Role of ENT Surgeon in Managing Battle Trauma During Deployment

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Abstract With technological improvements in body armour and increasing use of improvised explosive devices, it is the injuries to head, face and neck are the cause for maximum fatalities as military personnel are surviving wounds that would have otherwise been fatal. 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. Modern day battlefields pose unique demands on the deployed surgical teams and management of head and neck wounds demands multispecialty approach. Optimal result will depend on teamwork of head and neck trauma management team, which should also include otolaryngologist. Data collected by various deployed HFN surgical teams is studied and quoted in the article to give factual figures. Otorhinolaryngology becomes a crucial sub-specialty in the care of the injured and military otorhinolaryngologists need to be trained and deployed accordingly. The otolaryngologist's clinical knowledge base and surgical domain allows the ENT surgeon to uniquely contribute in response to mass casualty incident. Military planners need to recognize the felt need and respond by deploying teams of specialist head and neck surgeons which should also include otorhinolaryngologists.

Keywords Battlefield injuries · Head and neck surgery team · Role of otorhinolaryngologist

Introduction

Historically, military conflict has provided significant opportunities for the advancement of trauma surgery. The battlefields of the Global War on Terror have created unique demands on deployed surgical teams. Modern high-energy fragmentation devices often inflict complex head and neck injuries. With technological improvements in body armour and increasing use of improvised explosive devices, it is the injuries to head, face and neck (HFN), which are the cause for maximum fatalities. Data collected by coalition forces deployed in Iraq and Afghanistan shows that HFN injuries altogether comprise 21–39 % of total battle injuries between 2006 and 2008 [1]. In present conflicts, the exposed face of a soldier wearing the body armour may be a direct target by the enemy. Equivalent armour to protect the neck and face is not yet effective and requires further development. Insurgents and terrorists specifically target the major means of human communication, including the ears and the nasopharyngeal complex. Many attacks attempt to maximize noise, because a deafening blast disorients and confuses, as well as injures. Bombs aimed at soldiers are meant to kill, but if they fail to kill, they are intended to cause maximum panic, pain, and disfigurement. IEDs cause a disproportionate number of ear, nose, and throat injuries, because the shrapnel tends to spray upwards. So Otorhinolaryngology becomes a crucial sub-specialty in the care of the injured. Military planners need to recognise the felt need and respond by deploying teams of specialist head and neck surgeons which should also include otorhinolaryngologists, maxillofacial surgeons and ophthalmic surgeons. A study was conducted by a deployed American team of otolaryngologists after its inclusion in head and neck trauma team, which had historically consisted of neurosurgery, ophthalmology and

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Table 1 Breakdown of craniofacial surgical procedures—Sep 2004 to Jan 2011 (Air Force Theater Hospital, Balad Air Base, Iraq)

Surgical procedure	Number
Laceration/soft tissue injury repair	451
Maxillomandibular fixation	168
Surgical tracheostomy	158
Open reduction/internal/fixation (ORIF) mandible fractures	126
Dentoalveolar surgery/extractions	119
Incision/drainage/wound washout	115
ORIF orbital fractures	108
ORIF zygomaticomaxillary fractures	100
Shrapnel removal	99
Neck explorations	67
ORIF LeFort fractures	59
Craniotomy (assist)	50
Rotational muscle flaps	42
ORIF frontal sinus fractures	40
Management of nasal fractures	40
Post-traumatic cranioplasty	25
Split thickness skin grafts	23
Banking calvarium in abdomen after craniotomy	18
Canthotomy/cantholysis	18
ORIF Naso-Orbital-Ethmoid (NOE) fractures	16
Anterior cranial vault reconstructions	11
Definitive management of facial burn patients	8
Anterior iliac crest bone graft	4

oral surgery, from Sep 2004 to Jan 2011 in Iraq. Their data suggested that Otolaryngology team proved to be a critical component of head and neck multispecialty team. Apart from doing 257 operative procedures, they examined and treated 529 patients in a span of 5 months [2].

In this article we discuss various otolaryngologic injuries sustained in war and their management.

