Neck trauma management

Terry Martin

Abstract

Neck trauma may result from blunt, penetrating, or combined mechanisms. Although much of this trauma is minor, the complex, vulnerable and largely unprotected anatomy of the neck predisposes to major life threatening complications from even relatively low energy transfer injury patterns. This article reviews mechanisms of injury along with the principles of investigation and management.

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

Introduction

The adage '*when you discover injury in one compartment of the body and in another more distant compartment, then you must look for injuries in the intermediate compartment*' is never more pertinent than when concerning the neck. As a flexible link between the head and the thorax, the neck is the structural support for the head and yet allows it to rotate in any combination of eight primary movements in the three cardinal planes of motion. These are anteroposterior flexion and extension in the sagittal plane (pitch), lateral flexion and extension in the frontal plane (roll), and rotation clockwise and anticlockwise in the transverse plane (yaw). However, the lack of bony protection to the anterior structures and the vital structures within the neck predisposes to devastating injuries to the upper airway, oesophagus, major blood vessels and to nerves emanating from the spinal cord and brachial plexus, the sympathetic chain and also from the brain stem (cranial nerves).

For injuries to the neck, the clearest way to start is by distinguishing between those due to blunt force and those due to penetrating trauma. Given enough force, blunt trauma to the neck can have consequences on many structures and systems, although these injuries may well be covert and patients are often unconscious and unable to give a history or describe their symptoms. In contrast, penetrating injuries may appear localized and therefore easier to manage, but carry a high risk of concurrent injury to multiple vital structures.

Mechanisms of injury

Penetrating trauma

Penetrating neck injuries, defined as those that penetrate the platysma, are reported in 5–10% of all trauma cases in the USA where stab and gunshot wounds are frequent causes.[1] The neck is described in three anatomical zones (Figure 1), and injuries which are traditionally described according to the zone of the injury.

- zone 1 – between the sternal notch and the cricoid cartilage
- zone 2 – between the angle of the mandible and the cricoid cartilage
- zone 3 – between the base of the skull and the angle of the mandible

As with many other areas of trauma surgery, the role of selective non-operative management, particularly for zone 2 penetrations, is being expanded and clarified. Many penetrating neck injuries which would have been operated upon previously are now successfully managed without intervention following advanced imaging diagnosis.[2,3]

Blunt trauma

The physical loads generated within the neck are a complex combination of bending, shear and axial forces, and given sufficient force, any or all of the following three patterns may be seen:

- Fractures of cervical vertebrae and/or damage to the ligaments and soft tissues supporting the vertebral column. The fracture mechanisms range from complete 'burst' fractures under high axial loads to minor avulsion fractures of the vertebrae processes. Some of these injuries are stable, some unstable, and some potentially unstable. Further assessment and CT imaging will direct treatment options.
- Injury to the spinal cord may result from (i) impingement by splinters of fractured bone; (ii) by bending or shearing forces between cervical vertebrae; and/or by (iii) longitudinal distraction of the spinal cord. Any damage to the spinal cord, particularly in the atlas (C1) and axis (C2), can be fatal, or lead to permanent paralysis.
- Impact damage to other vital structures of the neck may include the trachea and larynx, oesophagus, thyroid and parathyroid glands, peripheral and autonomic nerves, major arteries, veins and lymphatics.

Injuries to the vertebral column and spinal cord

Excessive bending, shearing or axial displacements can be produced by direct or indirect loading on the neck causing significant relative displacements between the head and the torso.

Indirect loads can be generated by relative head to torso displacements produced by two main mechanisms (Figure 2):

- In a seat with no head rest, a rear impact results in the head being accelerated rapidly backwards, thus producing neck hyperextension ('whiplash'). The resulting damage mainly, soft tissue, is rarely life threatening.
- In a front impact, the head is influenced by a very short duration negative acceleration in which the 'reaction' motion causes the head to move rapidly forwards. The torso moves forward somewhat slower due to the security offered by the car occupant's seat belt, but this mismatch between head and torso causes shearing stress trauma at the linkage between the two – the neck. The higher relative mass of the torso potentially produces the most severe injuries with increasing likelihood of vertebral fractures and dislocations.

