Neck trauma management – surgery for major incidents

Elizabeth A Smithson
Philip M Bembridge

Abstract

Assessment and management of neck trauma is complex and challenging. Due to the intricate network of structures, life-threatening injuries pose a real threat from blunt, penetrating or combined mechanisms. Close collaboration of surgical, anaesthetic and emergency department teams is essential in these cases. This article reviews current literature, with particular focus on mechanism of injury, principles of investigation and management.

Keywords Blunt neck injury; neck trauma; NEXUS; penetrating neck injury; spinal cord

Introduction

The neck harbours a complex and intricate network of structures. Life-threatening injuries are posed by damage to the airway; major blood vessels; and neurological structures. Close collaboration between surgical, anaesthetic and emergency department teams is essential in managing these often complex cases. Severe injuries can require immediate surgical intervention. In other cases, imaging such as CT scanning offers valuable information in determining further management.[1]

Neck trauma can be broadly classified into the mechanism of injury – blunt; penetrating; or a combined mechanism. Whilst blunt and penetrating injuries have different pathophysiologies, many of the key management strategies are similar. Effective treatment relies on understanding what structures are at risk of damage.

Clinical anatomy

A thorough knowledge of the anatomy of the neck is essential when assessing and managing neck trauma.

The neck is the area between the clavicle and the mandible. It is clinically divided into an anterior triangle and posterior triangle.[2] For the purposes of assessing and managing penetrating trauma, the neck is also traditionally divided into three anatomical zones which is useful for communication between teams[3] (Figure 1). However, it is essential to remember that this is a very generalized approach and does not take into account the trajectory of a penetrating injury (see Tables 1 and 2, Figures 2–5).

Elizabeth A Smithson *MBChB (Hons) BSc (Intercal Hons) DTM&H PGCert FRCA is an ST6 at Bradford Teaching Hospitals NHS Foundation Trust, UK. Conflicts of interest: none declared.*

Philip M Bembridge *MBChB FRCA is a Locum Consultant at the Leeds General Infirmary, Leeds, UK. Conflicts of interest: none declared.*

The anterior triangle is bordered as follows:

- Anteriorly: the midline of the neck from the chin to the sternal notch
- Posteriorly: the anterior border of the sternocleidomastoid
- Superiorly: the inferior margin of the mandible[2]

There are four further smaller triangles in the anterior triangle:

1. Submental triangle
2. Submandibular triangle
3. Carotid triangle (also known as the superior carotid triangle)
4. Muscular triangle (also referred to as the inferior carotid triangle)[2]

The posterior triangle is bordered by the following:

- Anteriorly: the posterior margin of the sternocleidomastoid
- Posteriorly: the anterior border of the trapezius
- Inferiorly: the middle third of the clavicle
- Apex: the nuchal line of the occipital bone.[2]

Muscles of the neck

A penetrating neck injury is defined by breeching the platysma muscle which overlies the majority of the neck.

Blood vessels

The neck is highly vascularized and direct vascular injury can lead to catastrophic consequences. The neck encapsulates the carotid and vertebral arteries, as well as their branches. There is also an intricate network of veins allowing venous drainage of the head and neck.

As well as the structures already mentioned, it is essential to remember other key components of the neck include:

- Larynx, cricoid cartilage, hyoid bone, and trachea
- Oesophagus
- Lymphatics
- Vertebral column and spinal cord
- Thyroid

Injury to these structures can be occult and lead to delayed presentation or recognition of injury.

Mechanisms of injury

Penetrating trauma

Penetrating neck injuries are defined as those that penetrate the platysma,[4] accounting for 5%–10% of all trauma cases.[3]

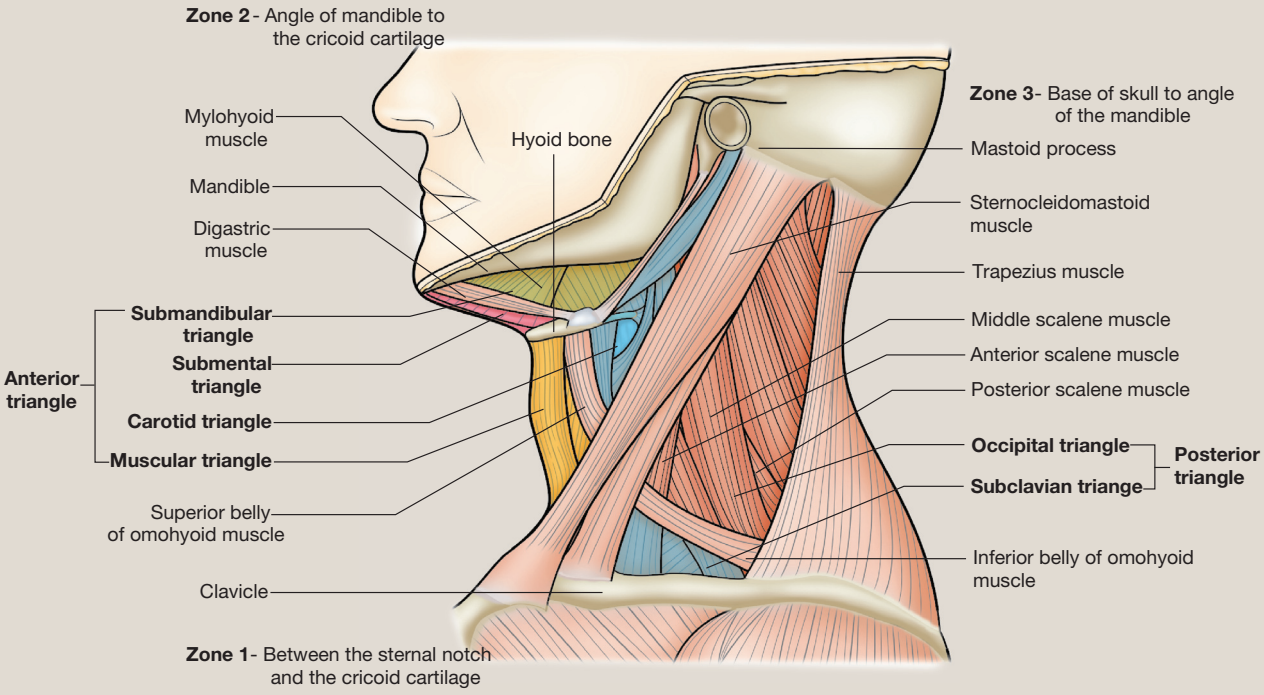
They are traditionally described depending on which clinical zone the injury occurs in; these zones suggest the likely structures that are injured. These zones are used as a broad communication tool between teams. In a stable patient, a 'no-zones' approach to management is now adopted. As mentioned earlier, there is a poor correlation between location of entry wound and internal injury.[3,5]

