

EXTREMITIES

Compartment Syndrome

1. All patients with a significant limb injury should be assessed specifically for compartment syndrome.
2. Compartment syndrome is a clinical diagnosis, disproportionate and persistent pain despite significant analgesia is the key feature.
3. If the clinical picture is unclear, compartment pressures may be measured
4. Patients at risk of compartment syndrome should receive hourly nursing assessment of pain level, conscious level and response to analgesia with documentation of any regional anaesthesia given.
5. Acute compartment syndrome is a surgical emergency with surgical release performed within 1 hour of definitive diagnosis.
6. Following surgical decompression, the patient should be referred to the on-call plastic surgical team at Southmead Hospital within 12 hours

Diagnosis of Compartment Syndrome

All patients with a significant limb injury should be assessed specifically for compartment syndrome. Limbs with both closed and open fractures can develop compartment syndrome. The diagnosis of compartment syndrome remains a clinical diagnosis. There is no definitive investigation to exclude compartment syndrome.

Symptoms of compartment syndrome include:

- Pain (out of proportion to injury sustained)
- Pain on passive stretch of muscles in compartment

Signs of compartment syndrome include:

- Tense (woody firm) compartments
- Paraesthesia
- Diminished or absent pulses
- Delayed capillary refill
- Neurological changes

In obtunded patients, or where the clinical picture is unclear compartment pressures may be measured (either a single or continuous measurement).

- If absolute compartment pressure exceeds 40mmHg, the affected compartments should be released unless other life threatening conditions take priority.
- If the difference between diastolic blood pressure and compartment pressure is **30mmHg** or less, the affected compartments should either be released or continuously monitored depending on the treating consultant decision.

Pressure monitoring should not be performed if the clinical diagnosis is clear and performance should not delay surgical treatment.

Documentation

Should include the following data

- Time of injury
- Mechanism of injury
- Time of evaluation
- Neurovascular status of limb (before and after any manipulation)
- Radiological findings (before and after any manipulation)
- Level of pain
- Conscious level
- Response to analgesia
- Any regional anaesthesia given

Patients at risk of compartment syndrome should receive hourly nursing assessment of these symptoms. Pain scores that do not reduce in response to treatment warrants **immediate** senior clinical assessment.

Management

Acute compartment syndrome is a surgical emergency. Once definitively diagnosed, surgical release should be performed urgently (within 1 hour). Surgical treatment should not be delayed for any reason, including starvation status or bed availability.

Immediate treatment

- All circumferential dressings should be removed
- Elevate the limb to heart level
- Avoid all regional anaesthesia and patient controlled analgesia
- Evaluation every 30 minutes is required. If symptoms fail to improve, proceed to surgical decompression
- The alternative of continuous pressure monitoring should only be instituted by a Consultant

Surgical Treatment:

- Surgical treatment of lower leg compartment syndrome should be via a dual incision 4 compartment fasciotomy (as per BOAST / BAPRAS guidelines)