***Terry Martin** BSc FRCS(Ed) FRCA is an Intensive Care Consultant and Medical Consultant Advisor for Aeromed GB and CCAT Aeromedical Training, UK. Conflicts of Interest: none declared.*

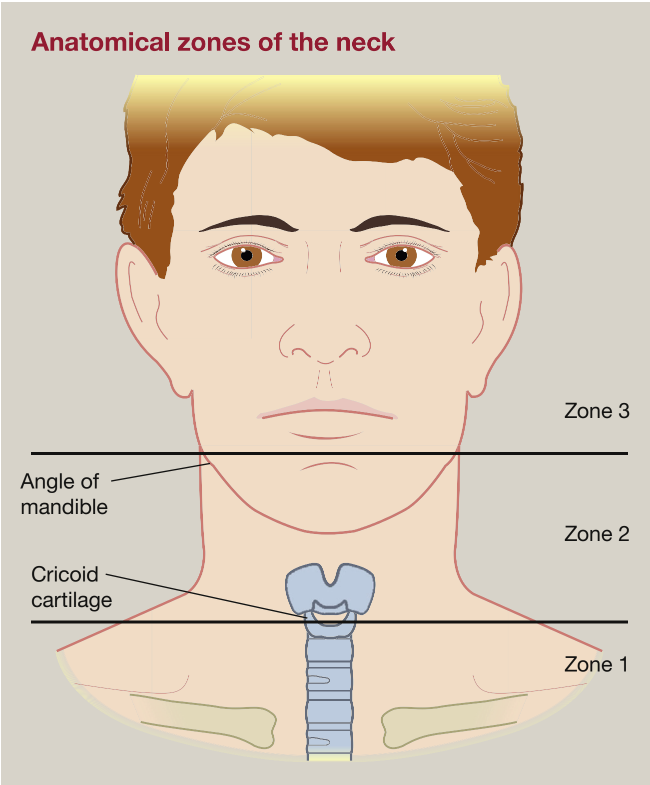

Figure 1

Direct loads fall mainly in to two major impact injury mechanisms (Figure 3):

- Compression-flexion: following an impact on the head when the head is flexed forwards. This injury often produces vertebral wedge and burst fractures, and/or dislocations.
- Compression-extension: following an impact in the face with the head in the neutral position or in extension. This injury often produces fractures of the spinous processes, damage to the vertebral load bearing surfaces and/or dislocations.

Any lateral bending or lateral rotation of the head prior to or during the impact will complicate these injuries.

Soft-tissue injuries of the anterior neck

Direct vascular injuries: Following high spinal cord transection or complete airway obstruction, injuries to major blood vessels in the neck offer the greatest risk of mortality and morbidity. The most serious sequelae of vascular trauma is not just major haemorrhage, but also includes (i) complications of airway obstruction from blood, air embolism from sucking wounds; (ii) focal cerebral hypoperfusion leading to infarction; and (iii) neurologic deficits following global cerebral hypoxia. Although direct pressure will control obvious haemorrhage, covert bleeding may only be identified by discoloration, swelling, lack of superficial pulses, and/or bruits.

Laryngeal injury: Upper airway obstruction is the second most common cause of death resulting from head and neck trauma but even a minor airway obstruction may suddenly become life threatening as swelling and inflammation develops. This may be delayed for several hours after injury. The anatomy of the larynx is complex (Figure 4), and the area of the front of the neck is relatively exposed and unprotected in frontal impacts. As such, the larynx may be crushed between a blunt object and the anterior cervical spine, leading to cartilaginous fractures, subluxation, and/or dislocation. The most common fracture of the thyroid cartilage is that of a vertical anterior split between the thyroid notch and the cricothyroid membrane producing avulsion of the anterior vocal cord attachments and haematoma.

