15 Ballistic Injuries

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Ballistic injuries to the face are uncommon in civilian practice, but the increased military activity in Iraq and Afghanistan, together with terrorist events has led to a number of cases being treated in centres throughout the UK.

Although the classic military ballistic injury is produced by the high-velocity round, the vast majority of cases today are from explosive devices, commonly the improvised explosive device (IED). Published data show that IEDs and other explosive devices accounted for 61 % of ballistic injuries in UK casualties injured in Afghanistan, with only 8 % being due to gunshot wounds. These mechanisms therefore differ from civilian causes of facial trauma in the amount of high-energy transfer to the tissues and the extent of contamination. The use of body armour has led to protection of the abdomen and torso, while the face, neck and limbs still remain relatively exposed. Consequently, patients injured by explosive devices often have multiple injuries, which can have a significant impact on their overall management plan and reconstructive options.

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15.1 Why Are Ballistic Injuries Different?

Blunt trauma to the facial skeleton tends to produce relatively predictable patterns of fracture. In the mandible, linear fractures occur, with comminution occurring only in high-energy injuries. In the maxilla, fractures follow the relatively common patterns, such as those described by Le Fort—often the higher the impact force, the higher the level of fracture. Furthermore, with most blunt trauma soft tissue loss and gross contamination is unusual.

In contrast, however, gunshot or shrapnel injuries transfer a lot of energy and blast effects deep into the tissues. Ballistic injuries differ from most other facial injuries, therefore, in a number of important respects (see Table 15.1 and Fig. 15.1).

Table 15.1 Key differences between ballistic and nonballistic injuries

Ballistic injuries are often dirty and heavily contaminated
There may be associated burns produced by the heat wave
With ballistic injuries there is often extensive soft tissue disruption and possible avulsion of tissue
Fractures do not follow the typical patterns seen in civilian injuries. They are often comminuted and may be associated with hard tissue loss
Transmission of the blast effect through the tissues may produce tissue damage distant form the injury

Fig. 15.1 Extensive soft tissue injury from blast. Note the charred facial hair due to heat exposure. A well-vascularised and relatively clean wound may be considered for closure after initial decontamination

15.2 Initial Assessment and Management

As in all polytrauma, management of the airway and rapid control of haemorrhage are the early priorities.

The commonest cause of early death in patients with ballistic injuries is airway compromise. Airway obstruction may result from a number of factors. Bilateral fractures or comminution of the anterior mandible may lead to loss of tongue support, while maxillary fractures can collapse and displace backwards and downwards along the skull base. Both scenarios carry a greater risk to the airway if the patient is supine. Coexisting head injury, alcohol or administration of opiates (either recreational or for pain relief) can compound the problem further. The airway can also be obstructed by foreign bodies, notably teeth, bone and prostheses (see Fig. 15.2). With the passage of time oedema will become an increasing problem.

All these factors may be exacerbated by a reduced level of consciousness or coexisting airway burns. Injury or bruising to the neck may indicate laryngeal damage.

When such injuries occur, a decision regarding the need for a surgical airway will be required quickly. Data from Vietnam reveals that 17 % of facial injuries required tracheostomy, while in a US level 1 trauma centre, 21 % required tracheostomy for civilian gunshot wounds. Throughout this airway management, cervical spine protection is mandatory.

Failure of a patient to respond to fluid resuscitation, in the absence of visible active bleeding, should alert the clinician to occult (hidden) bleeding elsewhere. Small penetrating injuries can be easily overlooked. They can also be a significant distance from a site where major internal haemorrhage is actually occurring. A thorough examination of the entire body surface and immediate imaging of the large body cavities is therefore necessary in these "nonresponders" (to fluid challenge).

External bleeding can normally be controlled by packing or haemostasis of vessels in the area. Where bone fragments are widely displaced, these should be reduced and temporarily stabilised. Penetrating neck injuries may require neck access and ligation or repair of major vessels. Very occasionally penetrating vessel injury in the upper part of the neck (often referred to as "level 3") may require an osteotomy of the mandibular ramus for adequate access (see Fig. 15.3).

It is also important to be aware that ocular and ear injuries are commonly seen in ballistic injuries and can be easily overlooked. Bilateral orbital blow-out fractures have been reported in victims of blast injury, including cases where there has been no direct impact on the globe or surrounding orbital rim.

