

# The face of war: The initial management of modern battlefield ballistic facial injuries

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## Abstract

There is an increased incidence of maxillofacial trauma in conflicts of the 21st century in comparison to those of the 20th century. This is attributed to the asymmetrical nature of modern war with the increased use of improvised explosive devices and improved thoraco-abdominal protection provided by current body armour.

This paper aims to briefly review the principles of the initial management of modern battlefield ballistic injuries. The opinions given in this paper are those of the authors and not necessarily those of the UK MoD.

## Introduction

The head and neck region accounts for 12% of the total body surface area. Despite this, head and neck injuries are seen in over 20% of battlefield casualties in 21st century conflicts.<sup>1,2</sup> In comparison, in the 20th century around 16% of battlefield injuries involved the head and neck.<sup>3,4</sup> This is most likely due to a decrease in thoraco-abdominal injury due to the effectiveness of current body armour in combination with the increased incidence of improvised explosive devices. In the most recent British Oral and Maxillofacial Surgery Cadre deployment in Afghanistan in 2008/2009, over 50% of military oral and maxillofacial injuries were due to improvised explosive devices (IEDs) and the majority of gunshot wounds were from high velocity rounds.<sup>5</sup>

Ballistic wounds have been traditionally divided into low and high velocity injuries<sup>6</sup> and blast injuries. However, the amount of energy exchanged to tissues is more important than the projectile's velocity. The energy exchanged to tissues depends on many factors including: projectile design, velocity, mass and flight, the distance to the target, the tissues hit and the protective barriers. Blast injuries are frequently multiple and in addition to injuries from projectiles, casualties often have blast, burn and blunt trauma wounds.<sup>7</sup>

The majority of trauma seen by surgeons in hospitals in the Western World is due to blunt trauma or low energy exchange penetrating trauma from knives and hand guns. The management of these injuries is well described and early definitive surgery with the use of plating techniques is advocated.<sup>8</sup> In contrast, the high energy exchange trauma seen in Afghanistan is frequently extensive and heavily contaminated with comminuted displaced fractures and tissue avulsion.<sup>5</sup> The management of these injuries, often in an austere environment, presents even greater challenges.

## Emergency management

The emergency management of battlefield trauma has been refined over the past decade.<sup>9</sup> All military patients are assessed for control of catastrophic bleeding prior to airway, breathing and circulation management. Polytrauma is the predominant form of battlefield injury and catastrophic blood loss is the leading cause of preventable death. Neck wounds can cause life threatening blood loss. However, the primary cause of death in head and face injuries is airway compromise.<sup>10</sup> The airway is at particular risk in unconscious patients with facial injuries. In an emergency a cricothyroidotomy may be required if airway manoeuvres or endotracheal intubation fails. A definitive endotracheal airway or a surgical airway should always be considered for patients with severe ballistic facial injuries. During evacuation, a temporary airway may be dislodged and patients may require a definitive surgical airway for frequent operations or postoperative care. Patients with facial burns must be assessed for airway damage and a definitive airway established before swelling ensues and the airway is lost.

Clinicians should have a high index of suspicion of haemo or pneumothorax in penetrating neck wounds. Haemorrhage from the face, although relatively rare, can be managed by pressure (e.g. nasal packing), diathermy, fracture reduction and immobilisation, suturing, embolisation of the bleeding vessel or tying of the external carotid artery.

Once casualty room emergency interventions are done the patient is assessed for emergency surgery for resuscitation and initial stabilisation. The concept of damage control resuscitation and surgery applies to all severely injured oral and maxillofacial surgery patients. Damage control resuscitation aims to prevent the lethal triad of hypoxia, acidosis and coagulopathy

by permissive hypotension and haemostatic resuscitation.<sup>11</sup> The physiological insult of surgery is limited by carrying out the minimum amount of surgery in the shortest time to stabilize patients and prevent infection.<sup>12,13</sup> Definitive surgery is delayed until the patient's condition has been optimized. Maxillofacial damage control surgery is restricted to tracheostomy, the arrest of haemorrhage, initial wound debridement, simple reduction and immobilisation of fractures and sight saving procedures such as lateral canthotomy.

### Assessment of facial injuries

A clear diagnosis of the extent of facial injuries should be made once the patient has been resuscitated and stabilized. This involves complete clinical and radiographic examinations. However, an assessment of the occlusion may be difficult in the orally intubated patient. Plain films give basic information on the site and displacement of facial fractures and show fragments within soft tissues without artifact scatter. Computed Tomography (CT) imaging can be invaluable and is available in many established Western Conflict Hospitals (Figure 1) but not all.



*Figure 1. 3 D CT of high energy exchange damage to midface from a high velocity round.*

When available, three dimensional CT images allow the clinician to perceive injuries in an easily understood format and are good at showing the extent of hard tissue, and to some extent soft tissue damage, and the displacement of fragments and shrapnel. However, unless the CT cuts are fine, minimally displaced fractures may infill and may not be identified radiographically. Vascular imaging may also be required to assess damage to major vessels.

A full evaluation of soft and hard tissue damage and soft and hard tissue loss should be made. If teeth have been avulsed then they should be accounted for. If they are displaced into the airway they may compromise the airway. If displaced into the sinuses or soft tissues they may cause infection later.

### Treatment of facial injuries

The modern initial management of ballistic injuries depends on two key factors. Firstly, the surgeon must analyse the mechanism and amount of energy exchanged to the injured tissues. Secondly, treatment of facial injuries must be undertaken in the context of the overall number and severity of injuries sustained by the patient.

