

# Maximising outcomes for maxillofacial injuries from improvised explosive devices by deployed health care personnel

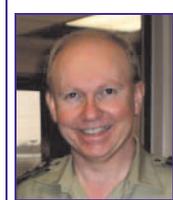
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WITH EXPERIENCE IN TREATING 5958 maxillofacial battle injuries in 2558 battle casualties over 6 years in Operation Iraqi Freedom and Operation Enduring Freedom in Afghanistan, the United States Army has developed a wound management protocol for maxillofacial injuries that maximises the functional and aesthetic outcomes for victims of improvised explosive devices (IEDs), rocket propelled grenades and ballistic injuries.<sup>1,2</sup> This protocol was developed in response to poor results from conventional civilian trauma management techniques with early casualties from IEDs.<sup>1,3</sup> This was because of the unique wounding

## Abstract

- ◆ Soldiers are now surviving previously catastrophic injuries due to improved body armour and helmets which protect the torso and head while the face remains exposed.
- ◆ Improvised explosive devices (IEDs) possess unique wounding characteristics that can result in devastating maxillofacial injuries.
- ◆ United States Army experience led to the development of a wound management protocol for maxillofacial injuries from IEDs that has greatly improved outcomes for these complex injuries.

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characteristics of IEDs and because better body armour resulted in soldiers surviving blasts so devastating as to have been previously fatal. Several clinical appliances were also introduced, which with the new protocol greatly improved outcomes in relation to facial appearance and jaw function, especially in regard to chewing, mouth opening, swallowing and speech.

In 2004, at one level 3 combat support hospital in Iraq, 46% of battle casualties were due to IEDs.<sup>2</sup> Up to 30% of all casualties now present with facial and neck injuries, although the face, head and neck represent only 12% of total body area. In comparison, an estimated 15% of soldiers who were evacuated for treatment in World War I had facial injuries, and this was in a war where trench warfare had resulted in a relatively greater proportion of facial and head wounds.<sup>4</sup> It has been postulated that, in current conflicts, the unprotected face of a soldier wearing body armour is not only exposed but targeted by the enemy.<sup>5</sup>

These severe facial injuries from IEDs present as an initial wound management problem with a high frequency of serious facial infections, as a later reconstructive surgical problem, and finally as a rehabilitation problem. As in previous conflicts, the quality of initial management is the paramount factor that determines the level of success of the final outcome.

## Pathophysiology of IED facial wounds

IED injuries can be termed avulsion, perforation or penetration fragmentation injuries.<sup>1</sup> IEDs commonly result in devastating facial injuries with significant later surrounding tissue loss because of the primary blast nature of the wounding mechanism, the transfer of large amounts of energy to the underlying tissue from penetrating ballistic fragments, and the secondary ballistic effects of shattered

hard tissue accelerating through the face. These factors cause severe tissue damage well beyond the apparent visible surface margin of the injury and include the vascular structures of soft and hard tissues.

After the first few days, the extent of the wound starts to declare itself, with evolving surrounding tissue wound margin breakdown, dusky margins, necrosis extending to and including the subcutaneous layer, fat necrosis and tissue dieback significantly beyond the initial visible wound margins.<sup>1,6</sup> This tissue breakdown and necrosis may mimic the appearance of an infection.<sup>1</sup> Experience demonstrates that early primary closure of such severe blast injuries will usually fail at around Day 5 post trauma.<sup>1</sup> Subsequent poor wound healing after early closure can lead to greatly increased scarring and later scar contracture, which is the greatest threat to the success of reconstructive surgery.<sup>6</sup> To illustrate the extent of surrounding tissue destruction in ballistic maxillofacial wounds from gunshots, an experimental study by Tan and colleagues found in dogs that necrosis extended as much as 30mm from the apparent wound margin, together with microthrombus formation and vascular endothelial loss.<sup>7</sup>