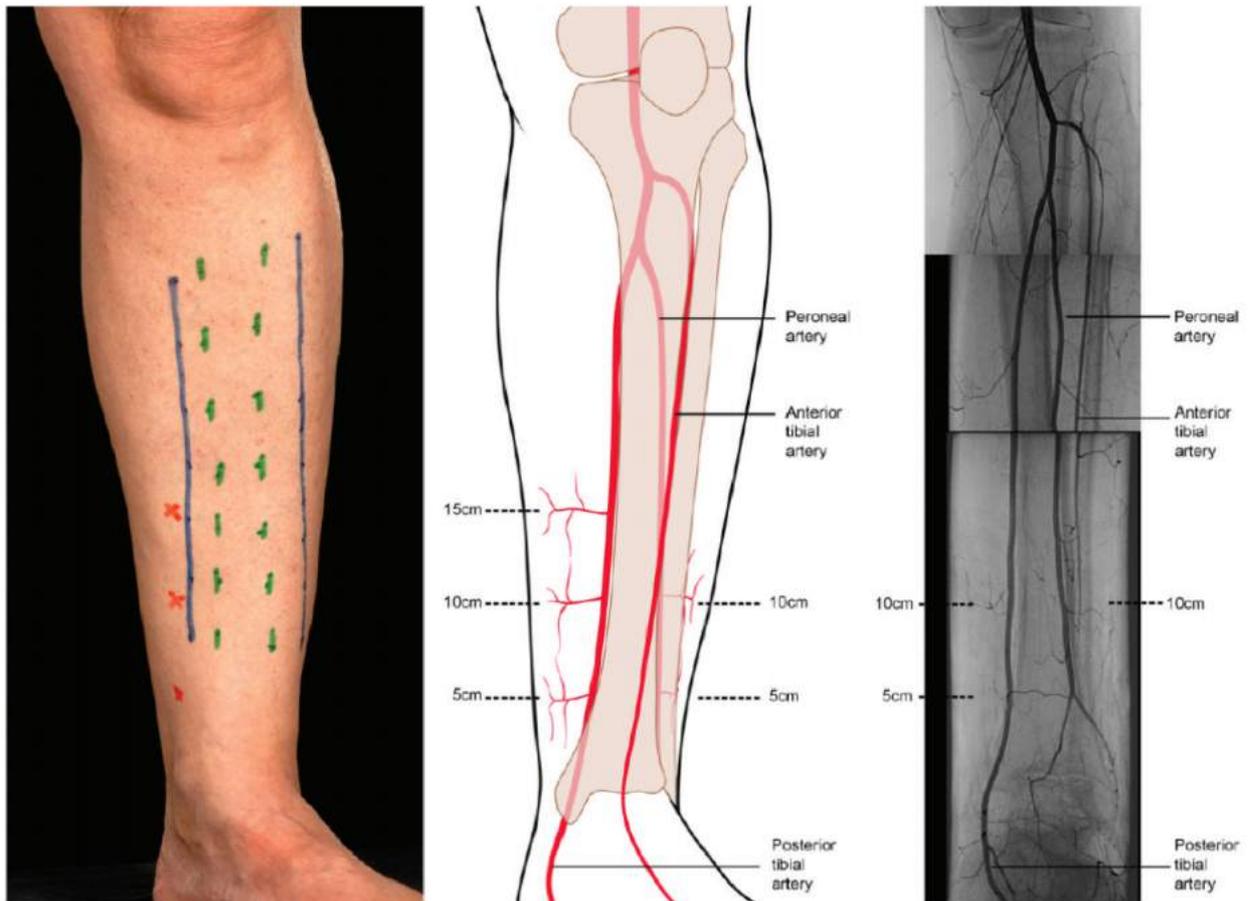
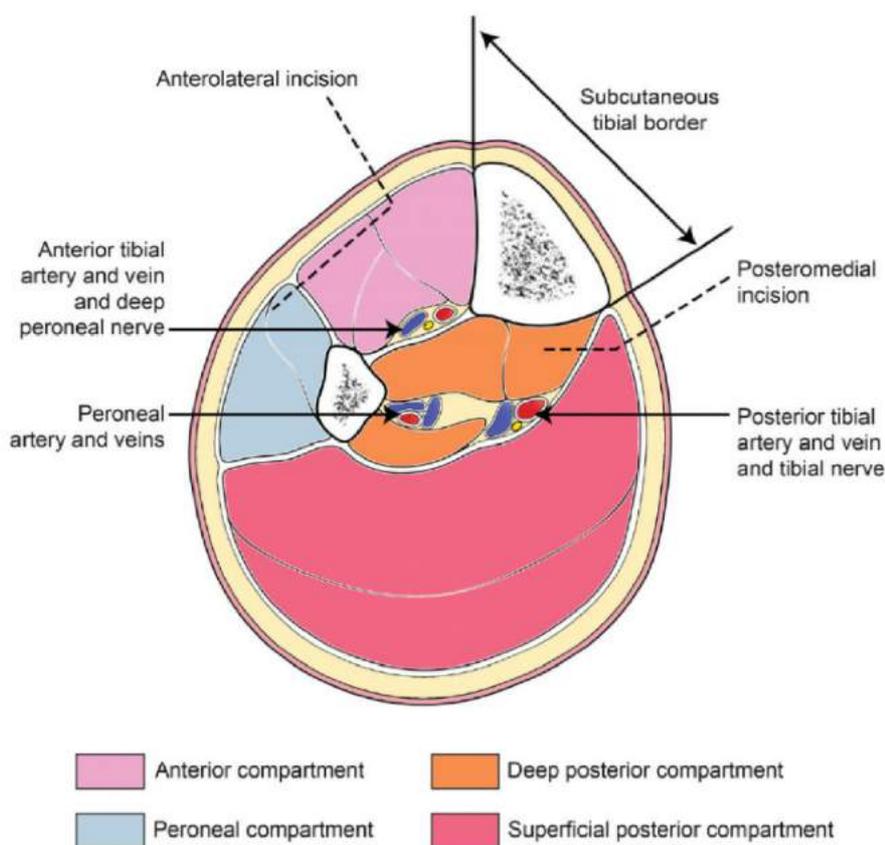


