Penetrating neck injuries: a guide to evaluation and management

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ABSTRACT

INTRODUCTION Penetrating neck injury is a relatively uncommon trauma presentation with the potential for significant morbidity and possible mortality. There are no international consensus guidelines on penetrating neck injury management and published reviews tend to focus on traditional zonal approaches. Recent improvements in imaging modalities have altered the way in which penetrating neck injuries are now best approached with a more conservative stance. A literature review was completed to provide clinicians with a current practice guideline for evaluation and management of penetrating neck injuries.

METHODS A comprehensive MEDLINE (PubMed) literature search was conducted using the search terms ‘penetrating neck injury’, ‘penetrating neck trauma’, ‘management’, ‘guidelines’ and approach. All articles in English were considered. Articles with only limited relevance to the review were subsequently discarded. All other articles which had clear relevance concerning the epidemiology, clinical features and surgical management of penetrating neck injuries were included.

RESULTS After initial resuscitation with Advanced Trauma Life Support principles, penetrating neck injury management depends on whether the patient is stable or unstable on clinical evaluation. Patients whose condition is unstable should undergo immediate operative exploration. Patients whose condition is stable who lack hard signs should undergo multidetector helical computed tomography with angiography for evaluation of the injury, regardless of the zone of injury.

CONCLUSIONS The ‘no zonal approach’ to penetrating neck trauma is a selective approach with superior patient outcomes in comparison with traditional management principles. We present an evidence-based, algorithmic and practical guide for clinicians to use when assessing and managing penetrating neck injury.

KEYWORDS

Penetrating neck injury – Trauma – Management – Review

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Introduction

Penetrating neck injury represents 5–10% of all trauma cases.¹ It is important for clinicians to be familiar with management principles, as mortality rates can be as high as 10%.² This can prove difficult however, as there are no international consensus guidelines and recent improvements in imaging modalities have altered the way in which such are now approached.^{3,4} Published guidance on the management of penetrating neck injury tends to focus on traditional approaches.^{3,5,6} This review provides a practical guide for the evaluation and management of penetrating neck injuries.

Background

Penetrating neck injury describes trauma to the neck that has breached the platysma muscle.⁶ The most common mechanism of injury worldwide is a stab wound from violent assault, followed by gunshot wounds, self harm, road traffic accidents and other high velocity objects.^{5,7} The neck is a complex

anatomical region containing important vascular, aerodigestive and neurological structures that are relatively unprotected.⁷ Vascular injury may include partial or complete occlusion (most common), dissection, pseudoaneurysm, extravasation of blood or arteriovenous fistula formation.⁸ Arterial injury occurs in approximately 25% of penetrating neck injuries; carotid artery involvement is seen in approximately 80% and vertebral artery in 43%.² Combined carotid and vertebral artery injury carry both major haemorrhagic and neurological concern.⁸ Aerodigestive injury occurs in 23–30% of patients with penetrating neck injuries and is associated with a high mortality rate.⁶ Pharyngo-oesophageal injuries are less common than laryngotracheal injuries but both are associated with a mortality rate of approximately 20%.^{7,9} Neurological structures at risk of involvement include the spinal cord, cranial nerves VII–XII, the sympathetic chain, peripheral nerve roots and brachial plexus. Spinal cord injury occurs infrequently (less than 1%), particularly in low velocity injuries such as stab wounds.¹⁰

The assessment and management of penetrating trauma to the neck has traditionally centred on the anatomical zone-based classification first described by Monson *et al.* in 1969 (Fig 1).^{11,12} More recently, the rigidity of this zone-based algorithm has been challenged, especially with regard to the mandatory exploration for zone II injuries.¹² Routine neck exploration in haemodynamically stable patients leads to a high rate of nontherapeutic intervention, missed injuries, increased length of hospital stay and an increased rate of complications.^{5,13,14} Additionally, Low *et al.* demonstrated in 2014 a poor correlation between the location of the external wound and the injuries to internal structures.¹⁵ These factors have brought into question the entire foundation of the traditional zonal approach. This review outlines a selective, non-zonal approach to penetrating neck injuries, where the entire neck is treated as a single entity.

Methods

A comprehensive MEDLINE (PubMed) literature search was conducted. The initial search strategy included terms 'penetrating neck injury' and 'penetrating neck trauma'. Additional search terms such as 'management', 'guidelines' and 'approach' were subsequently used. All articles in English were given consideration. Articles with only limited relevance to the review were discarded. All other articles which had clear relevance concerning the epidemiology, clinical features and surgical management of penetrating neck injuries were included.