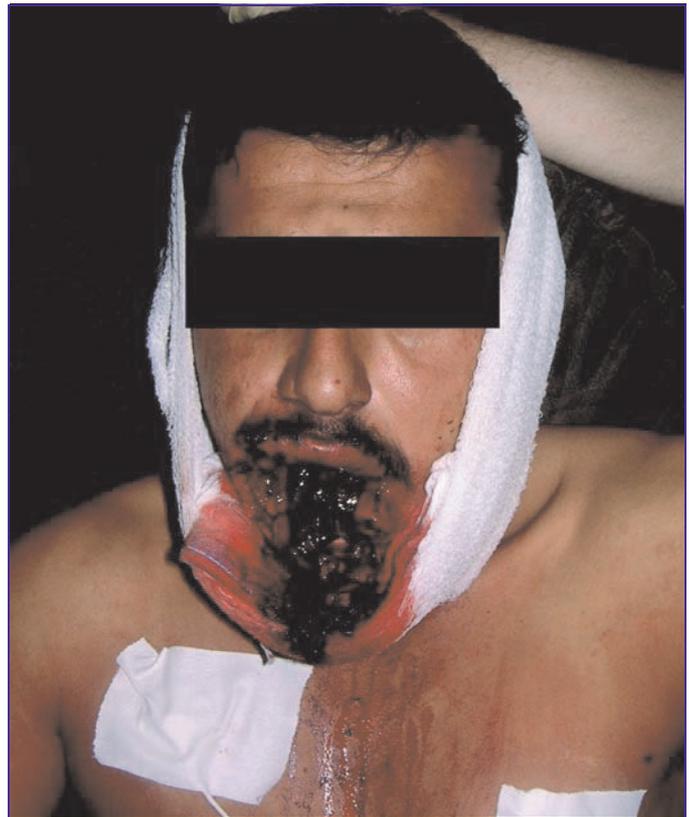
### Principles of management for maxillofacial wounds from IEDs at level 3 health care

In this section, we describe the major aspects of the US Army wound management protocol derived from the volume *The role of the oral and maxillofacial surgeon in wartime, emergencies and terrorist attacks*.<sup>8</sup> We also include practical information gained from our experience in the management of severe facial injuries.

IED injuries are generally multisystem injuries, and a multidisciplinary approach at the very start is vital in maximising wound outcomes. This may involve specialist teams in anaesthesia, trauma surgery, orthopaedic surgery, neurosurgery, oral and maxillofacial surgery, ophthalmology, and ear, nose and throat surgery (if deployed) to produce a comprehensive treatment plan with complete diagnosis of all injuries.

#### Airway management

In accordance with advanced trauma life support (ATLS) principles, management of the airway is the first priority. With facial and neck injuries from IEDs, the main airway threats are airway burns, epistaxis and facial haemorrhage into the airway, fracture displacement impinging airway patency, posterior tongue displacement, foreign bodies such as fractured teeth or secretions obstructing the airway, and laryngeal fractures. Management of these threats, after suctioning the airway, is by providing a definitive airway — either endotracheal intubation or a surgical airway. If multiple operating theatre visits are planned for care of a multiply injured maxillofacial patient, then a tracheostomy should be performed at the initial operation. Cricothyrotomy has an important role in an emergent situation;



*Patients with avulsive mandibular injuries should be nursed upright to promote airway patency. As always, advanced trauma life support principles take precedence in wound management.*

however, it should always be converted to a tracheostomy later for the evacuation phase.<sup>2</sup> All US soldiers are now issued with a nasopharyngeal tube for immediate airway control during the “buddy” phase of combat first aid in response to very recent research on potentially preventable combat deaths.