Laryngeal injury usually produces a loud stridor but this may be absent if the obstruction is severe enough to completely occlude the airway. Other evidence of laryngeal fracture includes oedema with loss of cartilaginous landmarks, dysphonia from

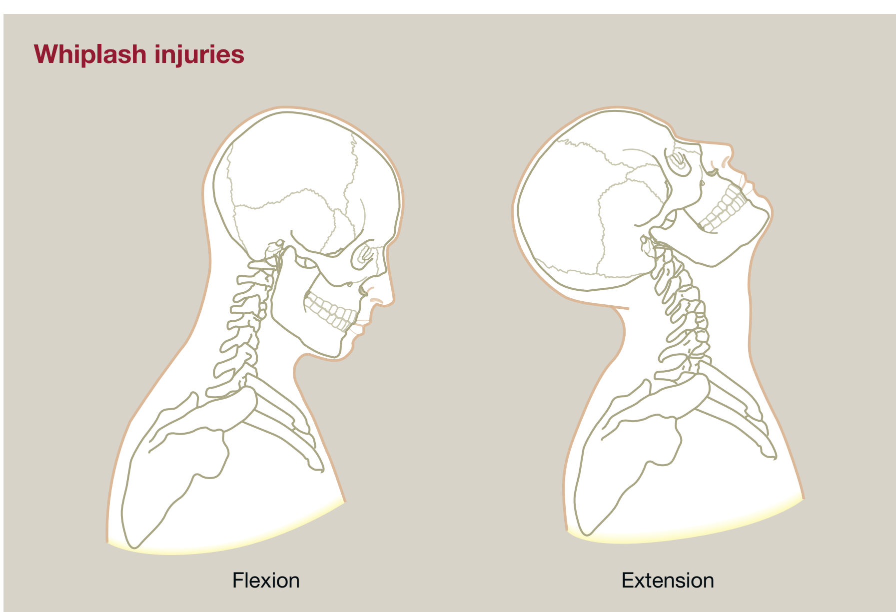

Figure 2

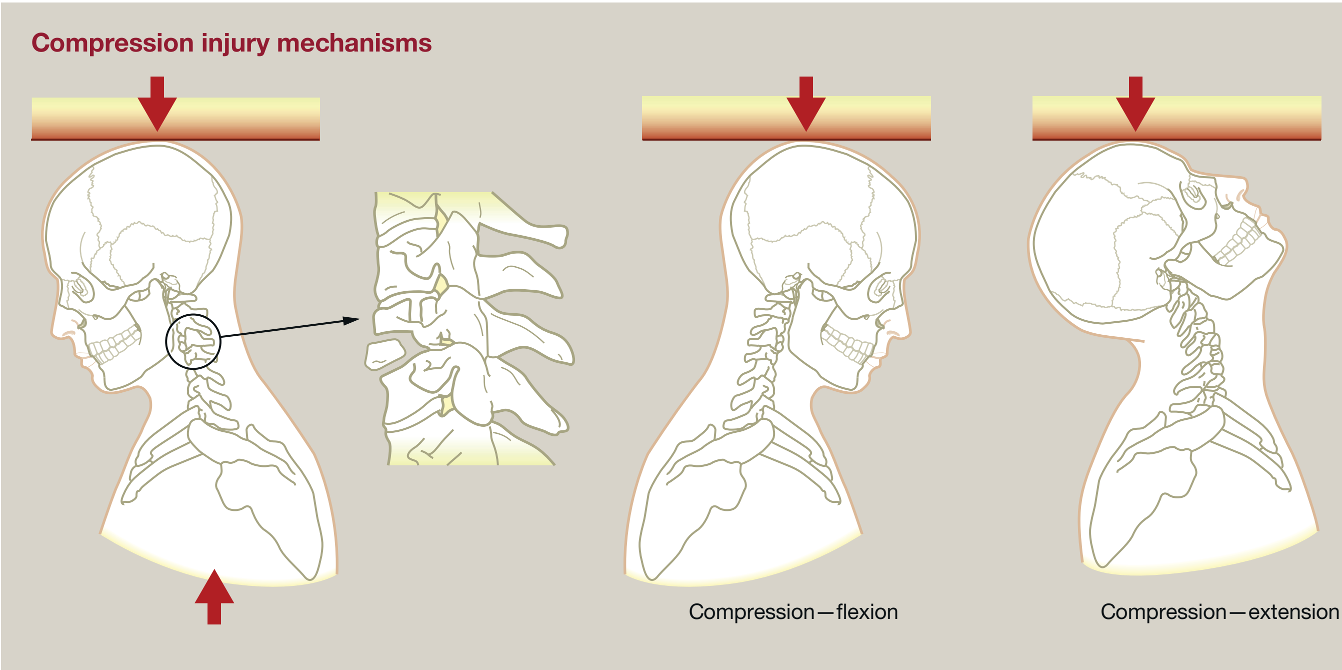

Figure 3

paresis or haematoma, pain increased by neck motion, dyspnoea, dysphagia, subcutaneous emphysema and local tenderness. A recent report[4] of a cohort of patients with laryngeal injury following endotracheal intubation reminds us that intubation alone, can cause long term problems with vocal cord damage and scarring, and that it is often unrecognized as a complication of emergency