Otorhinolaryngologic Injuries

Various otolaryngological injuries that the soldiers may sustain at the battlefield are:

- (1) Facial lacerations
- (2) Facial fractures
- (3) Airway compromise
- (4) Facial burns
- (5) Penetrating injuries to neck resulting in injuries to blood vessels and aerodigestive tract
- (6) Ear trauma resulting in tympanic membrane perforation, damage to other middle ear structures, sensorineural hearing loss and balance disorders
- (7) Nasal trauma
- (8) CSF leaks from nose/ear

(9) Facial nerve injury

The most commonly performed head and neck procedures in Iraq and Afghanistan included repair of facial lacerations, tracheostomy, neck exploration for penetrating neck wounds, maxillomandibular fixation, and operative reduction internal fixation of facial fractures [2, 3]. While the deployment of a fully-staffed trauma centre would be ideal in military conflicts, the reality of limited space for military medical personnel within the overall deployed manning allotment for the operational military commander places great stress on the head and neck trauma team. In the age of increasing surgical sub-specialization, the deployed trauma surgeon must be comfortable with the management of a wide variety of injuries.

Data collected by The 332nd Expeditionary Medical Group (EMDG) at the Air Force Theatre Hospital, Balad Air Base, Iraq, from September 2004 to May 2008 showed the presentation of craniomaxillofacial wounds in 21–39 % of combat casualties (Table 1) [3].

Scenario in India

Indian Armed Forces deploy surgical teams depending on the operational requirement. In case of urban warfare, where the number of facial injuries is expected to be much higher, an otorhinolaryngologist, may be deployed.

Mechanism of Injuries

IED facial wounds are classified as penetration wounds [4] but may be combined with a blunt facial injury if the casualty is thrown by the blast wind against nearby solid objects, such as vehicles. Penetrating missile trauma can be a low-velocity injury or a high-velocity injury. The wounding capacity of a missile is directly proportional to its velocity. 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.

Low-energy wounds are those caused by a projectile traveling at a velocity less than the speed of sound and usually result in the laceration of soft tissue with comminution of bone and the missile itself. High-energy wounds are produced by missiles traveling faster than the speed of sound. Large amounts of energy are transferred to the tissues of the body and result in perforating or avulsion wounds to the soft tissue, with ablation of cortical bone.

The high energy imparted to the tissues (and therefore the degree of damage from high-velocity missiles) is often underestimated. 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. High energy exchange wound margins may take 5 days to declare themselves. Blast injuries are frequently multiple and in addition to injuries from projectiles, casualties often have blast, burn and blunt trauma wounds. These injuries, therefore, do not lend themselves to early definitive treatment. In contrast, low energy exchange wounds, if adequately cleaned and superficial, can be successfully treated early [5].

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. Based on this analysis the management is planned. In the following sections management of different otolaryngological injuries is discussed separately.

Facial Lacerations

Facial soft tissue wounds have a profound effect upon patients' self esteem and interpersonal relationships. It is very difficult to come to terms with potentially lifelong facial disfigurement. Hence all efforts should be made to prevent disfigurement and scar contracture. Ballistic facial injuries are often heavily contaminated and frequently burned and there is further devastation of the deeper facial tissues beyond the initially visible edge of the wound [4]. So conventional primary closure at an initial stage may breakdown from developing deeper necrosis several days afterwards with the consequent development of additional scarring which can compromise reconstructive surgery outcomes months afterwards. The two most important factors affecting ultimate facial appearance and function are avoidance of scar contracture and maximum preservation of delicate and hard to replace facial soft tissues. This is achieved by thorough decontamination of soft tissue wounds by copious saline lavage and thorough removal of foreign bodies performed as soon as possible after injury coupled with minimum debridement (or trimming of soft tissue) in order to conserve facial tissue as much as possible [5]. Followed by saline lavage, wounds are further cleaned by gauze sponges soaked with dilute povidone iodine antiseptic solution. For gross contamination with foreign bodies, the US Army uses pulsatile lavage technique for ensuring scrupulous wound decontamination,

using battery powered, disposable pulsatile irrigation sets [3, 5] at low to medium pressure settings. If chemical contamination of the IED wound is thought possible, pulsatile decontamination as soon as possible may also be imperative to avoid mortality. Scrubbing brushes, pulsed lavage, copious irrigation and early adequate debridement are advocated to minimize infection and subsequent tattooing and scarring. 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. All efforts should be made to conserve facial tissues as much as possible. The use of diathermy should be judicious rather than extensive. The wounds should then be packed open with ribbon gauze and antibacterial agents. They should undergo serial debridement until judged able to be closed. Deep wounds should be explored on the operating table with facilities for surgical vascular control if required. Only wounds that have no gross contamination or deep extension should be closed primarily.