Blunt trauma

Blunt neck trauma can be caused by direct or indirect high-energy injury. Direct injury can be caused by a 'clothes-line' injury or a hanging attempt, whereas indirect can be the result of a road traffic collision, sports injury or a blast injury.[1]

Hanging and strangulation can be considered a separate entity as it causes a different spectrum of injuries. The clinical importance of this is an increased risk of cerebral ischaemia, in comparison with other blunt trauma mechanisms.[1,6]

Diagram showing the anterior and posterior triangles of the neck



Taken from Wikipedia (Creative Commons Attribution 3.0) https://en.wikipedia.org/wiki/File:Musculi_coli_base,_my_edits_for_tringles,_labeled_triangles.svg.

Figure 1

Muscles of the neck, including anatomy and function[1,2]

Muscle	Anatomy	Function
Platysma	Attaches inferiorly to subcutaneous tissues overlying the pectoralis major and deltoid. It extends superiorly covering the majority of the anterior and lateral neck. It inserts at the inferior border of the mandible, contralateral muscle and subcutaneous tissue of the face.	Draws the corners of the mouth inferiorly and lowers the lower lip
Sternocleidomastoid	Originates from the sternal manubrium and medial aspect of the clavicle. Attaches to the mastoid process of the temporal bone and superior nuchal line.	Flex the neck; extend the head; and rotate the head. Accessary inspiratory muscle.
Trapezius	Originates in the occipital protuberance and medial superior nuchal line. Attaches to lateral third of clavicle, acromion process and spinous processes of C7-T12	Shrugs shoulders; rotate, depress and retract the scapulae.
Suprahyoid muscles	Consists of the digastric; mylohyoid; and geniohyoid muscles	Elevate the hyoid
Infrahyoid muscles	Consist of the sternohyoid; sternothyroid; thyrohyoid; and omohyoid	Depress the hyoid

Table 1

Investigations

High-resolution CT imaging is the gold standard in trauma imaging. However, Focused Assessment with Sonography for Trauma (FAST) point-of-care ultrasound scanning (extended with pleural views) and chest X-ray can be employed for rapid diagnosis without transporting an unstable patient.

If haemorrhage is suspected, multi-detector CT angiography should be rapidly performed and opens avenues of treatment by interventional radiology.

However, multi-detector CT angiography may miss pharyngo-oesophageal injuries, with a low sensitivity of 53%. A CT scan with water-soluble contrast and no intravenous contrast is usually followed by flexible oesophagoscopy.[3]

Management

Neck injuries are heterogeneous and can prove challenging to treat. Management involves different surgical specialities — ENT; maxillofacial; cardiothoracics; neurosurgery; radiology;

Clinical zone of injury, applied anatomy and structures at risk of injury[1,3]

Zone	Anatomy	Structures at risk
3	Base of skull to angle of the mandible	• Pharynx • Carotid arteries • Internal jugular vein • Cranial nerves • Sympathetic chain • Parotid gland
2	Angle of mandible to the cricoid cartilage	• Laryngotracheal complex • Pharynx • Oesophagus • Carotid artery • Jugular veins • Vertebral arteries • Spinal cord • Vagus and phrenic nerves
1	Between the sternal notch and the cricoid cartilage	• Trachea • Oesophagus • Carotid artery • Jugular veins • Thoracic duct • Spinal cord • Cranial nerves • Vertebral arteries

Table 2

and vascular surgery. There is additional involvement from emergency medicine; interventional radiology; anaesthesia; and critical care. The rapid multidisciplinary assessment and management of the trauma patient should be centred around a structured recognized approach. The harmony and non-technical skills of the team is paramount in the outcome of such patients.

Usually, the patient is transported to the team, but occasionally with unstable patients, thought should be given to moving the team to the patient.

