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ENDGAMES

PICTURE QUIZ

The management of open tibial shaft fractures

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A 28 year old cyclist was hit by a car in a road traffic incident. It was a side on collision, and his left leg was caught between a bollard and the bumper of the car. The saloon car had been travelling at 30 miles per hour (48 km/h). The cyclist's left leg had been trapped for 10 minutes before being freed. He had no medical history, was taking no drugs, and had no allergies.

On arrival at the emergency department, he was managed according to the advanced trauma life support protocol with a primary survey. His cervical spine was immobilised, his airway was clear, breathing was normal with saturations of 100%, and he was haemodynamically stable, with a Glasgow coma scale of 15 out of 15. He had an 11 cm wound over the anterior part of the left lower leg with an open tibia fracture (fig 1). He was neurovascularly intact with a capillary refill of less than 2 seconds. A trauma series was ordered with additional radiographs for the affected limb.

Fig 1 Left leg with open tibial shaft fracture held in a gutter splint

Questions

1 How would you classify this injury?

2 How would you manage this patient initially?

3 How should this patient be managed definitively?

4 When should definitive management be carried out?

5 What specific complications would you expect with this injury?

1 How would you classify this injury?

Short answer

Open fracture of the tibia, Gustilo-Anderson type 3b.

Long answer

Tibial shaft fractures are the most common long bone fracture and usually affect the fibula too. The highest incidence is in young men—8 per 100 000 persons.[1] These fractures usually occur as a result of a high energy impact, and the most common causes are sports injuries and road traffic injuries.[2]

The Gustilo-Anderson classification describes the contamination, neurovascular status, and soft tissue injury associated with a fracture (table⇓).[3] The higher the classification type number, the greater the chance of infection, need for bone graft, and chance of amputation.[4] The classification is most accurately applied after debridement of the wound.[5]

This patient has a type 3b Gustilo-Anderson open fracture owing to inadequacy of soft tissue cover. Any signs of a vascular injury that resulted in a devascularised limb and required repair would make this a type 3c fracture.

The AO classification system is a comprehensive system that grades soft tissue injury—the skin (integument; I), muscle and tendon (MT), and neurovascular structures (N)—separately from injury to the skeleton.[6] The reliability of this system improves with the surgeon's experience.[7] Prognosis can be better predicted using the AO system than with Gustilo-Anderson grading.[8]

The grading of the skin lesion is done separately for open or closed fractures, with the letters "O" and "C" designating these two categories. Each category is divided into five severity groups. Thus, IC 1 represents the injury of the integument in a

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closed fracture. The digit "1" indicates the least severe injury. IC 5 has the most severe soft tissue damage (box 1).

According to the AO classification system of fractures this patient would have a 42-C3 IO3-MT2-NV1 injury.[9]

2 How would you manage this patient initially?

Short answer

According to the advanced trauma life support protocol as well as joint guidelines on the management of open fractures of the lower limb from the British Association of Plastic Reconstructive and Aesthetic Surgeons (BAPRAS) and British Orthopaedic Association (BOA). The patient requires systematic repeated neurovascular assessment, intravenous antibiotics, tetanus vaccination, reduction and stabilisation of the fracture, and referral to orthopaedics and plastic surgery.

Long answer

All trauma patients should initially be approached in the same way using the advanced trauma life support protocol.[10] Haemorrhage is controlled through pressure, which can be direct or indirect, with or without the use of adjuncts such as tourniquets. In the case of active bleeding, it is essential to secure the most distally based pressure, proximal to the zone of injury, before definitive urgent surgical management.[11]

Assessment of the open tibial fracture should be systematic, careful, and repeated at intervals to check for neurovascular deterioration. It is important to achieve anatomical realignment of the fracture in the emergency department because this reduces injury to the soft tissue. Neurovascular assessment should always be performed both before and after manipulation and operative intervention.

A Cochrane review showed that the use of antibiotics in open limb fractures protected against early infection compared with no antibiotics or placebo.[12] Intravenous antibiotics should be given within three hours of injury. Give intravenous co-amoxiclav 1.2 g three times daily until debridement, when gentamicin should then be added as first line treatment. If the patient is severely allergic to penicillin, intravenous clindamycin 600 mg four times daily is recommended. According to current combined BOA and BAPRAS guidelines,[13] if the patient is mildly allergic to penicillin, intravenous cefuroxime 1.5 g three times daily can be used. A tetanus booster should also be given, and—depending on the nature of the contamination—tetanus immunoglobulin may also be warranted.[14]

Wound review in the emergency department is necessary to identify the degree of contamination. Gross contamination can be removed, but do not perform definitive irrigation in this setting. The wound should be photographed after obtaining patient consent. The wound should then be covered with saline soaked gauze and covered with an impermeable film to prevent desiccation.