Figure 1: Recommended incisions for fasciotomy and wound extensions. From BOAST-4

- (a) Margins of subcutaneous border of tibia marked in green, fasciotomy incisions in blue and the perforators on the medial side arising from the posterior tibial vessels in red.
- (b) line drawing depicting the location of the perforators.
- (c) montage of an arteriogram.

The 10cm perforator on the medial side is usually the largest and most reliable for distally-based fasciocutaneous flaps. Care should be taken when making the medial incision particularly, and should normally be made no more than one finger's breadth posteriorly from the subcutaneous border of the tibia to avoid damaging these perforators.



If compartment syndrome occurs following a fracture and prior to definitive surgical stabilisation, temporary stabilisation should be performed **following** fasciotomy using appropriate methods (External fixation or temporary bridge plating).

Fasciotomy wounds should be dressed with saline soaked gauze

Negative pressure dressings should be avoided immediately following fasciotomy

Onward Management

- Following surgical decompression, the patient should be referred to the on call plastic surgical team at Southmead hospital as soon as possible and certainly within 12 hours to plan for transfer and coverage of fasciotomy wounds.
- If the patient still requires definitive fixation, they should be referred to the orthopaedic team (again, within 12 hours) who will liaise with the plastic surgeons.
- For those patients not requiring definitive orthopaedic fixation, referrals can be made to Plastics at Southmead for consideration of transfer (reviewed daily at 08:00) by email using this email address: nbn-tr.bristolplastics@nhs.net. Where more urgent discussion is required an on call SHO and Registrar are available at all hours through Southmead switchboard

Ideally arrange photos locally of the limb pre and post operatively which can be sent with the referral to aid planning.

- If there is any difficulty in contacting teams, the patient should be referred through the major trauma network via the Trauma Team Leader at North Bristol NHS Trust

Management of Open Fractures in Adults

1. Initial assessment and management should be undertaken in accordance with BOAST Guidelines on Open Fractures & NICE CG37 standards.
2. Administer antibiotics and analgesia as soon as possible, ideally within 1 hour of injury and in the prehospital setting if at all feasible.
3. The wound should be photographed, dressed with a saline soaked gauze dressing, and the limb splinted as soon as possible after arrival in the ED.
4. **All** open lower limb fractures should be transferred to Southmead MTC via the major trauma pathway **from ED to ED**.
5. **Isolated** open upper limb fractures should be admitted to their presenting hospital T&O department. If there are concerns regarding safe primary wound closure, then onward referral to the major trauma centre at Southmead should be at consultant to consultant level.
6. If transfer is required, there should be clear documentation of wound characteristics (ideally photographs), wound toilet, dressings and splintage. Photographic and radiographic images should be transferred to the Southmead PACS as soon as the decision for transfer is made.
7. In exceptional circumstances where surgical management of an open fracture must be delayed, appropriate management comprises debridement, stabilisation and dressing.

Immediate Management and Clinical Assessment

Immediate Management: Initial assessment and management should be undertaken in accordance with the BOAST guidance on open fractures.

Clinical assessment of the fractured limb must occur within the ED and as soon as realistically possible after arrival in the ED.

Vascular and neurological status of the limb should be regularly and systematically assessed, particularly after reduction or application of splintage.

Vascular Status

- Use hard signs (lack of palpable pulse, continued blood loss, or expanding haematoma) to diagnose vascular injury.
- Do not rely on capillary return or doppler signal to exclude vascular injury.
- If hard signs of vascular injury persist after any necessary restoration of limb alignment and joint reduction, immediate surgery for revascularisation is indicated.
- Do not delay revascularisation for angiography in people with complex fractures.

When assessing neurovascular status in a person with a limb injury, document for both limbs:

- Which nerves and nerve function have been assessed and when
- Sensation
- Motor function using the Medical Research Council (MRC) grading system
- Which pulses have been assessed and when
- How circulation has been assessed when pulses are not accessible.
- Document and time each repeated assessment.