intubation and/or prolonged oral intubation in ICU. Early tracheostomy offers better outcomes, and patients with laryngeal trauma will fare better if tracheostomized initially rather than intubated by the supraglottal route if intubation is indicated.

Cricoid cartilage injuries: Since the cricoid cartilage completely encircles the airway, displaced fractures require urgent surgical reduction to prevent the danger of obstruction, especially as post-trauma inflammation will further narrow the lumen.

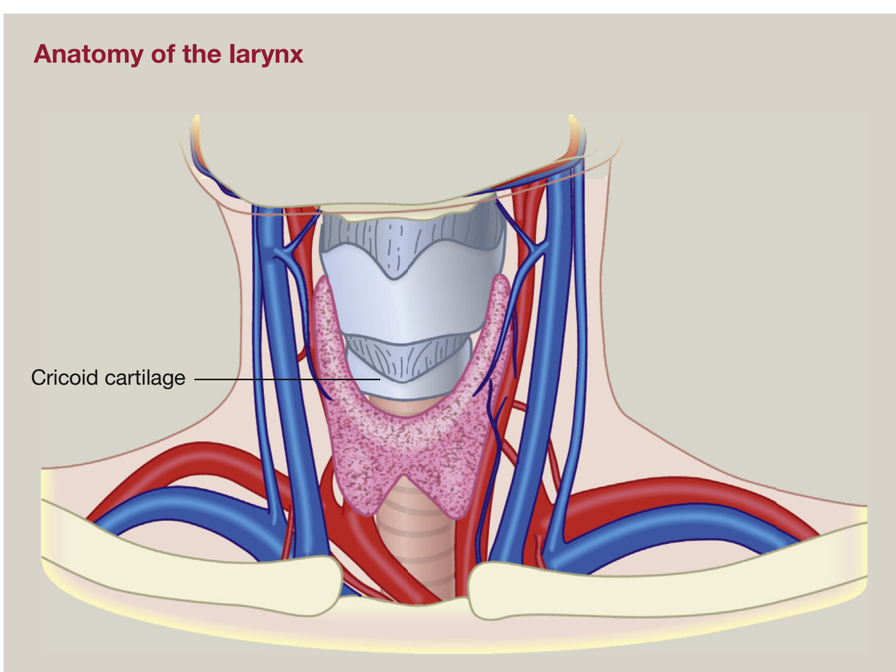

Figure 4

Visualization of the airway by laryngoscopy/bronchoscopy may help to prevent subglottic stenosis which commonly occurs if mucosal lacerations are not properly repaired.