Fig. 15.2 Large metallic shrapnel fragment at the skull base producing airway obstruction

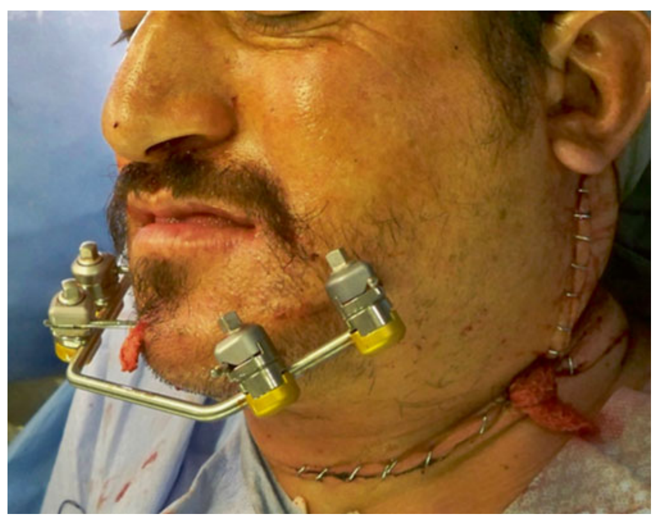

Fig. 15.3 The use of a proprietary wrist fixator (Hoffman 11 Compact, Stryker) for fixation of a comminuted fracture of the mandible. Note the neck access to control bleeding from the jugular vein which required ligation. The rifle round entered at the mandibular symphysis and exited the left neck

15.2.1 Initial Management of Ballistic Injuries

It is well recognised from historical records from previous conflicts that wound debridement and decontamination is the foundation of successful outcome in these cases. Failure to do this will result in poor outcomes despite the use of the most sophisticated forms of reconstruction. It was also recognised as early as the U.S. Civil War that it was not necessary to aggressively débride all damaged tissues in the face. If tissue can be retained it should be and revisited a day or so later to check its vitality. Such a conservative approach would not be possible in other parts of the body.

Prior to treatment it is essential to have a thorough appreciation of the extent of the tissue damage. Today imaging should include computed tomography (CT) scanning and three-dimensional (3D) reconstruction, together with any relevant models. It is also important to know the location of any rounds or projectiles which are still present within the tissues. Identifying their track through the tissues from the point of entry gives an indication about which structures could have been damaged en route.

General management of the wound forms the mainstay of successful treatment (see Table 15.2).

Heavily contaminated wounds may require serial debridement and packing. However, experience has shown that in the maxillofacial region, because of its excellent blood supply, early definitive soft tissue closure may be undertaken in less contaminated wounds. This requires careful judgement. Any soft tissue primary closure should be tension free and if uncertainty exists about the tissues, drainage should be instituted.

In some cases early reconstruction may be undertaken following wound debridement and decontamination. However, where there is any doubt about the viability of tissues it is better to wait 48 h for nonvital tissue to declare itself. This is sometimes referred to as a 'watch and wait policy.' The case shown demonstrates the management of a contaminated facial wound in an infant where definitive closure and fixation was delayed following thorough cleaning to ensure tissues were in the optimum state (see Figs. 15.4, 15.5, 15.6 and 15.7).

Table 15.2 Management principles in ballistic injuries

Thorough irrigation of contaminated tissues
Soft tissues with dirty wound edges should be gently but thoroughly scrubbed to prevent tattooing. Foreign bodies (if accessible) and detached bone fragments and teeth should be removed
If possible, periosteal stripping should not be undertaken
Identify and mark important structures such as branches of the facial nerve and the salivary ducts. These can be repaired later
Although antibiotic therapy is important, it is no substitute for thorough mechanical cleaning
Tissue defects can be temporarily packed

Fig. 15.4 An infant with a heavily contaminated fragment injury of the face. The early priority in this case is to decontaminate the wound prior to any consideration of definitive treatment