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.

Tetanus prophylaxis and broad spectrum antibiotics should be given to all cases.

Facial Fractures

In the management of facial fractures, preservation of bone is of great importance and only very small detached fragments are removed at initial stage [6]. Avulsed large fragments of bone can be stored in a surgically created subcutaneous pouch in the abdominal wall for later retrieval and reconstructive use [5].

Damaged facial nerves and salivary ducts should be identified with nylon sutures for easier identification at later reconstruction operations. Though earlier studies have suggested the use of conventional techniques of external pin fixation or intermaxillary fixation (IMF) to reduce and hold most facial fractures in their anatomical position, but in the recent studies American military facial surgeons used the following criteria to offer open reduction and internal fixation (ORIF) in case of facial fractures as a form of definitive repair with successful results:

(1) the fracture site should be exposed through either a soft tissue wound or because of an adjacent surgical approach, (2) treatment should not delay evacuation from

theater, and (3) treatment should allow the military member to remain in theater.

An otolaryngologist was a crucial member of the head and neck trauma team [7].

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.

Airway Management

The role of the deployed otolaryngologist in traumatic airway management has been proved to be crucial by various case studies done during Operation Iraqi Freedom. In the majority of HFN injuries the primary cause of death is secondary to airway compromise and with the exception of severe neck wounds haemorrhage is an unusual cause of death. The ability to perform an emergency cricothyroidotomy is a necessity for deployed medics, but is a temporary procedure and a tracheostomy needs to be performed when the necessary skill becomes available. Patients exposed to IEDs must be assessed for burn-related injuries, and a low threshold for endotracheal intubation or tracheostomy is indicated.

A recent study reviewed the traumatic airway experience of 6 otolaryngologists/head and neck surgeons deployed over a 30 month period in Iraq [8]. During this period, 196 patients presented with airway compromise necessitating either intubation or placement of a surgical airway. Penetrating face trauma (46 %) and penetrating neck trauma (31 %) were the most common mechanisms of injury necessitating airway control. The surgeries performed on airways included tracheotomies, cricothyroidotomies, and repair of laryngotracheal complex (thyroid cartilage repair, cricoid cartilage repair and tracheal repair). Colour coding was given according to the nature of urgency of airway requirement, being red for emergent airways, yellow for delayed airways and green for elective airways. Thus airway management was streamlined and no time was lost in decision making.

Neck Trauma

Penetrating neck injury in the contemporary battlefield remains a highly lethal insult, even with the availability for rapid aerial casevac to a forward surgical facility. 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. Those injuries causing significant vascular damage usually die rapidly and any attempt at medical intervention is unlikely to be successful. Exsanguination is the most common cause of death in penetrating neck trauma followed by tracheal disruption. All penetrating neck injuries require a definitive airway, as the extent of injury is often under-estimated. All injuries where the platysma has been penetrated must be surgically explored, even in asymptomatic casualties. This practice has led to decreased mortality rates associated with these injuries. A study of surgical management of penetrating neck trauma by six otolaryngologists deployed over a 30 month period in Iraq revealed a positive exploration rate (patients with positive intraoperative findings during exploration) to be 73 % [9]. The mortality of patients undergoing neck exploration for primarily high velocity penetrating neck trauma was found to be 4.6 %.

Approaches to Protecting the Neck

Neck injuries are predominantly fragmentation injuries and are therefore potentially preventable. Generally, neck protection is achieved by flexible collars attached to the body armour vest, though the size, design and detachability of the collar varies greatly between nations. Nape protectors attached to the rear of the combat helmet can also be used. Most designs of neck collar cover the lower portion of the neck leaving the upper portion vulnerable [10].

Ear Trauma

Middle and external ear damage has recently been documented as occurring in 10 % of head, face and neck injuries [11]. Pinna haematoma necessitates prompt incision and drainage to avoid cartilaginous haematoma. Tympanic membrane rupture is common and is often associated with more serious injuries elsewhere. It should be suspected in all servicemen subjected to blast injury, even if there are no obvious head, face and neck injuries and an audiogram should be performed after ruling out all other injuries. Even though most perforations heal spontaneously, the conditions of war make intervention imperative. In the bombing of the US embassy in Kenya, a study showed, five of 14 untreated membranes failed to heal, while all of those that were treated did heal [12].