Tracheal injury: Although rare, trauma to the trachea may follow a 'garotting' clothes line-type injury or an impact to the front of the neck below the laryngeal prominence of the thyroid cartilage. Tracheal rupture causes air to leak into neck and shoulder tissues and the impact may also cause a thyroid haematoma. The patient may present with extensive surgical emphysema around the neck (to the point of 'ballooning'), hoarseness and worsening dyspnoea, with tracheal deviation. In these cases, the high risk of airway obstruction requires rapid assessment and management, since the priority is to maintain and protect an adequate airway. Clearly, endotracheal intubation carries significant risks including possible spinal cord damage or complete airway disruption. Emergency intubation requires expert management, using faultless manual in-line immobilization or, if this cannot be guaranteed, a 'blind' technique, or an intubating laryngeal mask airway (ILMA). However, if the larynx has split from the trachea or separated between two tracheal rings, attempts at endotracheal intubation may be fatal if the ET tube is not placed securely within the lumen of the trachea. This situation requires inserting the tube below the tracheal disruption by cricothyroidotomy, tracheotomy, or, in experienced hands with the use of fibre-optic laryngoscopy/bronchoscopy[5] or by the retrograde Seldinger technique.

Oesophageal injuries: The oesophagus is normally a collapsed tube, shielded by surrounding structures. However, because it has extremely delicate walls, it can be easily breached by penetrating wounds either from within, or without the lumen. Simple tears of the oropharynx or nasopharynx respond well to saline irrigation, restriction of solid food, and antibiotics. More severe injuries require surgical repair.

Investigation following neck trauma

A whole patient approach (as per ATLS guidelines) should be standard. Following, or concurrent with <C>ABC, D (Disability) may focus more specifically on neck and spinal cord injury if not already discovered.

The investigations requested will vary depending on local resource, and likely injuries (e.g. a patient with a penetrating neck injury and normal neurology is less likely to subsequently develop cord injury than following a blunt injury, so may require fewer or different investigations).

Cervical spine clearance

Both penetrating and blunt trauma may cause unstable spinal injuries, and historically all patients with major trauma were managed with cervical collar immobilization as suspected spinal injuries. The situation is more complex than this, and increasingly, the role for cervical spine stabilization in patients following isolated penetrating neck trauma is less clear than for blunt trauma, and may actually be harmful.[6,7]

The likelihood of significant spinal injury after blunt trauma is extremely variable and dependent on the mechanism of injury. Hence, there is uncertainty about the optimal approach to screening for clinically important cervical spine injury following blunt trauma. The Eastern Association for the Surgery of Trauma (EAST) have a comprehensive review of this complex subject.[8]

Plain radiology has only limited use. Approximately two-thirds of fractures and almost half of subluxations and dislocations are not detected by plain X-rays, and one-third of patients with significant, often unstable cervical injuries, may be falsely identified as having normal spines. Thus, plain radiology may confirm suspected C-spine injury, but cannot reliably exclude it. High-quality CT scanning is preferred as the first front-line imaging method, as it is inevitably essential for definitive anatomical diagnosis.[8] If haemorrhage is suspected, the CT angiography should be done as rapidly as possible. Plain radiographs may still be used as first-line imaging procedures (such as to minimize radiation exposure, and rapid access to the procedure when compared to CT or MR), but CT must still be used to further evaluate areas that are suspicious or not well visualized on the plain films.

There are a number of practice recommendations to guide decision making regarding the use of plain Xrays, such as the National Emergency X-Radiography Utilization Study (NEXUS) criteria (Box 1).

The most recent recommendation by EAST in 2009[9], suggests a combination of the NEXUS criteria with a functional range of movement (ROM) evaluation to clear the cervical spine of asymptomatic blunt trauma patients (Box 2). Newer studies have identified and defined new clinical criteria with regard to mechanism of injury with improved sensitivity and specificity for predicting cervical spine fracture after blunt trauma, but there has been ongoing debate about the best recommended first-line imaging modality in all blunt trauma patients who do *not* meet the NEXUS criteria.