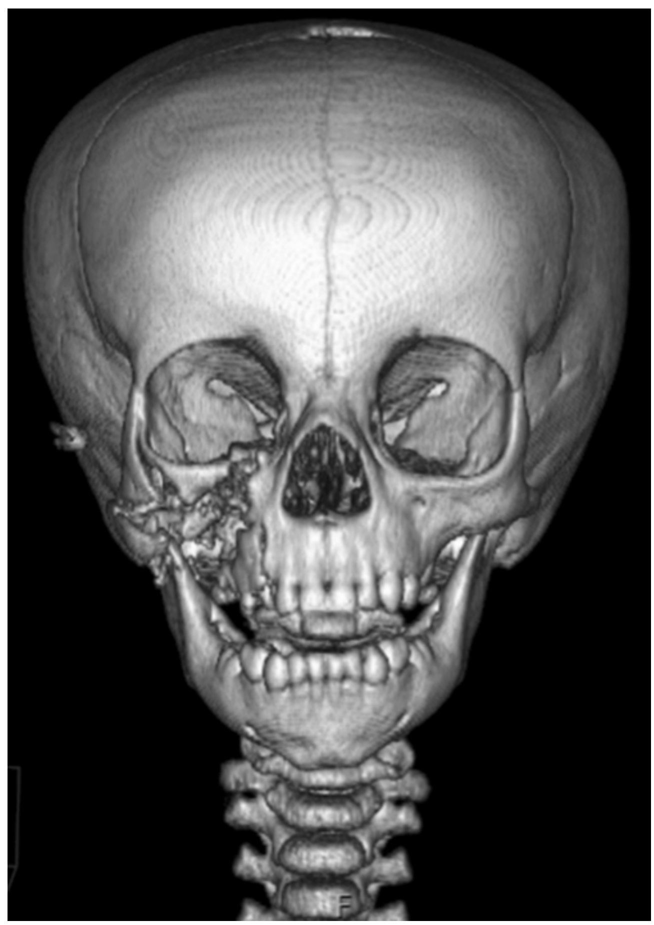

Fig. 15.5 CT scan showing the bony injury. Note the vertical split in the body of the zygoma

In cases where delayed definitive treatment is undertaken, temporary stabilisation of the bone fragments by a combination of interdental wiring, intermaxillary fixation (IMF) screws, conventional IMF, and external fixation will improve the patient's pain control and maintain alignment of the main fragments until definitive fixation is undertaken.

Fig. 15.6 Closure of the soft tissue wound 48 h after initial cleaning and dressing. Note that despite the initial appearance soft tissue loss is not extensive

Fig. 15.7 Radiograph showing the completed fixation

15.3 Repair of Ballistic Injuries

Contemporary management of maxillofacial injuries is based on the techniques of open reduction and internal fixation discussed elsewhere in this book. Those principles relating specifically to the management of ballistic trauma will be discussed further. It has previously been suggested that all fixation will eventually fail and that fracture healing is 'a race between bone healing and fixation failure.' We must, therefore, use fixation that provides 'adequate stability,' without overengineering and compromising healing.

Successful repair or reconstruction depends on the thorough understanding and appreciation of the increased damage to the hard and soft tissues, compared with conventional blunt trauma. Where fractures are comminuted, or involve loss of bone, or do not follow conventional fracture patterns, miniplate osteosynthesis is more likely to fail. This is because the typical tension and compression lines (described by Champey and others) are not present and the bone itself is unable to support any loading (referred to as "load sharing"). Consequently, in the early stages of healing all the displacing forces across the fracture site have to be supported entirely by the plates ("load bearing"). More substantial internal fixation should therefore be used. This typically involves the use of heavier plates. The authors' preference is for locking plates as these are reported to have a greater ability to withstand increased loading. However, the surgeon needs to be versatile in the approach, utilising other forms of fixation such as lag and positional screws as required.

Sequencing the repair of facial fractures is discussed in other parts of this book. The aim is to reconstruct the face in three dimensions, producing the correct height, width and projection of the facial skeleton with particular care to correct the orbital volume, dental occlusion and canthal position.

A sequence illustrating the management of a complex ballistic injury treated by wound debridement, second look and subsequent definitive open reduction and internal fixation 48 h later, is shown in Figs. 15.8–15.13.

Fig. 15.8 Extensive injury from high-velocity round. Note the small entry wound and large exit. The wound comprises both hard and soft tissue injury

Fig. 15.9 CT scan showing extent of bony injury

Fig. 15.10 Appearance after initial debridement and soft tissue repositioning. Note how nonviable areas are becoming perfused, enabling an improved decision on what tissues can be retained

Fig. 15.11 Fixation of the fracture with combination of load-bearing and load-sharing fixation

Fig. 15.12 Radiograph of injury treated by open reduction and internal fixation. Note the combination of locking reconstruction plate, miniplate and lag screw utilized to attain optimum stability

Fig. 15.13 Patient 2 months later showing reasonable cosmetic result

In some cases, an excessive degree of periosteal stripping would be required in order to securely plate some of the fragments. This risks devitalisation of small or comminuted fragments and their subsequent loss. In addition, any extended surgical access required would produce further trauma and scarring in already damaged tissues. In such cases, the use of IMF and external fixation can prove an effective and relatively simple way of treating these injuries definitively.