Initial assessment and stabilisation

Patients with penetrating neck injuries can decompensate rapidly and should be transported immediately to the nearest trauma centre. Impaled objects should not be removed in the field. A systematic approach to the management of penetrating neck trauma is critical. The initial evaluation and assessment involves resuscitation in accordance with the Advanced Trauma Life Support (ATLS) principles.^{4,5} Early inspection of a neck injury is advised to determine if the platysma muscle has been breached.⁴ Use of local anaesthesia facilitates a more accurate assessment of the wound.⁴ If the platysma is intact then, by definition, the wound is superficial. If the platysma is violated then it is a penetrating neck injury and the patient's signs and symptoms govern how to proceed with management.⁴ Surgical consultation should be obtained in all penetrating neck injuries, particularly because the patient may initially appear stable but may decompensate rapidly. This is preferably achieved with an attending emergency otolaryngology team.

Cervical spine immobilisation is not routinely recommended in penetrating neck injuries.¹⁶ The incidence of unstable cervical spine fractures in penetrating neck injuries is very low and cervical spine collars may obscure clinical signs and impair intubation.^{17,18} The exceptions to this are if there is focal neurology or a high clinical suspicion for spinal injury in an unconscious or heavily intoxicated patient. Additionally, the incidence of cervical spine injury and cervical spinal cord injury has been demonstrated to be significantly different depending on the mechanism of injury.¹⁰

Figure 1 Classification of anatomical zones of the neck (Monson 1969). Zone I extends from clavicles to cricoid, zone II from cricoid to angle of mandible, and zone III from angle of mandible to skull base.

Penetrating neck injuries that result from high energy injuries, such as gun shots or blunt force as in motor vehicle accidents, are at higher risk of cervical spine injury and immobilisation needs to be considered.¹⁰

Airway management

Immediate consideration should be given to the airway in a systematic approach and must address the following questions:

- > Does the patient require immediate airway protection?
- > What is the best approach and technique for airway protection?

This initially includes careful clinical examination for injury to the aerodigestive tract (oral, pharyngeal, laryngeal or tracheal).¹³ Clinical signs of airway injury include hoarseness, stridor, dyspnoea, subcutaneous emphysema (in the absence of pneumothorax), bubbling from the wound and large volume hemoptysis.^{5,12} The best method of achieving definite airway control in the setting of penetrating neck injury will vary according to the clinical circumstances, clinical skill and hospital resources.¹⁹ It is imperative to be prepared for unexpected difficulty. Have available at least two suction devices, a range of different sized tracheal tubes, rescue airway devices and a surgical airway kit. Additionally, it is best to avoid airway techniques not performed with direct visualisation, as blind placement of a tracheal tube into a lacerated tracheal segment can create a false lumen outside the trachea or convert a partial tracheal laceration into a complete transection.¹⁹

When the airway is threatened but anatomic structures are preserved, we recommend rapid sequence intubation to

secure the airway. Several studies at major trauma centres have found this to be a safe and effective approach to definite airway control.^{20–22} Bag and mask ventilation to preoxygenate in preparation for rapid sequence intubation or to reoxygenate following a failed attempt at intubation must be done with vigilance, as it may force air into injured tissue planes and distort airway anatomy or further disrupt surrounding soft tissue injury.^{19,20} If tracheal intubation is deemed necessary and the airway is predicted to be difficult because of distorted anatomy, we recommend fiberoptic intubation. Fiberoptic laryngoscopy and intubation allows the clinician to determine the integrity of the interior of the supraglottic and infraglottic airway while the patient maintains spontaneous respiration.²¹ This technique is limited by a patient's level of cooperation and ability to tolerate the procedure.

Invasive airway management represents the standard approach when orotracheal intubation by any method is unsuccessful or contraindicated.²² Immediate indications for a surgical airway include massive upper airway distortion, massive midface trauma and inability to visualise the glottis because of heavy bleeding, oedema or anatomical disruption.^{19,23,24} Cricothyotomy and tracheotomy are the two most commonly used procedures for severe neck trauma.²⁴ We recommend cricothyrotomy as the first surgical airway of choice, as it is the most direct, simple and safe way of bypassing upper airway obstruction or injury.²⁴ This may be difficult in the presence of distorted neck anatomy or if an anterior neck haematoma or laryngeal injury is suspected and carries potential risk to the vocal cords.²⁵ Tracheotomy may be necessary in the event of skeletal collapse, significant structural airway disruption and breakdown and/or partial or complete transection of the larynx or trachea.²⁵ The tracheotomy incision should be made as low in the neck as possible to avoid further injury to the laryngotracheal complex. The cervical incision should be made vertically, which allows for inferior extension if becomes necessary to achieve better anatomic exposure.²⁴ Tracheotomy, even when performed by experienced hands, is the primary cause of long-term laryngotracheal complications and should therefore only be performed if indicated.²⁴