For an airway burn, the maxim remains “if in doubt, intubate”.<sup>2</sup> An early decision regarding intubation for an airway burn is preferable to a late decision when progressive airway swelling may preclude intubation.<sup>2</sup>

If displaced facial fractures are threatening the airway, manual disimpaction of the fractures may provide temporary airway control, but haemorrhage from fracture manipulation is possible, and provision of a definitive airway remains the mainstay. For a “flail” anterior mandibular fracture causing loss of muscle support for the tongue and resulting airway impingement with posterior tongue displacement, simple temporary circumferential wire fixation of the flail segment will restore tongue support without the need to always progress to a definitive airway.<sup>2</sup> A deep tongue suture attached to a haemostat providing anterior tongue traction may also provide temporary tongue control until a definitive airway can be placed. It is essential not to lie such patients down if they can maintain their own airway patency sitting up, until the anaesthetist, surgeon and the operating team are ready to begin both anaesthesia and



Evolving tissue loss can develop well beyond the initially clinically apparent wound margins seen here. Definitive treatment of avulsive injuries is deferred until the patient reaches the national support base.

possibly an immediate surgical airway. The airway may become obstructed as soon as the patient lies back.

It is important to realise that, because of battlefield and transport conditions, patients often arrive with hypotension, hypothermia and acidosis, and require aggressive resuscitation measures and multiple surgical interventions.<sup>2</sup> These intensive efforts have been rewarded with a 95.5% survival rate for all casualties who reach Echelon III US Army combat support hospitals. In contrast, in World War I, 40% of casualties with facial injuries died after evacuation from the battlefield.<sup>5</sup>

#### **Airway management during prolonged evacuations**

During the possibly lengthy evacuation phase to the national support base, patients' airways may not be closely monitored, so any patient with a possible airway control problem should be formally assessed for tracheostomy before transport. Evacuation can last several days.<sup>1</sup>

#### **Haemorrhage management**

Significant and continuing haemorrhage can result from facial wounds. Local measures to control haemorrhage include direct digital pressure, packing with gauze, ligation with sutures, haemostats or vascular clips, diathermy, haemostatic agents such as Surgicel (Johnson and Johnson Wound Management Ltd, Gargrave, UK), or bismuth iodoform paraffin paste (BIPP) with ribbon gauze packs, and Foley catheters for epistaxis. In the US Army, all combat medics are now issued with HemCon (HemCon Medical Technologies Inc, Portland, Ore, USA), a very effective, albeit expensive, haemostatic dressing for controlling life-threatening haemorrhage.<sup>9</sup> Diathermy should be used with discretion to avoid damage to important structures such as facial nerves and salivary ducts.

Recently available commercial nasal packs are useful for difficult epistaxis not amenable to the usual measures, and are much easier to manipulate than the traditional nasal packing materials. These include the Meroceol Doyle's nasal dressing for anterior packing and the Epistat II nasal catheter (both from Medtronic Xomed Inc, Jacksonville, Fla, USA) for combined anterior and posterior nasal packing. These packs come with instructions for use. These packs should never be left in situ for longer than 72 hours because of the theoretical risk of toxic shock.

Bonewax or Surgicel are useful for "plugging" exposed bleeding vessels within bone. For scalp wound haemorrhage, several simple full-thickness blocking sutures are usually sufficient along the wound/flap margins. If haemorrhage is still troublesome, then folding back the flap of damaged scalp tissue, if feasible, to constrict blood flow to the area can be a helpful temporary measure until operating theatre access is obtained for definitive control.

#### **Soft tissue management**

All fragmentation wounds are regarded as contaminated.<sup>2</sup> This is especially true for wounds from IEDs, which can be packed with dirt, rocks, glass, metal, wood, grass, plastics, dead animal or human bones, or other body parts in the case of suicide bombers — all wounds from IEDs can be considered grossly contaminated.