In the emergency department reduction and stabilisation of the fracture in a splint under effective analgesia and, if appropriate, sedation, help minimise bleeding, protect against further soft tissue injury, and manage pain. Effective analgesia can include oral, intranasal,[15] and intravenous paracetamol or non-steroidal anti-inflammatory drugs,[16] opioids, or nerve blocks.[17 18]

Neurovascular examination should be carried out before and after the manipulation.

Radiography should also be performed. If there is any sign of neurovascular compromise, carry out reduction before imaging. Post-reduction radiographs are also needed. Anterioposterior and lateral radiographs of the injured limb are required (fig 2).

Fig 2 Anterioposterior radiograph of the left leg showing a comminuted fracture of the midshaft of the tibia and a transverse fracture of the fibula at the same level

The patient should be reassessed and referred to plastics and orthopaedic surgeons for definitive management.

3 How should this patient be managed definitively?

Short answer

Early debridement, skeletal stabilisation, and soft tissue reconstruction with antibiotic cover until soft tissue closure or 72 hours after the injury occurred.

Long answer

Antibiotics should continue until soft tissue closure or 72 hours after the injury occurred, whichever is sooner.[19]

Early accurate and meticulous debridement of traumatic wounds is the most important surgical procedure in the management of lower limb fractures.[20] This includes excision of all dead and devitalised tissue, including degloved and contaminated skin, as indicated by thrombosed subcutaneous veins. Further exploration of muscle and bone is required, with excision of all tissue except for neurovascular bundles. Irrigation of the wound is essential, although the best type of fluid to use remains controversial. Some early data suggest that low pressure irrigation may decrease the reoperation rate for infection, wound healing problems, or non-union.[21] Once debrided, these wounds can be temporised with a vacuum assisted dressing.[22] After debridement a fasciotomy may be considered.

Godina and Byrd's work led to a paradigm shift in the timing and type of wound coverage for open fractures.[19 23] Their work shifted the focus from allowing wounds to heal with temporary fixation to immediate or early (within 72 hours) wound coverage using aggressive debridement, early definitive internal fixation, and wound coverage with muscle flaps. This has been called "fix and flap."[24]

One stage internal fixation with a locked intramedullary nail and reconstruction can be used to stabilise these fractures if contamination is minimal and soft tissue coverage is achieved at the same time as the implant is inserted, because delayed cover leads to unacceptably high infection rates.[25]

To reduce the chance of infection, temporary external fixation to hold the fracture in place is recommended if definitive stabilisation and immediate wound cover are not carried out at the time of the primary debridement,[26] with internal fixation achieved at a later stage.

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Box 1 AO soft tissue classification

Closed skin lesions (IC)

IC 1: No skin lesion

IC 2: No skin laceration, but contusion

IC 3: Circumscribed degloving

IC 4: Extensive closed degloving

IC 5: Necrosis from contusion

Open skin lesions (IO)

IO 1: Skin breakage from inside out

IO 2: Skin breakage from outside in <5 cm, contused edges

IO 3: Skin breakage from outside in >5 cm, increased contusion, devitalised edges

IO 4: Considerable full thickness contusion, abrasion, extensive open degloving, skin loss

IO 5: Extensive degloving

Muscle and tendon lesions (MT)

MT 1: No muscle injury

MT 2: Circumscribed muscle injury, one compartment only

MT 3: Considerable muscle injury, two compartments

MT 4: Muscle defect, tendon laceration, extensive muscle contusion

MT 5: Compartment syndrome or crush syndrome with wide injury zone

Nerve and vessel lesions (NV)

NV 1: No neurovascular injury

NV 2: Isolated nerve injury

NV 3: Localised vascular injury

NV 4: Extensive segmental vascular injury

NC 5: Combined neurovascular injury, including subtotal or even total amputation

External fixation can be used for proximal tibial fractures that are difficult to align properly with an intramedullary nail, severely comminuted fractures that are difficult to align for reaming and nailing, and tibias with narrow intramedullary canals.[27]

All open fractures must be definitively covered with vascularised soft tissue as soon as feasible on a scheduled plastic surgery list after adequate preparation of the patient, including angiography or computed tomography as indicated. Ideally, this should be done within 48 to 72 hours but, at most, within seven days of injury. Any delay beyond this, despite dressing with vacuum assisted devices, is associated with a significant increase in deep infection rates.[25] Low energy fractures are covered by local fasciocutaneous flaps as long as the vascularity has not been compromised by the zone of injury and degloving. Diaphyseal fractures with periosteal stripping are best covered by muscle flaps. Such flaps must conform to the defect, eliminate dead space, and bring important cellular and humoral elements to the healing process.[28] These can be local flaps or free flaps depending on the site of the injury and donor site morbidity. They can be used with or without skin grafting as required.

4 When should definitive management be carried out?

Short answer

If the patient is in a specialist unit, on the next scheduled joint orthoplastic surgery list unless there is severe contamination. If in a non-specialist unit, primary debridement with or without fracture fixation should be carried out on the next scheduled orthopaedic list in discussion with the local plastic surgery unit.