Though it is possible to issue earplugs to troops, they are not as effective as they should be, as there is always a tradeoff between hearing protection and communication, which is so vital in wartime. The pressure wave can sometimes be severe enough to cause fracture of ossicles

and permanent inner ear damage. Early intervention by the Otolaryngologist can improve final outcomes.

A common problem at secondary and tertiary medical facilities treating complex polytrauma patients is that ear and balance deficits are often initially overlooked. Hearing loss can be misdiagnosed as unresponsiveness in cases of Traumatic Brain Injury. Patients with lower-limb amputations may have vestibular problems that are not readily identified.

Otolaryngologist, audiologists and physical therapists need to work closely together in treating blast-injured patients to manage oto-vestibular and hearing impairments by assessing middle ear integrity and function, hearing status, and vestibular dysfunction [13]. Physical therapists help to provide vestibular rehabilitation training and therapy.

The American Army has distributed “hear-through” devices to the deployed soldiers.

Further, in other research, the Army has determined that immediate treatment of traumatic hearing loss in the battlefield can prevent worsening damage. Use of steroids and anti-oxidants to combat free radicals released during noise induced hearing loss has shown to mitigate further damage after explosion.

These pro-active steps will have a dramatic impact on hearing loss caused by battlefield trauma.

Nasal Trauma

Nasal trauma may result in fracture or septal haematoma. Septal haematoma requires prompt incision and drainage to prevent infection and cartilaginous necrosis. Epistaxis should be managed by anterior and if necessary posterior nasal packing. Anterior packing can be performed with Merocel or Netcell nasal packs or ribbon gauze soaked in antibiotic solution. Posterior packing should be undertaken with nasal catheters or 12G or 14G Foley catheters, which are inflated in the nasopharynx to threequarters capacity and pulled anteriorly until they impact. Packs can be removed after 24–48 h and situation can be reassessed.

Cerebrospinal Fluid Leak

CSF leakage from ear or nose can occur in cases with base skull fracture. The cases with GCS scores >8 on admission are expected to resolve spontaneously with conservative management whereas in those with GCS scores <8 the outcome is poor. Knowledge of surgical anatomy, good pre-operative planning, intraoperative monitoring, and excellent microsurgical technique contribute to minimizing and avoiding complications. In the event of a complication,

however, the neurotologic surgeon should be prepared to manage it [14].

Facial Nerve Injury

Both blunt and penetrating craniofacial trauma may lead to severe facial nerve injury and sequelae of facial paralysis. Initial evaluation involves quantitation of motor deficits using a clinical grading system, such as the House-Brackmann scale. High resolution computed tomography is used for localization of nerve injury in suspected cases of temporal bone trauma. In the absence of gross radiographic abnormalities, electrophysiologic testing helps predict the likelihood of spontaneous recovery. In patients with deteriorating facial nerve injuries by electroneuronography, surgical exploration is the preferred management. Primary end-to-end neurotaphy or facial nerve decompression may be done. Secondary facial reanimation procedures, such as cranial nerve crossovers, dynamic muscle slings or various static procedures are useful adjuncts when initial facial nerve repair is unsuccessful or impossible [15].

Conclusion

The intent of this study was to review the data of deployed surgical head and neck trauma teams in current conflicts, to describe the distribution of wounds, mechanisms of injuries and their management, and identify areas of potential focused surgical training for deploying otorhinolaryngologists in the near-term and in future military actions. Previous wars have shown that an appropriately staffed hospital, efficient surgical techniques, and the presence of highly skilled specialists working as a team can provide excellent patient outcomes. The addition of an otolaryngologist has significantly improved the care American military personnel are receiving in theater. A multispecialty head and neck team without an otolaryngologist is devoid of the unique skills necessary to manage penetrating neck trauma, the acute airway, and reconstruction of head and neck wounds. The broader the scope of surgical training, coupled with a robust clinical practice to maintain the skills obtained during residency, will provide the military commanders with a valuable resource to provide a force-multiplying effect in the operating theatre. Battlefield ballistic injuries present a unique challenge to facial surgeons. Severely restricting the diversity of surgical practice, such as that limited only to general surgery, limits both the quality and scope of care provided to wounded patients in a wartime environment. The ability to provide definitive reconstructive surgery is critical to return the

patient to the highest quality of life attainable after their injury.

Military planners need to recognise this and respond by deploying teams of specialist head and neck surgeons, which should also include otorhinolaryngologists, maxillofacial surgeons, neurosurgeons and ophthalmic surgeons.

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