A high velocity round that strikes dense bone in the face will exchange much of its energy. The secondary projectiles of shattered bone and the tumbling of the round can cause further severe damage beyond its path and an avulsive exit wound. However, if the high velocity round has been fired at a distance it will impart less energy to the tissues. Hence, the effects may be similar to a low velocity round, namely, a penetrating wound with damage mostly confined to the missile tract. High energy exchange wound margins may take 5 days to declare themselves.<sup>14,15</sup> These injuries, therefore, do not lend themselves to early definitive treatment. In contrast, low energy exchange wounds, if adequately cleaned, can be successfully treated early.

The priorities of battlefield surgical treatment are to save life, eyesight and limbs and then to give the best functional and aesthetic outcome for other wounds. The treatment of facial injuries must be undertaken in this context and take into account the principles of damage control surgery.

Later definitive and reconstructive surgery will be greatly influenced by the initial surgery done. Hence, thought should be given at early operations as to the likely nature of the final surgery required. Obtaining early wound closure in areas of tissue loss or the injudicious removal of potentially compromised bone or soft tissues may lead to collapse and scarring. This may make subsequent treatment more difficult. Surgical judgment is required as to the amount of soft tissue and bony debridement that is initially required to adequately clean tissues and prevent infection, and what early definitive treatment can be done to give the best final form and function.

Battlefield casualties often have multiple injuries to different body sites. These injuries are frequently severe (Figures 1 and 2).



Figure 2. Severe ocular injuries from shrapnel in a patient not wearing eye protection.

Teamwork is important to ensure optimal results. In the head and neck, neurosurgeons, oral and maxillofacial surgeons, plastic surgeons, ophthalmic surgeons and otolaryngology surgeons can exchange knowledge and surgical expertise.

### Soft tissue injuries.

Ballistic facial injuries are often heavily contaminated and frequently burned. Early adequate debridement is advocated to minimize infection and subsequent tattooing and scarring.<sup>14</sup> This may involve the use of scrubbing brushes, pulsed lavage and copious irrigation. CT scans should be fully evaluated to identify foreign bodies and these should be meticulously removed. Surgical dermabrasion with a scalpel blade can be used to remove all debris that may cause subsequent wound tattooing which is difficult to correct when established. The use of diathermy should be judicious rather than extensive. Although cleaning must be thorough, any tenuous blood supply to tissues should not be compromised by aggressive handling or periosteal stripping of bone. As facial tissues are so well vascularised, tissue should be preserved wherever possible. If in doubt about the cleanliness and viability of wounds, they should be packed open with ribbon gauze and antibacterial agents. They should then undergo serial debridement until judged able to be closed. Only wounds that have no gross contamination or deep extension should be closed primarily. Deep wounds should be explored on the operating table with facilities for surgical vascular control if required. Anastomosis of nerves and salivary ducts should be done as soon as is practical. When soft tissue facial wounds are ready to close, well designed local rotational flaps can often be used to close mild to moderate skin defects. However, the rotational flap should not compromise the blood supply to a larger soft tissue flap that may be required later if the wound breaks down. Prompt evacuation is a

key feature in the management of coalition personnel. Procedures such as soft tissue flaps and nerve repairs that are not essential aspects of damage control surgery are often undertaken within a few days, on return to the patient's home country.

Tetanus prophylaxis should be given if the patient is at risk and broad spectrum antibiotics given. Infection with unusual pathogens such as *A baumannii* has not proved a problem in facial injuries.

### Facial fractures

Providing the soft tissue environment around the facial fracture is favourable, blunt and simple low energy exchange ballistic fractures can be managed by conventional open reduction and internal fixation plating techniques. However, primary reconstruction with bone plates and screws in the austere combat environment often yields poor results with subsequent soft tissue infections and plate exposures.<sup>7</sup> Where the soft tissue environment is not favourable and with moderate to high energy exchange ballistic trauma, serial debridement of wounds will be required and plating techniques are generally contra-indicated. Once wounds are infection-free and the viability of tissues has declared itself, plating techniques can be used.

Conventional techniques of external pin fixation or intermaxillary fixation (IMF) can be used to reduce and hold most facial fractures in their anatomical position. IMF is useful for most mandibular and low level maxillary fractures. Pin fixation can be used for most facial fractures, often in conjunction with IMF. The adequate stabilization of facial fractures is necessary to prevent collapse and fibrosis that is so difficult to treat once established. IMF or placement of an external fixator by a closed technique does not require wide periosteal stripping at the fracture site that may compromise the bony blood supply, introduce infection and displace comminuted bone. No foreign body is introduced at the fracture site. IMF with arch bars or intermaxillary screws<sup>16</sup> is often an effective treatment but compromises the patient's airway. Special precautions for the release of fixation are required during patient evacuation. With external fixators, the mouth can be opened during fracture healing. Hence, oral hygiene and patient nutrition are improved and trismus due to fibrosis and scarring is reduced. Any soft tissue or bony defects may continue to be debrided with the fixators or IMF in place.

### Further management

The definitive management of complex ballistic facial injuries is best undertaken by multidisciplinary teams in hospitals specializing in this care. Adequate nutrition and good oral hygiene are essential. Physiotherapy and

physiological support may also be required. Definitive treatment and reconstruction may include rotational flaps, bone grafts, free flaps, distraction osteogenesis, implants or prosthesis. However, the correct early management of facial ballistic injuries is crucial in achieving the best possible surgical outcomes.

### Conclusions

Battlefield ballistic injuries present a unique challenge to facial surgeons. The facial surgeon should have a low threshold for providing a surgical airway in ballistic facial injuries and be assiduous in the prevention of blood loss. An appreciation of the energy exchanged to facial tissues and the overall condition of the patient is

essential in the early treatment phase. If the viability of tissues is in doubt they should be packed open and serially debrided. IMF and external fixation techniques have found a new prominence in the treatment of ballistic facial fractures. Teamwork and good surgical planning are required to ensure optimal results.

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