Catastrophic haemorrhage

Patients with neck trauma can suffer exsanguinating haemorrhage through major vessel injury.

Management of catastrophic haemorrhage is the initiation of massive transfusion and the surgical rapid arrest of bleeding; haemostatic dressings can be used which are more effective than standard gauze.[5] A Foley catheter can be inserted in a wound and the balloon inflated to put pressure on a bleeding site; the catheter is knotted to prevent blood draining. An iTClamp is a specialist device used to temporarily stem bleeding — more commonly in the pre-hospital setting.

The practice of resuscitative thoracotomy — bilateral anterior thoracotomy, clamshell incision — is established in thoracic trauma with a duration of traumatic cardiac arrest less than 15 minutes of penetrating trauma or 10 minutes of blunt trauma — and has been used in arrest following neck trauma (with application of thoracic aortic clamp) with a duration of traumatic cardiac arrest less than 5 minutes.[7,8]

Airway

Airway management can be complex in neck trauma; the negative pressure from spontaneous ventilation can splint open damaged airways but when a threatened or obstructed airway is identified, definitive airway protection with a cuffed tracheal (or bronchial) tube should be secured with the tip distal to the site of injury. Emergency front-of-neck access or tracheostomy may be required. Rarely, an open airway can be cautiously secured through an open trachea.[7,8] Inappropriate spinal cord immobilization and cricoid pressure can be detrimental. Signs and symptoms indicating urgent need for definitive airway securement are listed in Box 1.

'Hard signs' suggest upper aerodigestive tract or vascular injury and patients should be transferred directly to an operating theatre for surgical exploration. They also indicate that the airway should be secured.

A combined approach with ENT and anaesthetics may be required with senior support involved early (however time critical airway intervention should not be delayed waiting for senior support).

Please note, conventional emergency front-of-neck access, cricothyroidotomy, can worsen already damaged anatomy. It is not recommended in cases of laryngotracheal separation. Care needs to be taken to avoid creation of false passages in all airway instrumentation.[1]

Delayed sequence intubation, the administration of deep ketamine sedation with preservation of airway reflexes and maintenance of spontaneous ventilation, to allow for pre-oxygenation of combative or agitated patients, is emerging in the literature for neck trauma.[10]

Indications for urgently securing a definitive airway[1,7–9]

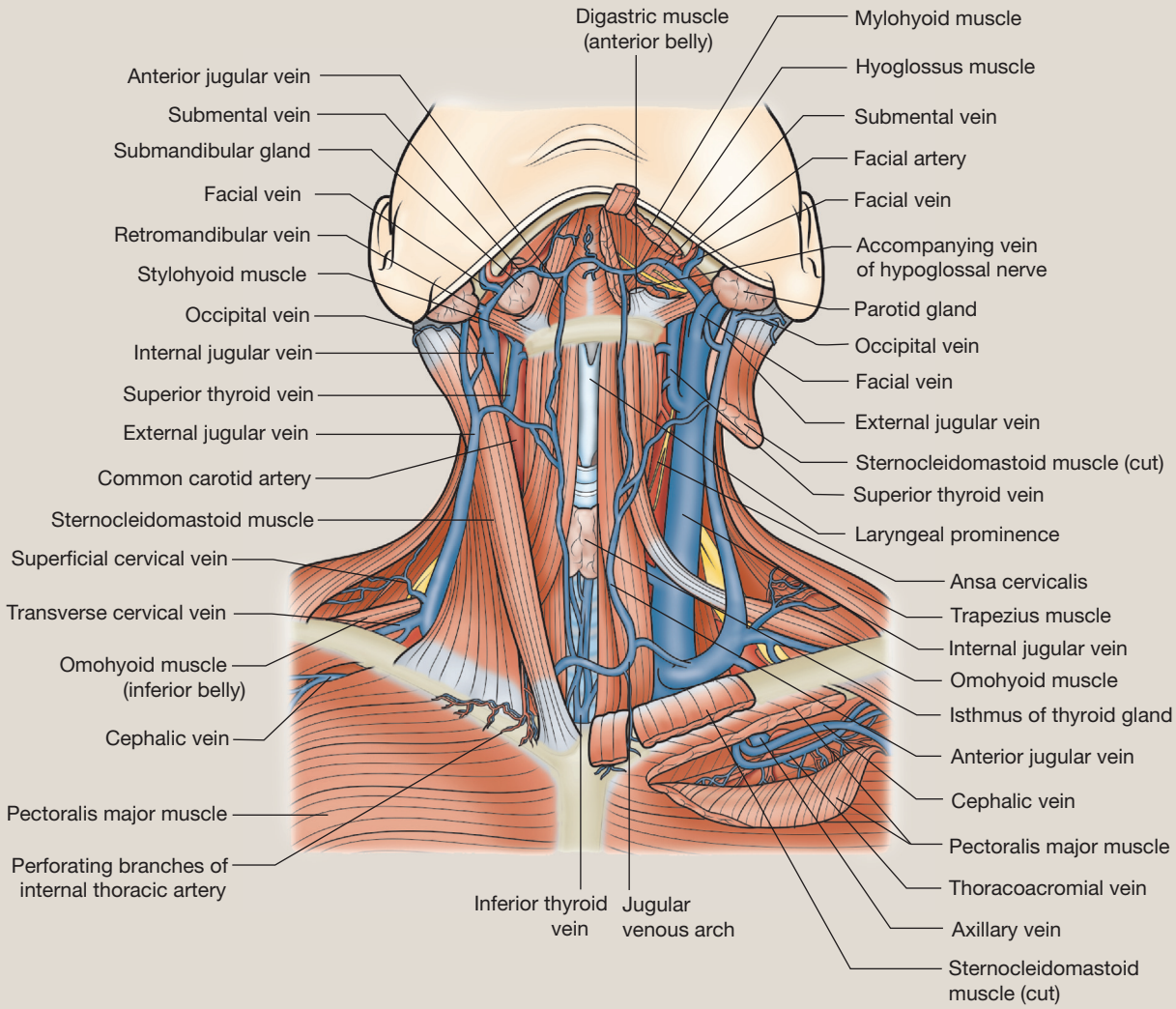
'Hard signs' of vascular injury:
- Uncontrolled haemorrhage
- Ecchymosis and rapidly expanding or pulsatile neck haematoma
- Vascular bruit or palpable thrill
- Pulse deficit
- Profound shock