Dilemmas in clearing the cervical spine

Uncertainties remain in managing patient who are difficult to assess clinically. Prolonged cervical immobilization using a collar has a number of detrimental effects, so safe early removal is a laudable goal. Obtunded patients present particular challenges, but even an alert patient who continues to have neck pain after a normal CT scan of the cervical spine, has several possible clinical options. These include: (i) immobilizing the cervical spine with a hard collar; (ii) obtaining a dynamic flexion-extension radiograph; or (iii) early MRI. Although an injury to bony structures

National Emergency X-Radiography Utilization Study (NEXUS) low-risk criteria[6]

Cervical spine radiography is indicated for patients with neck trauma unless they meet ALL of the following criteria:

- No posterior midline cervical-spine tenderness
- No evidence of intoxication
- A normal level of alertness (score of 15 on the Glasgow Coma Scale)
- No focal neurologic deficit
- No painful distracting injuries

Box 1

EAST 2009 Recommendations for Spinal Clearance[5]

In awake, alert patients with trauma without neurologic deficit or distracting injury who have no neck pain or tenderness with full range of motion of the CS:

- CS imaging is not necessary and the cervical collar may be removed

All other patients in whom CS injury is suspected must have radiographic evaluation.

This applies to patients with pain or tenderness, patients with neurologic deficit, patients with altered mental status, and patients with distracting injury.

- The primary screening modality is axial CT from the occiput to T1 with sagittal and coronal reconstructions
- Plain radiographs contribute no additional information and should not be obtained

If CT of the CS demonstrates injury:

- Obtain spine consultation

If there is neurologic deficit attributable to a CS injury:

- Obtain spine consultation
- Obtain MRI

For the neurologically intact awake and alert patient complaining of neck pain with a negative CT:

- Continue cervical collar
- Cervical collar may be removed after negative MRI
- Cervical collar may be removed after negative and adequate F/E (dynamic) radiography

For the obtunded patient with a negative CT and gross motor function of all four extremities:

- F/E (dynamic) radiography should not be performed
- The risk/benefit ratio of obtaining MRI in addition to CT is not clear, and its use must be individualized in each institution. Options are as follows:
- Continue cervical collar immobilization until a clinical examination can be performed
- Remove the cervical collar on the basis of CT alone
- Obtain MRI
- If MRI discloses nothing abnormal, the cervical collar may be safely removed

Box 2

can be easily detected with a CT scan, debate surrounds the need for an MRI to evaluate ligamentous injuries.

Ultimately, there is controversy about the appropriate investigations, partly because the incidence of ligamentous injury in the setting of a negative CT is low (<5%), MRI is expensive, and obtaining an MRI of the cervical spine may put an obtunded, critically ill patient at significant risk. Dynamic screening of the cervical spine to assess instability may have a role in experienced hands.[10] Many centres pragmatically will simply loosen the cervical collar in obtunded patients following a normal fine slice CT of the neck, and reapply it when the patient begins to wake for clinical assessment.

Investigation of penetrating neck injuries

Because of the proximity to the thoracic outlet, all zone 1 injuries require angiography in order to determine the integrity of major vessels which might require urgent thoracic surgery as opposed to simple neck exploration. Similarly, zone 3 injuries benefit from early angiography because high internal carotid artery injuries are difficult to visualize by open exploration. However, the advent of computed tomographic angiography (CTA) offers a pluripotent imaging triage system that can now accomplish rapid, safe and non-invasive evaluation of critical neck structures to identify or exclude injuries without the need for wide open exploration.[11] Hence, screening algorithms have adopted a ‘no zone’ paradigm and some authors[12] conclude that a comprehensive physical examination, combined with CTA, is adequate triage to effectively identify or exclude vascular and aerodigestive injury after penetrating neck trauma. The authors argue that zone-based algorithms result in a higher incidence of non-therapeutic neck exploration and an increased reliance on invasive diagnostic modalities (endoscopy and angiography) with their associated risks.

For centres without access to CTA, a plain CT scan of the neck is a suitable examination for identifying the extent and location of laryngeal fractures, especially in patients who are not appropriate for flexible laryngoscopy. However, clues to the existence of an oesophageal rupture may be seen on plain chest X-ray, such as pleural effusion, pneumothorax, subcutaneous emphysema, mediastinal air or mediastinal widening. These are all suggestive, but not diagnostic, and CT improves both sensitivity and specificity for detecting ectopic air from the ruptured oesophagus. Even oesophageal contrast studies suffer a high (up to 50%) false-negative rate, so oesophagoscopy is recommended for all cases of high suspicion where radiology fails to confirm the diagnosis.