Do not irrigate open fractures in the emergency department before debridement.

The wound is handled only to remove gross contamination and to allow photography, then covered in saline soaked gauze and an impermeable film to prevent desiccation

The wound should be splinted including the joint above and below the site of fracture.

Antibiotics & Analgesia

Antibiotics (Flucloxacillin 1g and Gentamicin 5mg/kg or Teicoplanin 400mg and Gentamicin 5mg/kg if penicillin allergic) should be administered within 1 hour and in the prehospital setting if possible. This should be continued until 72 hours post injury or wound closure (whichever is soonest).

Consideration must be given to tetanus status.

Early, judicious analgesia should be administered as soon as possible. Regional techniques may mask the signs of compartment syndrome and should be used only following discussion with a senior member of the surgical team.

Spintage

Appropriate splints should be applied as follows:

- Foot / ankle / tibia – Above knee back-slab including foot
- Femoral fracture – skin traction or pneumatic splint
- Upper limb – back-slab

On the whole, there is a very limited role for the use of external fixation with these fractures.

Imaging

- Imaging including the joint above and below the fracture should be undertaken in all patients. CT angiography of both lower limbs should be included in their initial trauma CT scan whenever possible. Ideally, CT angiography should be performed before surgical debridement, although it must not delay surgery.
- For patients initially managed in a trauma unit, radiographs should be transferred to the Southmead PACS as soon as the decision for transfer is made.

Surgical Care of Open Fractures

A combined plan for the management of both the soft tissues and bone is formulated by the plastic and orthopaedic surgical teams and should be clearly documented in the patient records.

- The 6 hour rule does not apply. Patients are better served by a planned consultant led Orthoplastic debridement and excision within working hours, unless significant contamination (Farmyard, Sewage, Aquatic) or vascular injury.
- Vascular impairment requires immediate surgery and restoration of the circulation using **shunts**, ideally within 3-4 hours, with a maximum acceptable delay of 6 hours of warm ischaemia. This should occur before skeletal stabilisation and definitive vascular reconstruction
- Compartment syndrome also requires immediate surgery, with 4 compartment decompression via 2 incisions (see separate guideline)

- The primary surgical treatment (wound excision, debridement and fracture stabilisation) of severe open tibial fractures only takes place in a non-specialist centre if the patient cannot be transferred safely
- If definitive skeletal and soft tissue reconstruction is not to be undertaken in a single stage, then vacuum foam dressing or an antibiotic bead pouch is applied until definitive surgery.
- Definitive skeletal stabilisation and wound cover are achieved within 72hours and should not exceed 7 days.
- Vacuum foam dressings are not used for definitive wound management in open fractures.

Limb Salvage

Perform emergency amputation when:

- A limb is the source of uncontrollable life-threatening bleeding, *OR*
- A limb is salvageable but attempted preservation would pose an unacceptable risk to the person's life *OR*
- A limb is deemed unsalvageable after dual consultant assessment.

Include the person and their family members or carers (as appropriate) in a full discussion of the options if this is possible.

Multidisciplinary assessment involving an orthopaedic surgeon, a plastic surgeon, a rehabilitation specialist and the person and their family members or carers (as appropriate) is recommended to inform the decision whether to perform limb salvage or delayed primary amputation

Transfer of Patients from Trauma Unit to Major Trauma Centre

Centres that cannot provide combined plastic and orthopaedic surgical care for severe open tibial fractures must transfer care of the patient to the major trauma centre as early as possible following injury.

All open lower limb fractures should be transferred to Southmead MTC via the major trauma pathway from ED to ED.

Isolated open upper limb fractures should be admitted to their presenting hospital T&O department. If there are concerns regarding safe primary wound closure, then onward referral to Southmead should be at consultant to consultant level

Transfer Arrangements:

Transfer to the Major Trauma Centre is arranged from the Trauma Unit ED to Southmead ED and is co-ordinated by the Trauma Team Leaders at those units.

Southmead Trauma Team Leader: 07703 886400

Documentation:

In patients requiring transfer, documentation of the wound characteristics (photographic where possible), wound toilet, dressings, antibiotics given, and splintage should be undertaken in the Emergency Department.

Exceptional Cases

BOAST 4 guidelines emphasise that open fractures are best managed by timely specialist surgery rather than emergency surgery.