Antibiotic coverage is indicated for 24 hours on admission. The antibiotic choice can be influenced by the amount of wound contamination and the specific site of injury, along with coverage for *Clostridium* and *Bacteroides* species, which are frequently present and not easy to culture. Battlefield wounds are commonly at risk of *Clostridium tetani* contamination. Tetanus status should be reviewed and tetanus prophylaxis provided if the patient is at risk.<sup>1-3</sup> The latest evidence-based US Army guidelines for preventing infection following combat-related injuries for open maxillofacial wounds is to administer cefazolin (2 g intravenous infusion every 8 hours for the first 24 hours following injury) or clindamycin (900 mg intravenous infusion every 8 hours for 24 hours).<sup>10</sup>

The greatest emphasis in management of facial wounds from IEDs is now given to preserving the injured soft tissues and acting to minimise later scar contracture. The development of significant scar contracture is the single most devastating influence on final facial appearance and jaw function.<sup>1,3</sup>

Preservation of soft tissues is maximised by the earliest possible decontamination of all facial wounds by thorough irrigation and very gentle debridement of foreign bodies. Injured facial and neck soft tissues are maximally preserved to allow for later evaluation about viability at a higher level of care by the reconstructive surgeon. Conservation of damaged tissues at the level 3 facility gives time for the tissues to declare their long-term vitality (or lack). Although preservation of potentially viable attached bone fragments is also important, preservation of all damaged soft tissue is paramount. Soft tissues of the face are much more difficult to replace than other areas of the body and can require



*Primary management principles for avulsive injuries such as this are pulsatile irrigation, debridement and packing, with no attempt at closure.*

complex flaps and/or tissue expansion. Missing bone and teeth can be replaced more easily with bone grafts and dental implants. Nevertheless, periosteal stripping and bone removal are minimised at this level of care. Meticulous debridement of foreign bodies should include all tooth and root fragments embedded in soft tissues. Removal of bone should be limited to very small fragments only.<sup>1</sup>

Thorough irrigation with a pulsatile irrigation system with large quantities of saline is the most effective and expedient method of wound decontamination.<sup>1</sup> Systems such as the disposable battery-powered InterPulse, or SurgiLav (both from Stryker Corp, Kalamazoo, Ind, USA) or Pulsavac (Zimmer Co, Warsaw, Ind, USA) are commercially available and simple to use.

US Army oral surgeons advise that a superior outcome can be achieved with these wounds if initial gross irrigation, debridement and packing are carried out as soon as possible in the emergency room (after primary ATLS management) without waiting for an operating theatre to become available.<sup>1</sup> Early pulsatile irrigation and decontamination is especially important for a good outcome in relation to patient survival if chemical contamination of the wound is suspected. Nevertheless, all patients with facial soft tissue injuries are later routinely taken to the operating theatre for thorough examination of all injury sites, together with pulsatile lavage with copious saline irrigation. Following the lavage, gentle but thorough wound debridement is carried out both with a scrub sponge using the sponge side and with gauze sponges using a diluted povidone iodine antiseptic solution to remove all visible contaminants.<sup>1,2</sup> In the Australian situation, irrigation in the emergency room may not be possible or appropriate, so early transfer to the operating room is crucial to achieve outcomes similar to US Army results.

Such meticulous and repeated cleansing as soon as possible (termed “serial debridement and irrigation” or “D & I”) greatly improves the aesthetic outcome months later. Hypertrophic scarring, infections, scar contracture, unsightly “tattooing”-type skin discolouration, and granulomas due to foreign body retention can all be dramatically

reduced, thereby lessening the need for later surgical revision and laser therapy.<sup>1</sup>

Experience has demonstrated that delayed wound closure for fragmentation injuries together with serial debridement and irrigation of contaminants are most important to minimise later evolving tissue loss. Multiple factors predispose to such tissue loss, and include the compromised underlying tissue from the effects of penetrating high-energy blast injuries, the unclean nature of the battlefield situation resulting in very contaminated wounds, patient compromise related to shock and multiorgan failure, and lack of optimal wound care during a lengthy evacuation to the national support base, which promotes an environment very favourable to later bacterial infection.<sup>3</sup>