Experience has shown there is still a place for these techniques in the early stages of care prior to definitive treatment. The basic principle of external fixation involves the insertion of transosseous pins either side of a fracture and connection with a rigid rod. Two pins are required on either side of the fracture and in any major fragments for optimum stability. With external fixation, extensive periosteal stripping of viable fragments is not required. It is therefore a useful technique which can retain bone where viability is tenuous. Rods can span multiple fragments and with sufficient pins this provides load bearing fixation.

External fixation systems specifically designed for the maxillofacial region are available. However, if necessary other similar products can be used to achieve the same outcome. The case shown demonstrates a proprietary metal external fixator used to stabilise a comminuted mandibular fracture (see Figs. 15.14, 15.15, 15.16 and 15.17).

Fixators specifically designed for the maxillofacial region are available and some are composed of titanium rather than steel. This has the advantage of enabling magnetic resonance imaging (MRI) scans to be undertaken if required. The case shown shows how an external fixator can be made using easily available materials.

15.3.1 Management of Tissue Loss

Management of tissue loss can be extremely challenging. If bony union is to be successful there has to be adequate bone to bone contact and viable soft tissue coverage. The options to replace lost "hard" tissues (bone) are to use autogenous or alloplastic materials, or sometimes a combination of the two. In head and neck cancer surgery, much experience has been gained in microvascular free tissue transfer in the reconstruction of posterior sited defects following resection. Flaps such as the radial forearm, lateral thigh, fibula, deep circumflex iliac artery (DCIA) and scapula form part of the