'Hard signs' of aerodigestive tract injury
- Stridor and noisy breathing
- Massive surgical emphysema
- Tracheal deviation/shift (due to neck injury)
- Large volume haemoptysis/haematemesis
- Airway obstruction from blood or secretions
- Voice changes (hoarse, croaky, husky, or absence)
- Bubbling or sucking neck wounds
- Difficulty or pain when swallowing secretions

Other indications for intubation:
- Severe hypoxia and respiratory failure or apnoea
- Alteration in mental status or neurological signs
- Suspected airway burns (facial/perioral/intraoral burns/blisters/swelling, entrapment, singed nasal hairs, soot in mouth/nostrils, bronchospasm, painful swallow, difficulty swallowing secretions, or pharyngeal oedema)
- Symptomatic patients with prolonged travel times

Box 1

A diagram of key vasculature – showing the arteries and veins of the neck



Source: https://commons.wikimedia.org/wiki/File:Sobo_1911_593.png.

Figure 2

Breathing

Penetrating injuries, particularly in zone 1, can cause tension pneumothorax or haemothorax, compromising ventilation, especially when positive pressure ventilation is used. Rapid finger thoracostomy can be performed based on clinical examination with subsequent chest drain insertion.

In haemothorax, surgical intervention is indicated in the presence of:

- 1500 ml of blood drainage in 24 hours through the chest tube
- 300–500 ml/hour for 2 to 4 consecutive hours after chest tube insertion
- Great vessel or chest wall injury
- Pericardial tamponade.

If a patient does not need an emergent finger thoracostomy, a small Seldinger chest drain (pigtail percutaneous thoracostomy) may be equally as effective and better tolerated than a surgical chest drain for pneumothorax or haemothorax.

Circulation

Vascular 'hard signs' are listed above in Box 1. Treatment of bleeding should focus on surgical or interventional radiology haemostasis and blood product resuscitation. In addition to laboratory tests of haemoglobin, platelets, clotting and calcium, thromboelastography can be used. Normothermia should be targeted. Tranexamic acid administration is now standard practice in trauma management.

Neurology

There is a strong recommendation against using cervical spine immobilization in isolated penetrating neck injury as the application of a collar can hide development of life-threatening complications such as rapidly expanding haematoma, surgical emphysema, tracheal deviation, and diminished or absent carotid pulses.[5]

NICE recommend immobilization if the patient:

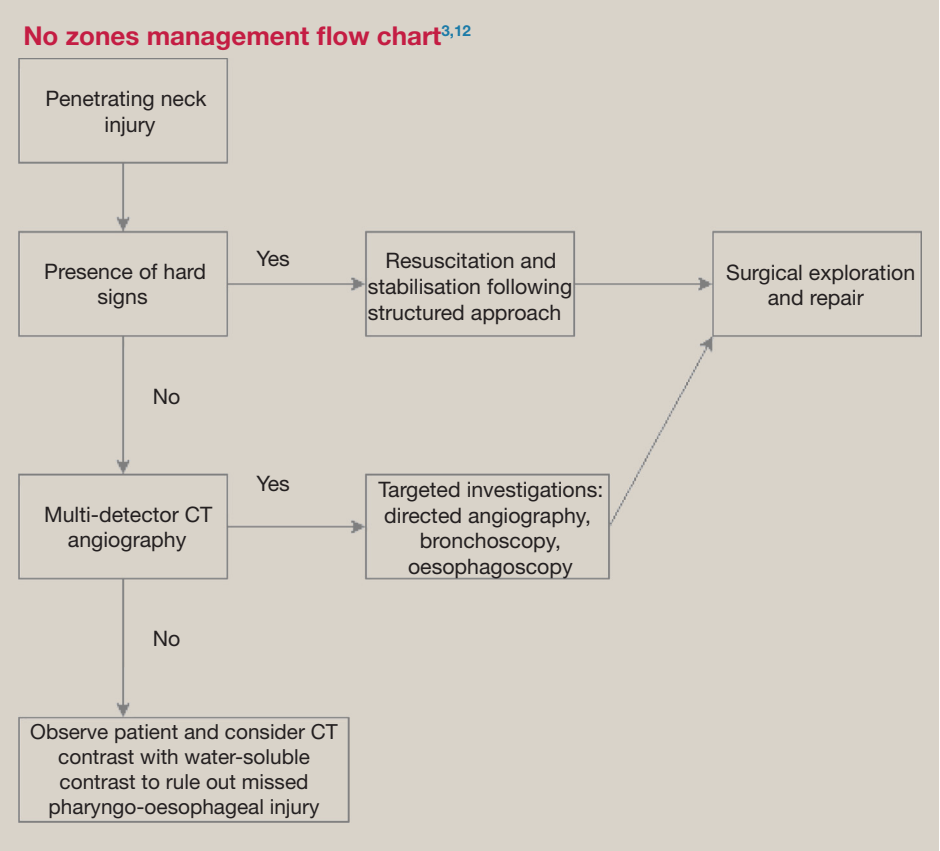


Figure 3

- has any significant distracting injuries
- is under the influence of drugs or alcohol
- is confused or uncooperative
- has a reduced level of consciousness
- has any spinal pain
- has any hand or foot weakness
- has altered or absent sensation in the hands or feet
- has priapism
- has a history of past spinal problems, including previous spinal surgery or conditions that predispose to instability of the spine.

The Canadian C-Spine rules, or the NEXUS low-risk criteria can be used to 'clear' a patient's spine.[8,11]

Supine C-Spine immobilization causes deterioration in respiratory function, increases risk of skin pressure damage, and can increase intracranial pressure in the presence of associated head injury.[11] With patients that are confused or agitated, forceful restriction can cause more harm than good.

Exposure

Antibiotic prophylaxis should be commenced in those with visceral injury, and in those with contaminated wounds requiring washout. Penetrating trauma acquired in a contaminated environment (e.g. outdoors/soil/manure) or with wounds with foreign bodies are likely to contain tetanus spores. These injuries will require cleaning in addition to tetanus immunization and prophylaxis.

Injuries to specific structures

Injuries to the vertebral column and spinal cord

Along with complete airway obstruction, high spinal cord transection following neck trauma poses the greatest risk of mortality and morbidity.[4,5,8,12,13]

Direct or indirect loading on the neck can cause significant displacement between the head and torso, resulting in excessive bending, shearing, or axial displacements.

Direct loads are the result of two mechanisms:

1. Compression—flexion. An impact on the head can result in it flexing forwards, producing vertebral wedge and burst fractures, as well as dislocations
2. Compression—extension. When an impact in the face occurs with the head in the neutral or extended position, this can result in fractured spinous processes, damage to vertebral load-bearing surfaces and/or dislocations

If there is any lateral bending or rotation of the head, the injuries will be complicated.[4,12,13]

Indirect loads tend to be generated by two main mechanisms:

1. 'Whiplash' or neck hyperextension is the result of the head being accelerated rapidly backwards following rear impact (for example, in a car with no head rests).
2. Following front impact, the head undergoes a negative acceleration resulting in it rapidly moving forwards. This can cause the most severe injuries, including vertebral fractures and dislocations.[4,12,13]