Only wounds with no gross contamination and limited deep extension have primary closure. Otherwise, after thorough irrigation, the wound is packed with ribbon gauze (this can be coated with antibacterial agents such as bacitracin-coated iodoform or BIPP). Serial debridement and irrigation are continued until definitive closure becomes indicated. This may involve several operating theatre visits, which can often be conveniently scheduled at the end of other operations frequently necessary in these multisystem trauma patients. Wounds that are deep and penetrating that are difficult to debride effectively are packed with iodoform, BIPP or regular ribbon gauze. Avulsive injuries are similarly packed and left open with no attempt at closure.<sup>1,2</sup>

Thorough exploration of deep wounds is essential to identify any vital structure injuries or severed nerves and salivary ducts. If anastomosis of such structures is not practical at this stage, then the ends of the damaged structures should be tagged to enable identification and repair at the higher level of care, and notes added to the medical record.<sup>1</sup>

No mucosa to skin anastomosis of tissue defects or local flaps are undertaken at this level of care, so that remaining anatomical layers are more readily discernible at the reconstructive surgery stage. A *single* ribbon gauze pack (changed every 12 hours) is placed into deep wounds to enable complete and uncomplicated removal at the higher level of care. Ribbon gauze can be tied together to form a single dressing to pack large avulsive defects (superficial covering wet to dry dressings should also be regularly changed). Sutures should only be used as a tacking measure to secure these packs, and not for closure. (Superficial wounds that are successfully decontaminated should have primary closure with underlying resorbable sutures reapproximating the dermis to enable a tension-free skin closure, and fine nylon sutures for the epidermis with eversion of the skin edges.)<sup>1,2</sup>

The best aesthetic results are achieved through effective and thorough treatment in this initial management phase. A transfer summary should clearly describe instructions for wound management and specify the date for removal of sutures<sup>1</sup> (remove skin sutures from the face within 5 days).

### **Neck trauma**

Neck trauma and spinal injury from blasts are common. Detailed management guidelines merit separate considera-

tion; however, morbidity is high if penetrative neck injuries are missed (ie, oesophagus), whereas surgical exploration carries a low morbidity. At least 25% of arterial injuries are asymptomatic. The important signs of penetrating neck trauma can include stridor, hoarseness, crepitus, expanding haematoma, active external haemorrhage, bruit or thrill, dysphagia, haemoptysis, cranial nerve dysfunction and/or brachial plexus injury. Immediate management of a penetrating neck trauma is intubation, cricothyrotomy or tracheostomy and controlling external bleeding with pressure while avoiding probing of the neck until surgical exploration is performed. Consideration for the possibility of spinal injury is important in all cases of penetrating neck trauma.

### Infections

It was in the Vietnam War that combat-related maxillofacial infections were first found to be significant. The frequency of infection of war wounds of all anatomical regions was 3.9% in hospitals within Vietnam, compared with 7.1% in the maxillofacial region, despite rapid evacuation, frequent use of “prophylactic” antibiotics and early wound care.<sup>5</sup>

In Iraq and Afghanistan, casualties treated in multiple health care settings, including austere battlefield situations, can develop complex infection problems, including multi-resistant microorganisms. The US Army considers the matter of wound infection so important that it issues soldiers with a “combat pill pack” for pain relief and prevention of infection at the self/buddy aid phase of management. This pack includes a single oral dose of moxifloxacin 400 mg for use with open wounds when evacuation is expected to be delayed for more than 3 hours.<sup>10</sup>

A very recent evidence-based comprehensive review of combat-related maxillofacial infections recommended that patients with open wounds such as those associated with fractures be commenced on a prophylactic antibiotic (cefazolin 2 g intravenous infusion every 8 hours) for a maximum duration of 24 hours from time of injury.<sup>5</sup> A longer course conferred no advantage in preventing infection.<sup>5</sup> The review emphasised that serial debridement and irrigation and wound stabilisation remain the foundation of treatment for both prevention and treatment of infections.<sup>5,10</sup>