Surgery compared with conservative management

The decision to take a patient presenting with a penetrating neck injury immediately for surgical intervention is largely dependent on the physiological status and clinical findings on examination.¹² If there is evidence of haemodynamic instability or what trauma centres refer to as 'hard signs' of injury to vital structures of the neck (Box 1), the patient should undergo operative exploration and bypass imaging.^{5,12,15} The absence of hard signs does not exclude injury to underlying structures and the decision to take the patient to the operating theatre therefore depends on whether the physiological status of the patient is unstable.¹⁵ Surgical techniques for repairing injury to vital structures are discussed below.

Surgical management of vascular injury

As exsanguination accounts for up to 50% of the mortality from penetrating neck injuries, we recommend that

Box 1 'Hard signs' indicating immediate explorative surgery in penetrating neck injury.

- > Shock
- > Pulsatile bleeding or expanding haematoma
- > Audible bruit or palpable thrill
- > Airway compromise
- > Wound bubbling
- > Subcutaneous emphysema
- > Stridor
- > Hoarseness
- > Difficulty or pain when swallowing secretions
- > Neurological deficits

clinicians are familiar with haemorrhage control techniques in the interim of surgical intervention.⁵ Specific to penetrating neck injuries, bleeding that is not amenable to control through simple external compression can be amenable to Foley balloon catheter tamponade.^{5,25} This is a well-recognised technique for temporarily arresting bleeding and can sometimes avoid the need for emergency surgery. It involves introducing the Foley catheter into the wound, following the wound track and inflating the balloon with 10–15 ml of water until resistance is met (Fig 2). The catheter is then clamped and the neck wound is sutured (Fig 3).²⁶ If compression or balloon tamponade successfully controls the haemorrhage, angiography can be arranged to identify the source of bleeding prior to operative or endovascular intervention.⁵

If a vascular injury from a penetrating neck injury is suspected, immediate consultation with a vascular surgeon should be obtained. Zone 1 vascular injuries may also require input from a cardiothoracic surgeon as treatment may require a sternotomy or thoracotomy to gain proximal access to vascular structures.⁴ When a common or internal carotid artery injury is identified during a neck exploration, the consensus from the literature suggests that repair of the artery has superior patient outcomes than artery ligation.^{27,28} This is irrespective of whether or not a preoperative focal neurological deficit was present.²⁷ Carotid repair methods are extensive and usually depend on location and size of the injury. The two most common techniques include transverse arteriorrhaphy with interrupted 6-0 polypropylene suture and vein or thin-walled polytetrafluoroethylene (PTFE) patch angioplasty with continuous 6-0 polypropylene suture.²⁷ Isolated jugular venous injuries are generally innocuous as the low-pressure venous system usually tamponades or occludes without major haemorrhage.²⁹

Surgical management of laryngotracheal injury

If injury to the laryngotracheal complex is suspected, panendoscopy and bronchoscopy under general anaesthesia should precede surgical exploration.^{5,24} If an injury is identified, repair is usually indicated, with the exception of small mucosal defects or undisplaced fractures of the laryngeal framework, which can be managed conservatively.⁵ Significant skeletal fractures and associated soft tissue injuries

Figure 2 Foley catheter balloon tamponade. A Foley catheter is introduced into the bleeding neck wound following the wound track. The balloon is inflated with 10–15 ml water or until resistance is felt. The catheter is clamped to prevent bleeding through the lumen. The neck wound is sutured around the catheter.

warrant open repair.⁵ A review of the details of each open surgical repair is beyond the scope of this review. Stenting may also be used to manage severely displaced laryngeal fractures that may cause skeletal instability or breakdown. Stents also have the added benefit of bolstering the soft tissues and arytenoids, impeding haematomas, web formation and aspiration.²⁴ Surgeons who expect to be involved in acute laryngotracheal trauma must have access to a variety of stent designs and sizes at all times.²⁴

Surgical management of pharyngo-oesophageal injury

Cervical oesophageal injuries are less common because of the central and protected position of the oesophagus. These are often silent injuries with no findings on clinical examination.⁵ All patients with suspected oesophageal injury must have intravenous antibiotics, nil by mouth and given surgical nutrition.⁵⁰ If patients demonstrate hard signs of oesophageal injury or if early imaging demonstrates oesophageal perforation, operative repair is generally required.⁵¹ If not treated early, oesophageal injuries may cause mediastinitis and abscess or empyema formation from leakage of gastric contents.⁵⁰