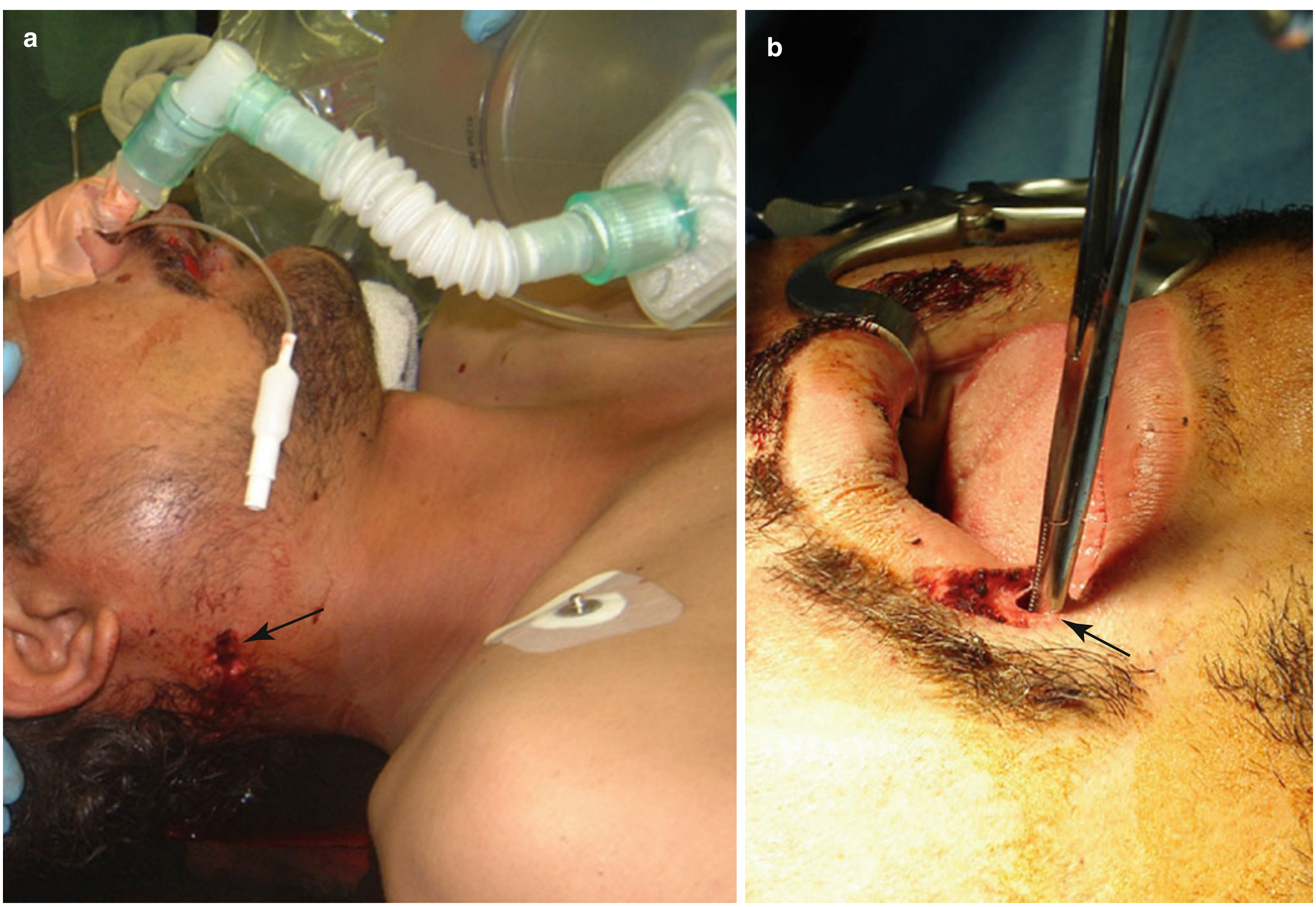

Fig. 15.14 High-velocity gunshot injury. Note the small entry (lip) and exit in the neck

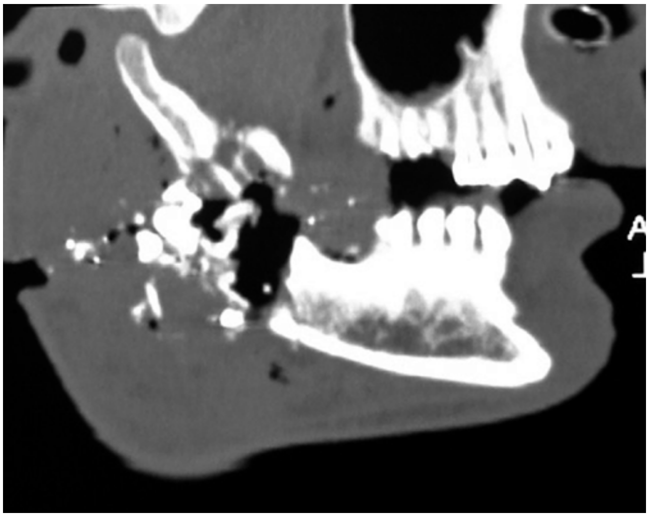

Fig. 15.15 CT scan showing extent of internal bony disruption

Fig. 15.16 Transosseous bicortical pins are inserted into the major fragments of the mandible. Aim for at least two pins in each major fragment and one or more in each sizable intermediate fragment

Fig. 15.17 A piece of plastic tube such as an ET tube or chest drain is cut to length and holes cut to accommodate the ends of the pins. The tube is then pushed over the pins and the tube filled with acrylic resin inserted with a large-bore syringe. The tube may be secured with wire or some other locking device if required

Table 15.3 Reconstructive principles in ballistic injuries

It is imperative that the tissue bed is viable and free of contamination or infection
Experimental evidence suggests that blast injury can affect the intima of vessels. This may propagate some distance from the wound, adversely compromising the local vasculature. This effect is thought to resolve over approximately 1 week. If doubt exists, angiography or some other vessel imaging is recommended to assess the presence and patency of vessels
Patients subject to blast injury are often extremely sick and this may impact on the complexity and length of surgery they can withstand in the early stages
There may be coexisting injuries to anatomical sites normally used to harvest flaps (e.g., limbs, hip). This may preclude the use of a preferred flap
There is still some controversy on the timing of definitive reconstruction. There is little doubt that delayed reconstruction leads to increased wound contracture, but immediate reconstruction must be tempered by the issues discussed above if a successful outcome is to be achieved

armamentarium of many reconstructive surgeons. Each of these flaps has particular qualities. Selection of the flap is therefore tailored to the particular defect.

Prior to complex reconstruction there are a number of issues particular to ballistic injuries that are worthy of note (see Table 15.3).

Ideally autogenous reconstruction should be the surgical aim. However, prostheses can prove to be useful temporary or permanent options for reconstruction. This is especially the case in areas such as the nose or ear where aesthetically good reconstruction is technically difficult. Titanium implants have revolutionised the retention of these prostheses.

Suggested Reading

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