Early management of spinal cord injury

Although spinal cord injury (SCI) is not common, it has the potential to pose major problems in terms of clinical and logistic care, as well as extreme financial challenges to the healthcare providers, the state, and sometimes to the individual patients and their families. Recent global reviews of SCI have identified a broad epidemiology which show that SCI is more common amongst young men (mean age about 33 years, mode 19 years) with the incidence varying little in the developed world.

Injury can occur to any part of the cord, and the mechanism and anatomical area of injury have a high prognostic relationship. The most common causes of SCI are:

- motor vehicle accidents – 44.5%
- falls – 18.1%
- sports injuries – 12.7%.

Although in adults the most common levels of injury are C4 to C6 and the commonest level for paraplegia is the thoracolumbar junction (T12), a better indicator of function is probably the ASIA score (Table 1). Data from the USA suggest that the spread of injury severity is more often paraplegia than tetraplegia, i.e.:

- incomplete paraplegia – 21.3%
- complete paraplegia – 27.9%
- incomplete tetraplegia – 29.5%
- complete tetraplegia – 8.5%.

ASIA impairment scale

ASIA grade	Lesion	Criteria
A	Complete	No motor or sensory function preserved in the sacral segments S4 and S5
B	Incomplete	Sensory, but not motor function preserved below the neurological level including sacral segments S4 and S5
C	Incomplete	Motor function preserved below the neurological level and >half of the key muscles below neurological level have a muscle grade <3
D	Incomplete	Motor function preserved below the neurological level and at least half the key muscles below neurological level have a muscle grade >3
E	None	Motor and sensory functions are normal

Based on Marino *et al*. ASIA Neurological Standards Committee 2002. J Spinal Cord Med 2003.

Table 1

However, it should be remembered that other injuries are often associated with traumatic SCI, including bone fractures (29.3%), loss of consciousness (17.8%), and traumatic brain injury affecting emotional and/or cognitive functioning (11.5%). Blunt visceral injuries and burns are also common.

With all the variations in injury site and severity, as well as the associated complications and associated injuries, a thorough understanding of the pathophysiology of spinal trauma is needed in order to make sensible and efficacious clinical decisions. The most difficult cases are those with injury to both the spinal cord and the associated sympathetic chain. Normal physiology can be grossly deranged in these patients and the exact nature of the dysfunction depends on the level and severity of the damage.

Trauma in the high thoracic and cervical spine often involves damage to the sympathetic chain and loss of sympathetic responses below the level of the lesion. Vagus parasympathetic nerves are unaffected by spinal damage since they leave the brain above the injured zone. Since vascular 'tone' is controlled by the sympathetic nerves, a high cord injury causes blood vessels to become dilated. Sympathetic stimulation of the heart causes a tachycardia, so sympathetic injury results in unopposed vagal tone. This combination of unopposed vagal (parasympathetic) stimulation and loss of vascular tone results in neurogenic shock. This state is pathognomonically characterized by 'hypotension in the presence of bradycardia'. Such 'relative' hypovolemia caused by vascular dilation and venous pooling will worsen the physiologic effect of any true fluid losses. The bradycardia caused by unopposed vagal influence may progress to asystole when the vagus is further stimulated by procedures such as the placement of an oropharyngeal or nasopharyngeal airway, nasogastric tube, or urinary catheter. Atropine, a potent parasympatholytic agent, may be administered prior to all such manoeuvres, and ECG monitoring should be considered.

In view of the potentially significant consequences to high spinal injury, expert management in the immediate post-injury period is essential not only for survival, but also to reduce the risk of exacerbated loss of neurological function and/or permanent neurological deficit. Expert recommendations include the following essential components of the early management of suspected spinal cord injury patients:[13]

- early and accurate clinical assessment
- haemodynamic and respiratory support
- appropriate spinal column stabilization
- timely transfer to a specialist unit.

