function, arthritis and relevant medications including steroids and immune modulating medications.
- Social status including smoking and alcohol intake as well as support network available.

Additional investigations may be required for more complex reconstruction. Vascular studies, including Doppler or CT or MR angiogram, may be helpful to detail both the injured limb and any potential donor sites for free tissue transfer. This can be useful because, as previously indicated, the 'zone of trauma' can extend significantly beyond the wound and apparently uninvolved vessels may be damaged. The use of such investigations however is very variable.

The term 'reconstructive ladder' has been used to describe reconstructive methods which increase in complexity as you ascend the ladder; it suggests that the simplest method that will cover the defect is used. Often now the term 'reconstructive toolbox' is used, as this advocates that the wound is closed by the most appropriate but not necessarily the most simple method of wound closure. For example, it may be possible to achieve wound healing with a relatively simple procedure such as a skin graft, but if a specialist area such as the palm of the hand or sole of the foot is involved, or if further surgery is planned, a more robust cover or one that can be elevated again at a later stage may be deemed more appropriate. Either model provides a logical sequence for considering wound closure in any elective or traumatic wound (Box 1).

Skin grafts

Skin grafts can be split or full thickness depending on how much of the dermis is harvested along with epidermis. Split skin grafts include only part of the dermis and leave a partial thickness defect which is left to re-epithelialize from epidermal cells within the remaining dermal appendages. A full-thickness graft contains the full thickness of both the dermis and epidermis and results in a full thickness defect in the skin which is closed primarily.

Skin grafts can be used on defects which provide a vascularized bed (i.e. beds capable of granulating; this includes fat, fascia, muscle, paratenon and periosteum). The graft 'takes' as a result of ingrowth of new vessels from the base of the wound and therefore it cannot be used to cover tendon denude of paratenon, bone stripped of periosteum, cartilage or metalwork.

Flaps

In contrast to grafts which rely on the blood supply of the wound to sustain them, flaps bring with them their own blood supply and so can be used to cover wounds which are not suitable for skin grafts, for example exposed tendon, bone including fractures and metalwork.

Flaps can be classified by their proximity to the defect, the type of tissue within them and their blood supply.

Local flap: tissue adjacent to the wound is mobilized and used to cover the defect; local flaps are often described by their shape (e.g. rhomboid), movement (advancement, rotation, transposition), or blood supply (random pattern, axial with a recognized blood

The reconstructive ladder

- Secondary intention
- Primary closure
- Skin graft
- Local flap
- Regional flap
- Free flap

Box 1