US Army experience has been that, despite the use of broad-spectrum antibiotics and early wound care during evacuation, these casualties still have a high frequency of infection and wound breakdown.<sup>1</sup> Treatment of infected wounds needs to be definitive, with removal of all necrotic tissue and foreign bodies, together with empiric broad-spectrum antibiotics for 7–10 days and gram stains, cultures and sensitivities obtained to direct antibiotic therapy.<sup>3</sup>

Culture for *Acinetobacter baumannii* is now automatically performed on casualty arrival in the US. In addition, the arriving casualty is placed in contact and airborne isolation pending results. This is because of the resistant nature of *A. baumannii* and the frequency of its occurrence. Management of such infections may be with an aminoglycoside and ticarcillin.<sup>3</sup> Facial wounds have a lower

incidence of *A. baumannii* infections because of higher oxygen tension levels.

### Radiographic examination

In the US Army, all maxillofacial fragmentation injuries are mandatory indications for computed tomography (CT) scanning with a transportable scanner in the theatre of operations. This is to localise deep fragments and determine the trajectory path, as otherwise it is not possible to correctly assess the true depth of the injury and identify vital structures of the head and neck involved.<sup>2</sup>

If CT scanning is not available, all patients with suspected facial fracture should have, as a minimum, a facial series of maxillary and mandibular plain films which include a Water’s sinus view, lateral skull view, submentovertex view, posteroanterior mandible, Towne’s view, lateral oblique mandibular views and orthopantomogram if available.<sup>1</sup> If a neck injury is suspected, then a soft tissue neck series (anteroposterior and lateral films) and cervical spine series should also be taken if CT scanning is not possible.

### Facial fracture: initial management at level 3 care

Immediate fixation of mandibular fractures is indicated when flail anterior mandibular fractures result in airway impingement of the tongue and when continuing haemorrhage from fracture sites threatens the airway. In the case of midfacial fractures, immediate fixation is indicated in the case of severe posterior fracture displacement or haemorrhage obstructing the airway. In general, intervention for zygomatic fractures is performed at a higher level of care.<sup>1,2</sup>

Otherwise, fracture treatment can be delayed, and consists of simple fracture fixation, which may be undertaken to reduce patient morbidity and improve functional and aesthetic outcomes. Usually this involves external pin fixation or circumdental wire fixation around teeth using elastics for intermaxillary fixation. Using elastics (together with a pair of scissors tied around the neck) instead of intermaxillary wires makes airway access easy in case it is required quickly.<sup>1,2</sup> Undertaking simple fracture fixation using wires or external pins gives much better pain control than narcotic analgesics alone and improves wound management, which decreases the likelihood of wound infection.

External pin fixation of severe facial fractures is essential to prevent collapse of the facial tissue normal dimensions, and so preserves the tissue planes to provide easier dissection at later reconstructive surgery, which makes a better outcome possible.<sup>3</sup> For some patients with mild fracture displacement, fixation may be deferred until after evacuation to a level 4 hospital. Experience has shown the disposable, single use Hoffman II wrist appliance to be the most convenient and practical method of external pin fixation for mandibular, midfacial and panfacial fractures.<sup>1,2</sup>

In Iraq, open reduction and internal fixation (ORIF) of facial fractures in fragmentation wounds such as IED injuries led to poor outcomes with tissue loss, plate

exposure and infections. ORIF is now limited to treatment of fractures without significant tissue loss or contamination. Generally, definitive management of facial fractures with ORIF is now carried out much later at the national support base.<sup>1,2</sup>

The nasal cavity should be examined for septal haematomas. Septal haematomas can cause infection and necrosis of the septum, so early drainage is mandatory, together with nasal packing to avoid the haematoma reforming.<sup>1</sup> Examination should also include assessment for any hearing loss from the blast.<sup>1</sup> In the Australian situation, there should be early involvement of a deployed ear, nose and throat surgeon if such injuries are suspected.