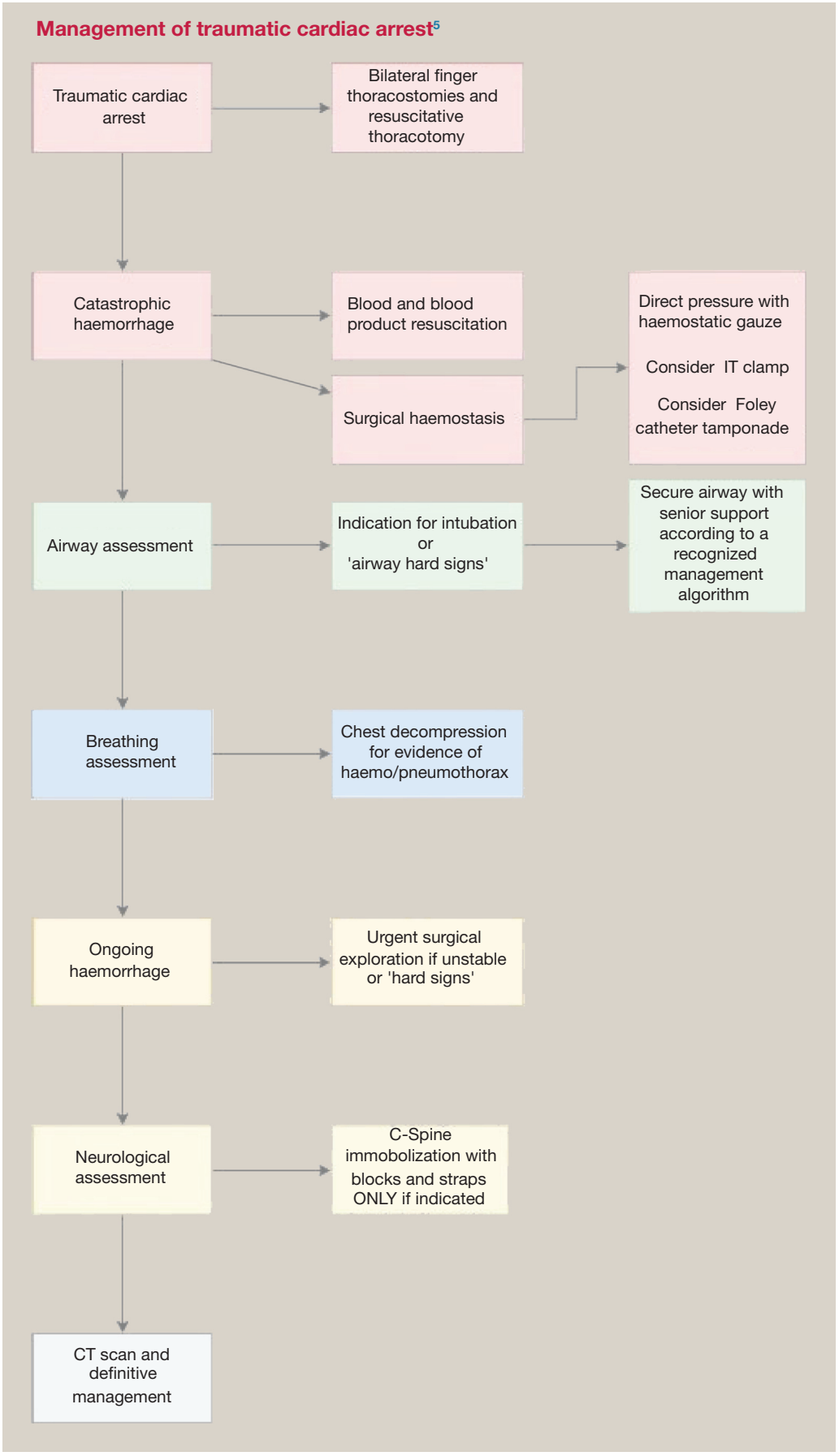


Figure 4

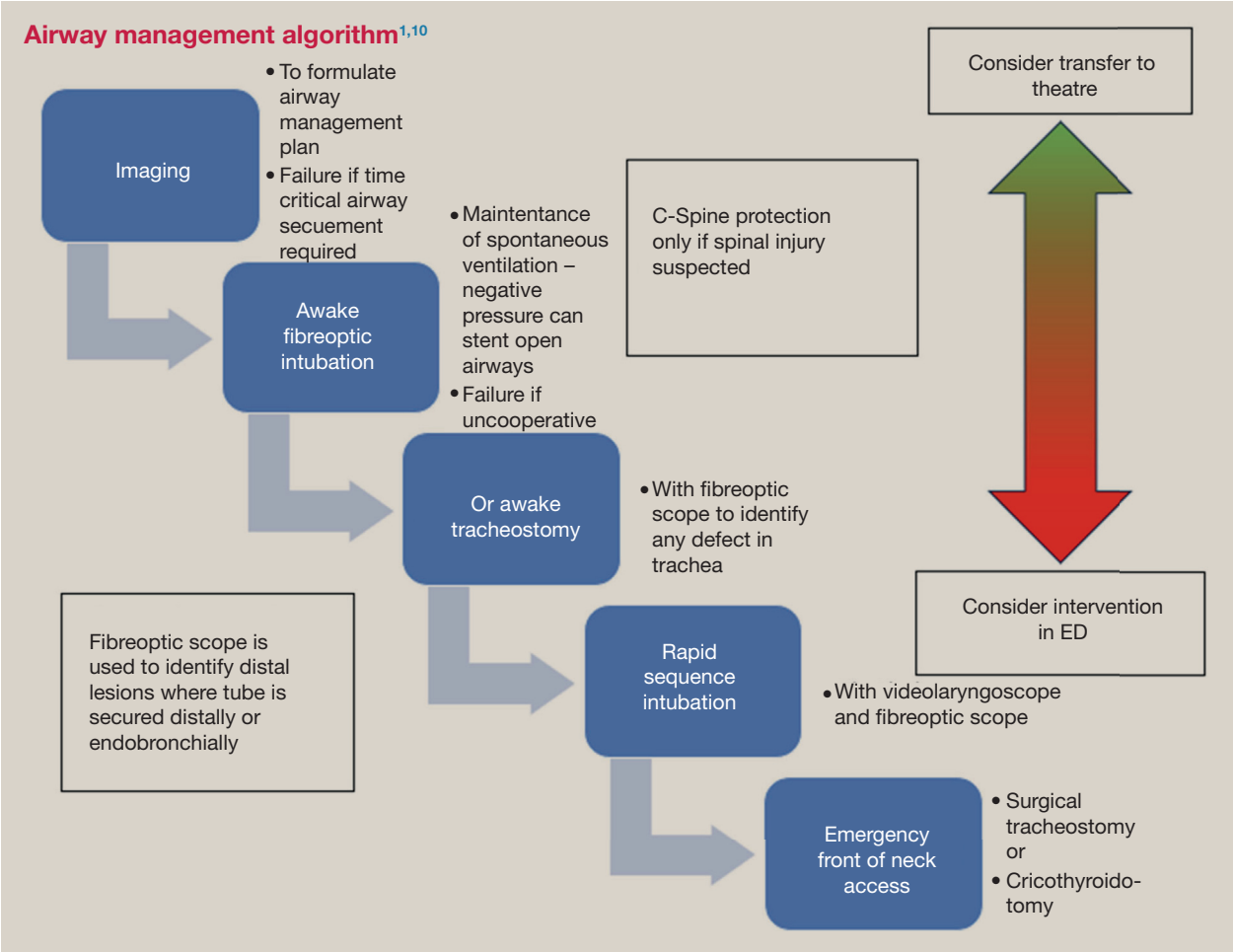


Figure 5

Incomplete cord injuries

Central cord syndrome — arm weakness with loss of sensation, temperature, light touch, and pressure below the injury — can result from neck hyperextension in older people with spinal stenosis and from neck flexion in younger people. This may only present with 'burning hands'.