Exceptions to this include:

1. Wounds heavily contaminated by marine agriculture or sewage matter
2. Open fractures with vascular compromise
3. Patients requiring emergency surgery for reasons other than their open fracture.

In these cases, appropriate management comprises:

- **Wound excision:** Removal of contaminated and dysvascular edges
- **Debridement:** Extensions proximally and distally to fully expose the zone of injury and thorough lavage with excision of contaminated or devitalised soft tissue.
- **Stabilisation:** This can be achieved with a cast, a temporary plate or an external fixator at the discretion of the operating surgeon
- **Dressings:** As per local preference

Queries: We are happy to discuss any aspects of the management of patients with open fractures within the Severn Trauma Network. Please contact Mike Kelly or Umraz Khan (via NBT switchboard 0117 3235999) or the orthopaedic consultant on-call.

Referral Guidelines to Specialist Peripheral Nerve Injury Unit

Key Points

1. The following guideline outlines the conditions that would particularly benefit from early assessment at a peripheral nerve injury unit (Royal National Orthopaedic Hospital, Stanmore, Middlesex)
2. In indicated cases, prompt referral of patients with early intervention is associated with improved outcomes
3. Contact Benita Patel PNI Unit Co-ordinator on 0208 909 5803 or the on-call PNI Unit Registrar via main switchboard on 0208 954 2300.
4. Provide a full statement of condition of the patient and associated injuries together with relevant medical history.
5. If urgent transfer for emergency intervention at the PNI Unit is planned, get an anaesthetic review prior to transfer to ensure fitness to travel and for subsequent surgery.

Indications for Referral to Royal National Orthopaedic Hospital, Stanmore Middlesex

Brachial Plexus Injury

- MRI proven cervical nerve root avulsion (pseudomeningocele visible) – urgent transfer indicated when patient fit to travel.
- Clinical deficit associated with blunt trauma to neck or shoulder.
- Clinical deficit associated with penetrating injury.
- Clinical deficit associated with subclavian or axillary artery disruption – urgent transfer indicated following vascular repair and patient being fit to travel.
- Clinical deficit (particularly of axillary nerve) following shoulder dislocation with associated tuberosity fracture – urgent assessment indicated following treatment of shoulder dislocation (local management of tuberosity lesion preferable when trauma work load allows, otherwise this can be performed at RNOH).
- Ongoing clinical deficit following shoulder dislocation.
- Ongoing pain and clinical deficit following definitive fixation of clavicular fracture.

In cases of low energy transfer injury and no ongoing pain it is reasonable to observe patients for a period to assess for signs of recovery. If no recovery is noted by 6 weeks then referral should be considered. If no recovery is noted by 3 months referral is strongly recommended.

Supracondylar Fracture

- Deficit of ulnar, median or radial nerves with ongoing pain pre or post reduction of fracture and / or pain in named median nerve distribution.

Radial Nerve

- Radial nerve deficit post fixation of humeral fracture.
- Ongoing pain and loss of function with associated humeral fracture.

In cases of deficit following fracture either with or without fixation where pain is not a feature it is reasonable to observe for 3 months. If no recovery of function is noted by 3 months referral should be strongly considered.

Lumbosacral Plexus Injury

- Flail lower limb following pelvic fractures – urgent referral once stabilisation of bony injuries is achieved and patient stable for transfer.

Visualised Disruption of Major Nerves

Including brachial plexus, median, ulnar and radial with very proximal division, sciatic, peroneal and tibial nerves.

- Urgent referral once patient fit for transfer

Referral Pathway

Please contact Benita Patel PNI Unit Co-ordinator on 0208 909 5803 or the on call PNI Unit Registrar via main switchboard on 0208 954 2300.

Please provide a full statement of condition of the patient and associated injuries together with relevant medical history. An assessment of the nerve injury and extent of lesion together with a full description of the mechanism of injury is essential. If urgent transfer for emergency intervention at the PNI Unit is planned, please get an anaesthetic review prior to transfer to ensure fitness to travel and for subsequent surgery.

References

British Orthopaedic Association and Bristol Association of Plastic, Reconstructive and Aesthetic Surgeons. Standards for Trauma: BOAST 5: Peripheral Nerve Injury
<https://www.boa.ac.uk/wp-content/uploads/2014/12/BOAST-5.pdf>