If the paranasal sinuses are contaminated with penetrating foreign bodies, thorough sinus debridement is always indicated to prevent later infection.<sup>2</sup> The nose and ears should also be examined for cerebrospinal fluid rhinorrhea or otorrhea, and the casualty referred for neurosurgical assessment if this is evident.

Casualties with facial injuries from IEDs will in general also sustain traumatic brain injury and will require referral to a neurosurgeon. Traumatic brain injury can result from blunt concussive blast injury alone or from deeply penetrating facial trauma.

Patients with fractures potentially involving the orbits or affecting vision should always be sent for an ophthalmological consultation. Retrobulbar haemorrhage can lead to blindness and, if suspected, an emergency lateral canthotomy and cantholysis is indicated.<sup>1,2</sup> In such cases, medications such as mannitol and high doses of corticosteroids (mentioned in the literature as a temporary measure to slow swelling) are not recommended as they may have significant adverse effects in patients with multisystem injuries.

### Facial burn management

Facial burns frequently result from IED injuries because of heat from the blast and because the face is often the least protected body region. The most important aspect of management is to realise that facial burns are often a sign of an airway burn, which requires immediate assessment and management.<sup>11</sup> Early recognition of airway injury is vital.<sup>12</sup> Patients with airway burns have twice the mortality rate of casualties who have facial burns alone.<sup>11</sup> Progressive pharyngeal oedema can ultimately obstruct the airway and needs immediate consideration for oral endotracheal intubation.<sup>12</sup> In the US Army, the oral surgeon assists the anaesthetist in diagnosis and provides surgical management of airway problems.



*External pin fixation applied to mandibular fracture fragmentation injury allows wound stabilisation to minimise infection, improved pain control, and preservation of normal facial dimensions to maximise the outcome of reconstructive surgery.*

Direct laryngoscopy is indicated to assess for signs of airway injury. Reassessment for signs of respiratory distress should be frequent.<sup>12</sup> Signs of an airway or inhalation injury include soot in the sputum, singed nasal hairs, burns to the pharynx, nose and mouth, a change of voice, a hoarse or brassy cough, a productive cough and inspiratory stridor.<sup>11</sup> If there are signs of an airway burn, immediate intubation is essential.

Because of progressive facial oedema from burns, fixing the endotracheal tube with the conventional tape around the head may result in

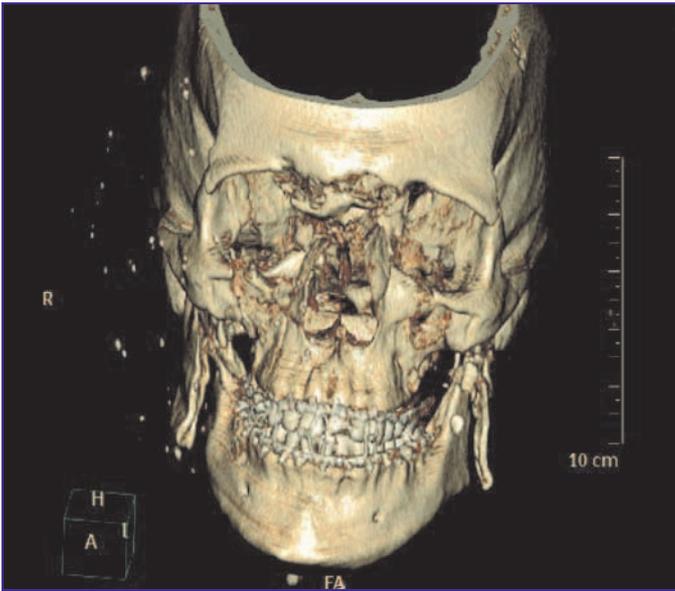
further facial injury. Ligating the tube with a loop of 24-gauge stainless steel wire to the anterior mandible below the incisor teeth using a titanium maxillofacial screw (such as an IMF screw, KLS Martin Group, Tuttlingen, Germany) is an expedient and secure option. Alternatively, the tube can be wired directly to the lower incisor teeth with a circumdental wire. Wirecutters always need to be immediately available (taped to the patient's chart or bed) in case of airway emergency.