Unsurprisingly, spinal patients admitted early to a specialist spinal care unit have a decreased in-hospital rehabilitation time and fewer secondary complications compared to those admitted to non-specialist centres. Likewise, patients transferred to a spinal unit within 24 hours of their initial injury are more likely to show early neurological improvement than those who were admitted after 24 hours. This was reflected in a systematic review of prehospital interventions for patients with potential spinal cord injuries which recommends transport of patients with acute traumatic SCI to a definitive hospital centre for spinal care should occur within 24 hours of injury.[14]

Evidence suggests that decompression within 24 hours of injury (ideally within 6 hours for incomplete SCI lesions) enhances recovery after cervical SCI. Achieving this in many environments presents significant logistic issues, including patient transfers and the availability of imaging or surgical resources. ◆

REFERENCES

1. Alao T, Waseem M. Neck trauma. NCBI Resources. 5 July 2020 (Stat Pearls), https://www.ncbi.nlm.nih.gov/books/NBK470422/#article-25616.s12 (accessed 6 February 2021).
2. Burgess CA, Dale OT, Almeyda R, Corbridge RJ. An evidence based review of the assessment and management of penetrating neck trauma. *Clin Otolaryngol* 2012; **37:** 44–52.
3. Tisherman SA, Bokhari F, Collier B, et al. Penetrating zone II neck trauma. Eastern association for the surgery of trauma practice management guidelines. *J Trauma* 2008; **64:** 1392–405, https://www.east.org/education/practice-management-guidelines.
4. Lowery AS, Malenke JA, Bolduan AJ, et al. Early intervention for the treatment of acute laryngeal injury after intubation. January 28 2021. JAMA Otolaryngology—Head & Neck Surgery. JAMA Network Online, https://jamanetwork.com/journals/jamaotolaryngology/article-abstract/2775609. 06 Feb 2021 Accessed.
5. Sawhney C, Arora MK, Kumar S, et al. Initial management in blunt trauma neck. *J Anaesthesiol Clin Pharmacol* 2018 Apr-Jun; **34:** 275–6.
6. Haut EER, Kalish BT, Efron DT, et al. Spine immobilization in penetrating trauma: more harm than good? *J Trauma* 2010; **68:** 115–21.
7. Stuke LE, Pons PT, Guy JS, et al. Prehospital spine immobilization for penetrating trauma—review and recommendations from the prehospital trauma life support executive committee. *J Trauma* 2011; **71:** 763–70.
8. Hoffman JR, Mower WR, Wolfson AB, et al. Validity of a set of clinical criteria to rule out injury to the cervical spine in patients with blunt trauma. National Emergency X-Radiography Utilization Study Group. *NEJM* 2000; **343:** 94–9.
9. Como JJ, Diaz JJ, Dunham CM, et al. Cervical spine injuries following trauma: update from the eastern association for the surgery of trauma practice management guidelines committee.

J Trauma 2009; **67:** 651–9, https://www.east.org/education/practice-management-guidelines.

10 Brooks RA, Willett KM. Evaluation of the Oxford protocol for total spinal clearance in the unconscious trauma patient. *J Trauma* 2001; **50:** 862–7.

11 Drain JP, Weinberg DS, Ramey JS, et al. Indications for CT-angiography of the vertebral arteries after trauma. *Spine (Phila Pa 1976)* 2018 May 01; **43:** E520–4.

12 Shiroff AM, Gale SC, Martin ND, et al. Penetrating neck trauma: a review of management strategies and discussion of the 'No zone' approach. *The Am Surgeon* 2013; **79:** 23–9.

13 Consortium for Spinal Cord Medicine. Early acute management in adults with spinal cord injury: a clinical practice guideline for health-care professionals. *J Spinal Cord Med* 2008; **31:** 403–79.

14 Ahn H, Singh J, Nathens A, et al. Pre-hospital care management of a potential spinal cord injured patient: a systematic review of the literature and evidence-based guidelines. *J Neurotrauma* 2011; **28:** 1341–61.

FURTHER READING

Levy DB, Gruber BS. Western Trauma Association guidelines for neck trauma.
https://emedicine.staging.medscape.com/article/827223-guidelines.