Long answer

Multiple debridements are more likely to result in deep infection.[12] Primary wound debridement, excision, skeletal stabilisation, and soft tissue coverage should therefore ideally take place in a specialist centre. The procedure should be carried out by a team of experienced orthopaedic and plastic surgeons on a routine trauma emergency list within 24 hours. Because this is often not possible, the timing of debridement and type of fracture fixation must be discussed with the local plastic surgery unit to arrange appropriate plastic surgical support during the primary debridement or timely transfer for soft tissue cover within seven days, but ideally within 48-72 hours.

BAPRAS and BOA guidelines state that debridement can wait until the next day unless any of the following factors are present[12]:

- Gross contamination of the wound:
  - Marine contamination
  - Agricultural contamination
  - Sewage contamination
- Compartment syndrome
- A devascularised limb
- Multiple injuries.

Pedestrians struck by motor vehicles with lower extremity fractures have a high incidence of concomitant spine, chest, or intra-abdominal injuries.[29] These areas should be repeatedly assessed for deterioration and, if deterioration is found, urgently referred to general surgeons.

5 What specific complications would you expect with this injury?

Short answer

Neurovascular compromise, compartment syndrome, infection, delayed union, non-union, and limb loss.

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Long answer

Complications may be classified as early, intermediate, or late (box 2)

It is imperative that devascularised limbs are identified and recognised as a surgical emergency. Absent pulses should be attributed to a vascular injury and not vasospasm, and urgent vascular referral and exploration are warranted. Ideally, circulation should be restored within three to four hours of the injury, after which muscle necrosis begins to occur.[12] The maximum acceptable delay is six hours of warm ischaemia time. Capillary refill in the toes can be misleading and, if the circulation is not normal compared with the contralateral limb, the threshold for exploration should be low. Angiography should not delay surgical intervention, and the level of the injury should be assumed to be at the fracture site.

Compartment syndrome is an orthopaedic emergency and must be diagnosed and treated promptly. Disproportionate pain, which does not respond to analgesia and is worse on passive stretch, is the most important sign. A high index of suspicion is needed in all patients with tibial shaft fractures. In a patient with altered consciousness, compartment pressure measurements may be warranted, and a difference of 30 mm Hg or less than the diastolic blood pressure is the threshold for surgical decompression.[30]

The most common long term complications in open tibial shaft fractures are infection and non-union. Infection rates of open tibial fractures have been reported to be between 21.1% and 45.7%, depending on severity of injury according to the Gustilo-Anderson grading system.[31] With the use of early antibiotics and debridement rates are falling.[32] Open tibial fractures have a high incidence of non-union owing to loss of blood supply, the presence of infection, or inadequate fixation.[33] The time to union typically takes three to six months, after which treatment will depend on the cause of non-union.[34] Septic non-unions will need more aggressive treatment of infection,[35] hypertrophic non-union will require improved stabilisation,[36] and atrophic non-union will need bone grafting or further reaming to stimulate bone formation.

Limb loss may occur as a result of severe soft tissue trauma, neurovascular compromise, compartment syndrome, or infection (such as gangrene or osteomyelitis).

Patient outcome

Our patient promptly underwent surgical debridement and internal fixation under the care of the orthopaedic and plastic surgeons. He was found to have a Gustilo-Anderson type 3b defect. Definitive tissue repair was carried out at the same time with a free latissimus dorsi flap reconstruction and skin graft after intramedullary nail fixation (fig 3).

Fig 3 Intraoperative photograph of the left leg after debridement and gastrocnemius free flap and meshed skin graft reconstruction

After fixation he remained in bed for 24 hours and gradually mobilised with physiotherapy. He continued on intravenous antibiotics for 48 hours and was discharged to rehabilitation five days later with no complications. He was followed up for one year, by which time he had recovered function. The fracture healed with no complications (fig 4).

Fig 4 Anterioposterior radiograph of the left leg, four months after surgery, showing a united tibia and fibula after intramedullary nailing

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Box 2 Classification of complications

Early (0-1 week)

- Neurovascular injury
- Compartment syndrome

Intermediate (1-4 weeks)

- Inadequate debridement
- Haematoma formation
- Infection
- Flap necrosis
- Compartment syndrome

Late (more than 1 month)

- Delayed union or non-union
- Osteomyelitis
- Failure of fixation

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Table

Table 1| Gustilo-Anderson classification system of fractures

Characteristic	Type 1	Type 2	Type 3a	Type 3b	Type 3c
Wound size	<1 cm	>1 cm	<10 cm	>10 cm	Any size
Contamination	Clean	Moderate			
Soft tissue injury	Minimal	Minimal	Crushed tissue	Extensive	Extensive
Fracture pattern	Simple	Moderate comminution	Segmental with displacement		
			Diaphyseal segment loss		
			Gunshot wound		
Soft tissue coverage	Adequate	Adequate	Adequate	Inadequate—plastic surgery needed	Possible amputation needed
Vascular injury	None	None	None	None	Present

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