Immediately after the primary survey and management of life-threatening injuries, vision-threatening injuries should be assessed. Because of the progressive oedema from facial burn injuries, the orbits should be assessed for compartment syndrome. Failure to carry out a timely lateral canthotomy and cantholysis can lead to blindness as increasing intraorbital pressure reduces the blood supply to the retina. US Army experience has shown that canthotomy should be carried out immediately if there is suspicion for such a complication.<sup>1,2</sup> An excellent description of lateral canthotomy and cantholysis is given in the US Department of Defense publication *Emergency war surgery*.<sup>13</sup>

Ocular burns have been reported to occur in about 25% of facial burns from all causes.<sup>11,12</sup> Initial management consists of copious irrigation with saline and temporary adhesive covers such as steripeel (or even simple kitchen plastic cling wrap in a first aid situation) to prevent dehydration of the globe.

Facial burns are initially managed with gentle debridement using saline and gauze, followed by ophthalmic bacitracin ointment to the periorbital area and regular bacitracin ointment to the face. Silver sulfadiazine (silvadene) and other topical burn medicaments should be avoided on the face because of their caustic effects on the globes.

In regard to extent of burns, it should be noted that patients with more than 15%–20% total body surface area burns will develop hypovolaemic shock without administration of sufficient intravenous fluids.<sup>14</sup>



Three-dimensional computed tomography scan of panfacial fractures from an improvised explosive device in August 2007, showing the extent and depth of the fragmentation injury and foreign body contamination.

Immediately upon notification, the US Army now air transports a specialist burns team from the US to meet and manage each seriously burned casualty during the evacuation phase to improve the outcome.

## Discussion

Future Australian Army deployments, such as to some Asian and Pacific regions, may not always have the US as a coalition partner to provide surgical and hospital support in treating facial injuries. As it is also possible that the Australian Army may in future undertake changing responsibilities in Afghanistan or other trouble spots, casualties from IEDs may become more common. For the Australian Army, the outcomes of facial injuries from IEDs can be greatly improved by updating health policies and doctrine to make use of the extensive US Army experience in wound management, together with the introduction of several clinical appliances within the theatre of operations, if they are applied in a timely fashion.

Definitive management of maxillofacial injuries from IEDs is a specialist task that can require very lengthy and complex treatment, as evident in the US Army experience at large dedicated oral and maxillofacial surgery units such as Brooke Army Medical Center. Management of these patients involves burns specialists, plastic surgeons, ear, nose and throat surgeons, anaesthetists, maxillofacial prosthodontists and oral and maxillofacial surgeons. Oral and maxillofacial surgeons are designated a critical wartime specialty by the US. They are rotated regularly to the theatres of operations to provide primary management of

these injuries at Echelon III combat support hospitals and are an integral part of the in-theatre head and neck trauma team, which includes a neurosurgeon and ophthalmologist.

For the Australian Army, primary management of facial injuries may need to be undertaken initially by deployed personnel who are not specialists in this area, such as general surgeons, medical officers, dental officers and nursing officers at level 3 health facilities who can be trained in these methods. Consideration might be given to formally addressing the health care challenge posed by facial wounds from IEDs by allocating Royal Australian Army Dental Corps personnel to an educational role for ADF medical, dental and nursing officers in maxillofacial trauma primary management.

## Competing interests

None identified. The views and opinions expressed herein are those of the authors and do not necessarily reflect those of the US Department of Defense or the Department of the Army or the Australian Army.

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