Surgical treatment of oesophageal injuries depends on the timing since the inflicted injury. Patients presenting within 12 hours of injury may undergo direct suture repair

Figure 3 Foley catheter balloon tamponade in a zone 2 neck injury. The catheter is knotted on itself (black arrow) acting as a clamp to prevent flow of blood through the lumen. The wound is suture around it (white arrow).

and drainage.⁵⁰ After 12 hours of injury, morbidity and mortality increases and direct repair is less likely to be successful.^{50,52} These patients should ideally undergo debridement and drainage with a planned delayed repair. The majority of studies suggest that repair with a single layer is equally safe and effective as a double-layer repair in a penetrating neck injury.^{33,34} All patients should be monitored closely and returned to the operating theatre for repeat exploration if signs of infection develop.

Patients who are stable

Historically, the management of patients without hard signs was dependent on the zone of injury.^{12,35} Zone II injuries, which constitute the majority of penetrating neck injuries, always underwent mandatory surgical exploration.³⁵ Zone I and III injuries were evaluated more selectively due to difficult anatomic accessibility.¹² Further evaluation often included angiography, bronchoscopy and/or oesophagoscopy – a labour and resource-intensive process often requiring input from multiple specialities.¹² Although these studies have high sensitivity for detecting respective injuries, they are also invasive to the patient and carry a small but significant risk of complications. Over the 2000s, there

Figure 4 Algorithm for no-zonal management of penetrating neck injury. Approach patients with a penetrating neck injury like any trauma patient with Advanced Trauma Life Support resuscitation. Patients who are unstable and demonstrating any of the 'hard signs' or visceral injury must be immediately taken for surgical exploration. All patients who are stable should have a multidetector helical computed tomography with angiography to evaluate for visceral injury.

have been numerous studies with evidence that suggests approaching the neck with a 'no zone' approach provides superior outcomes for the patient with a penetrating neck injury.^{12,14,15} This entails clinicians assessing the entire neck as a single entity and managing penetrating injuries with a selective approach based on the clinical findings and the physiological status of the patient.

While there are studies from high-volume trauma centres in the United States recommending physical examination alone is sufficient for penetrating neck injury evaluation, most trauma centres have a relatively low volume of such injuries and, consequently, clinicians are less experienced in managing these injuries.⁴ For these reasons, we recommend clinicians consider multidetector helical computed

tomography with angiography (MDCT-A) in the evaluation of patients who do not require immediate operative intervention.¹² This imaging modality has been recognised to be both highly sensitive and specific in detecting vascular, laryngotracheal and many pharyngo-oesophageal injuries, thereby eliminating the need for multiple imaging studies to assess each type of injury.^{5,15,55,56} It can also provide information on the trajectory of the wound track and suggest whether imaging of the thorax is also required.³⁷

MDCT-A has resulted in a significant decrease in formal neck explorations and a virtual elimination of exploratory surgery.¹⁵ One limitation of MDCT-A is the potential to miss pharyngo-oesophageal injury, with some studies reporting the sensitivity to be as low as 55%.^{9,12} This,

coupled with the high mortality rate of pharyngo-oesophageal injury, means that additional imaging in a stable patient with potential pharyngo-oesophageal injury is often required. A contrast swallow is usually performed first, followed by a flexible oesophagoscopy in the event of non-diagnosis. Flexible oesophagoscopy has a sensitivity close to 100%.⁵⁸

Routine evaluation of all patients who are stable with MDCT-A is therefore advised regardless of the zone of injury. Further assessment with angiography, bronchoscopy, contrast swallow/flexible oesophagoscopy or surgical exploration may be guided by the MDCT-A findings.⁵

Conclusions

The no-zonal approach to penetrating neck injury evaluation and management is contemporary and against the grain of the anatomical zones management algorithms that have guided clinicians over the past 50 years. Evidence is accumulating to suggest that the non-zonal approach is superior over traditional approaches to penetrating neck trauma, especially with respect to reduced negative neck explorations. We have suggested a no-zonal algorithmic approach which employs MDCT-A for clinicians to use in the evaluation and management of penetrating neck injuries. There are currently no international guidelines and generally a lack of consensus in the literature regarding optimum assessment and treatment of penetrating neck injuries. Further research is therefore warranted to continue advancing our understanding of the management of penetrating neck injuries.

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