Anterior spinal artery syndrome or anterior spinal cord syndrome — motor function, pain and temperature sensation loss with maintained touch sensation and proprioception — is a rare complication of traumatic flexion injuries.

Brown–Séquard syndrome — ipsilateral loss of motor function, proprioception, vibration and touch sensation, and contralateral loss of pain and temperature sensation — is caused by spinal cord hemisection in penetrating wounds (gunshot or knife wounds).

Posterior spinal artery syndrome is seldom caused by trauma.

Direct vascular injuries

Occur in 25% of penetrating neck traumas and can include partial or complete occlusion, dissection, pseudoaneurysm, extravasation of blood or arteriovenous fistula formation. Serious consequences include:

- Major haemorrhage
- Airway obstruction from blood
- Focal cerebral hypoperfusion resulting in infarction
- Neurological deficits following global cerebral hypoxia

Carotid artery injury is best repaired rather than ligated irrespective of presence of neurological deficit, and there is a range of techniques including transverse arteriorrhaphy with interrupted 6–0 polypropylene suture and vein, or thin-walled polytetrafluoroethylene (PTFE) patch angioplasty with continuous 6–0 polypropylene suture. Isolated jugular venous injuries are mild due to their low pressure.[3]

Tracheal injury

This may follow a 'clothes-line' type injury or an impact to the front of neck below the thyroid cartilage. The patient may present with significant surgical emphysema, dysphonia, or tracheal deviation. There is a high risk of airway obstruction, so prompt assessment and management is essential. There may be a question of whether to perform bronchoscopy. There should be a multidisciplinary team approach to this question, but in a patient who is already intubated and ventilated, it is minimally invasive and may provide useful clinical information.

Injuries to the larynx

Injury to the hyoid bone or larynx significantly increases mortality.[13]

Surgical management of laryngeal injuries depends on the degree of injury, which can be classified according to the Schaefer Classification (Box 2), with less severe injury favouring observation and symptomatic management. Laryngeal skeletal

Schaefer Classification[14]

Group 1: Minor endolaryngeal haematomas or lacerations without detectable fractures. Usually managed conservatively with close airway monitoring.

Group 2: More severe oedema, haematoma, minor mucosal disruption without exposed cartilage, or nondisplaced fractures. Often managed conservatively, however will need panendoscopy as the injuries may be more severe than the signs seen on flexible nasendoscopy.

Group 3: Massive oedema, large mucosal lacerations, exposed cartilage, displaced fractures, or vocal cord immobility. Likely to require a tracheostomy to secure a definitive airway prior to surgical correction of injuries.

Group 4: Same as group 3, but more severe, with disruption of anterior larynx, unstable fractures, two or more fractures lines, or severe mucosal injuries. Will require tracheostomy as a definitive airway as well as surgical fixation and stenting.

Group 5: Complete laryngotracheal separation. High mortality as the altered anatomy may make tracheostomy difficult.

Box 2

fractures can be reduced and repaired, and complete tracheal or laryngeal reconstruction is possible in higher groups (where laryngotracheal stenting can be used), with optimal treatment outcome within 24 h.[14]

Cricoid cartilage injury, if displaced, requires immediate surgical intervention to prevent airway obstruction as the cricoid cartilage completely encircles the airway and post-injury inflammation will further narrow the lumen. Hyoid bone injuries can cause tenderness, oedema, dysphagia and profuse bleeding. As well as securing the airway, management may involve excising fragments of the fracture. Thyroid cartilage fracture causes avulsion of the anterior vocal cord attachments and haematoma. This can lead to dysphonia, aphonia, or laryngeal obstruction. If displaced, it may need realignment or open reduction.

Conservative management involves maintaining nil-by-mouth, head-of-bed elevation, voice rest, NG feed, proton-pump inhibitors and anti-reflux medication, intravenous dexamethasone with or without nebulized dexamethasone, humidified oxygen and/or saline nebulizers with serial flexible laryngoscopy every 24 h. Laryngeal injuries can lead to delayed upper airway obstruction due to oedema and inflammation, and the patient should be observed in critical care.

An interval water-soluble contrast swallow test and liaison with speech and language therapy is important. Follow-up for long-term strictures should be implemented.

Oesophageal injuries

The oesophagus is normally a collapsed tube and shielded by surrounding structures, however it can be breached by penetrating wounds and the relation of the oesophagus to the cervical fascia and relation to mediastinum leads to morbidity from injury. Simple tears respond well to saline irrigation, restriction of solid food, antibiotics, and anti-reflux medication. More severe injuries require surgical direct suture repair within 12 hours. After this timepoint debridement and drainage with planned delayed repair are required due to risk of infection. Speech and language input is important with ongoing issues with swallow.

Thyroid injuries

The thyroid is superficial so is vulnerable — isolated injury to the thyroid is rare but possible with disease such as goitre. It is well-vascularized and haemorrhage or haematoma can cause immediate or delayed compression of the airway; surgical exploration is indicated. Uncomplicated haematoma can be managed conservatively, and CT scan will guide this. The thyroid stores a considerable amount of hormone which can trigger thyroid storm in hyperthyroidism.

Nerve injuries

Cranial nerves VII–XII, the sympathetic chain, peripheral nerve roots and brachial plexus can be injured, the management of which is beyond the scope of this article.

Salivary glands

The submandibular or sublingual glands are rarely injured but can be with submandibular penetrating neck trauma and can be associated with injury to the facial or lingual nerve. Blunt injury can cause chronic obstruction of the excretory system with subsequent sialadenitis. Haematoma may obscure diagnosis and sialocele is the formation of a salivary cyst where the drainage is damaged. If found to be injured at the time of neck exploration, the gland can be removed; if diagnosed later then conservative management with antisialagogues, pressure bandages and aspiration, progressing to gland removal if unsuccessful. Salivary duct injuries can be treated with distal marsupialization.

Special patient groups

Paediatric patients and pregnant patients are at increased risk of non-accidental injury and a holistic approach should be taken. Pregnancy causes increased airway and mucosal oedema, potentially adding difficulty to management of neck trauma in these patients.

In paediatrics, spinal injuries are uncommon, the cervical spine is more susceptible to damage due to larger relative head size, increased range of motion (ligamentous laxity, horizontally orientated facet joints, and weaker muscles), growth plate injury and physiological wedging of immature vertebral bodies. Semi-rigid collars are not recommended, but manual inline stabilization can be used where injury is suspected. NEXUS rules are valid in paediatrics, but the Canadian C-Spine rules have not been validated. As the spinal column is more elastic than the spinal cord, SCIWORA (spinal cord injury without radiological anomaly) can occur and can be subsequently detected on MRI. Central cord syndrome can occur in paediatrics neck trauma causes hyperextension.[15]

In the frail patient, fall from standing height can be a significant mechanism. Frailty increases mortality and adverse events, and can lead to under-triage, delayed diagnosis, and consequent sub-optimal care. ◆

REFERENCES

1 Shilston J, Evans DL, Simons A, et al. Initial management of blunt and penetrating neck trauma. *BJA Educ* 2021; **21**.
2 Kohan EJ, Wirth GA. Anatomy of the neck. *Clin Plast Surg* 2014; **41**.
3 Nowicki JL, Stew B, Ooi E. Penetrating neck injuries: a guide to evaluation and management. *Ann R Coll Surg Engl* 2018; **100**.
4 Martin T. Neck trauma management. *Surgery for Major Incidents.* 2021; **39:** 430–6.
5 Simpson C, Tucker H, Hudson A. Pre-hospital management of penetrating neck injuries: a scoping review of current evidence and guidance. *Scand J Trauma Resuscitation Emerg Med* 2021; **29**.
6 Dunn RJ, Smock W. Strangulation injuries. *Wis Med J* 2003; **102**.
7 Sheppard FR, Cothren CC, Moore EE, et al. Emergency department resuscitative thoracotomy for nontorso injuries. *Surgery* 2006; **139**.
8 Burlew CC, Moore EE, Moore FA, et al. Western trauma association critical decisions in trauma: resuscitative thoracotomy. *J Trauma Acute Care Surg* 2012; **73**.
9 Verdonck P, de Schoutheets JC, Monsieurs KG, et al. Penetrating and blunt trauma to the neck: clinical presentation, assessment and emergency management. *B-ENT* 2016; **Suppl 26**(2)**:** 69–85.
10 Owston H, Jones C, Groom P, et al. The anaesthetic management of the airway after blunt and penetrating neck injury. *Trauma* 2020; **22:** 3–6.
11 NICE. Spinal injury: assessment and initial management. *NICE Guideline* 2016; **24**.
12 Alao T, Waseem M. Neck trauma. NCBI Bookshelf, 2023.
13 Dodds N, Hollis S, Islam M, et al. Anatomical injury patterns, demographics and outcomes data for blunt and penetrating neck injuries on the Trauma Audit and Research Network database. *Bull Roy Coll Surg Engl* 2023; **105:** 70–5.
14 Malvi A, Jain S. Laryngeal trauma, its types, and management. *Cureus* 2022; **14**: e29877.
15 Gopinathan NR, Viswanathan VK, Crawford AH. Cervical spine evaluation in pediatric trauma: a review and an update of current concepts. *Indian J Orthop* 2018; **52:** 489–500.

Practice points

- Neck trauma poses a complex set of challenges; knowledge of clinical anatomy is key to identifying underlying injuries
- Mechanisms include blunt, penetrating or combined injuries
- The anatomical 'zones of injury' can be used as a communication tool
- 'Hard-signs' of vascular or aerodigestive tract injury expedite treatment
- Management follows a structured approach with the multidisciplinary team
- Unstable patients are managed with urgent surgical exploration during stabilization
- Stable patients are managed using a no-zones approach following multi-detector CT imaging