The Viscera and Glands of Neck: Part III (Trauma and Injuries to the Neck)

14

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14.1 Injuries to the Front of the Neck

14.1.1 Initial Considerations

Trauma to the front and sides of the neck can be potentially life-threatening. Injuries here, place both the airway and the major vessels to the brain at risk. Minor injuries can very quickly become life-threatening, due to the many vessels and delicate structures confined to this tight space. Neck trauma can lead to follwing consequences which can be potentially life threatening. (i) external haemorrhage, (ii) soft tissue haematoma resulting in airway obstruction and (iii) impaired cerebral circulation. Neck hyperextension can result in tracheal tears, vertical fractures of the larynx and trachea, and even complete laryngo-tracheal separation. Direct blows to the neck usually result in injuries to the thyroid and cricoids cartilages. Both mechanisms may occur when the neck is hyperextended following sudden deceleration during a vehicle collision which is followed by a direct impact to the front of the neck as the victim is thrown forward onto the steering wheel. During this impact the trachea and oesophagus may also be injured following compression against the cervical spine. Sudden increases in intratracheal pressure against a closed glottis has also been reported following improper use of seat belts or high impact blunt chest trauma. The most common findings on chest x-ray are subcutaneous emphysema, pneumomediastinum and pneumothorax.

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Generally, in penetrating injuries and lacerations, if the platysma muscle has not been breeched, there is a low risk of serious injury. Conversely, it would be wise never to explore a neck wound under local anaesthetic if it extends deep to the platysma. Many important structures are in close proximity and therefore at risk, especially in the root of the neck.

Pharyngoesophageal injury is particularly difficult to diagnose and is often overlooked. It requires a high index of suspicion. In adults, blunt trauma to the front of the neck has a high risk of laryngeal fracture. Laryngeal oedema from blunt injuries may occur several hours after the injury and therefore these patients must be observed carefully. Paediatric laryngeal fractures are rare because of the elasticity of cartilage and higher position of the larynx in the neck. Common causes of injury include

A. Motor vehicle collisions
B. Sports (e.g. martial arts and racket sports)
C. Assaults, gunshot, penetrating knife wounds etc.
D. Attempted suicide
E. Inhalation of smoke, hot air or steam

Trauma to the front of the neck can present with a wide array of symptoms. Following blunt impacts, injuries that may occur include

A. Oedema/haemorrhage. The mucosa lining the oropharynx and upper airway is in most places thin, friable, easily distensible, ciliated and supported by a well vascularised but loose submucosa. It performs many functions. In addition to warming and moistening the air, the upper respiratory tract comprises the first line of defence against foreign particles and micro organisms. Mucus secretions and cilia trap particles which are then moved towards the pharynx and eventually swallowed. Antibacterial and pro-inflammatory proteins are also secreted. Following trauma, fluid exudates are rapidly produced and the entire mucosal surface can become quickly oedematous. This is seen particularly after thermal inhalation, because of the widespread distribution of the inhaled heat stimulus. Because of this, intubation is often necessary.
B. Fractured larynx. In young patients, the larynx is elastic and tends to flex. Consequently imaging of the larynx may not necessarily show any fractures. Nevertheless, at the moment of impact, the severe deformity that momentarily occurs can result in significant damage not only to the cartilage, but also to the lining submucosa. Bleeding and oedema can then result in the rapid onset of mucosal swelling, which can threaten the airway. When assessing laryngeal injuries on CT it is important to look at the thickness of the mucosa. This may give an indication of underlying injury and potential airway risk. In older patients, similar to the costal cartilages, the cartilages of the larynx often become partially calcified. This is then places the larynx at greater risk of fracture. Fractures of the larynx may then lacerate the pharyngeal mucosa, resulting in haemoptysis. In any patient that has sustained anterior neck trauma, the symp-

tom of haemoptysis should be regarded as an indication of upper airway trauma. However, often the amount of blood loss is relatively small and this may not be immediately apparent.

C. The hyoid bone is commonly fractured following attempted strangulation, martial art injuries, crash helmet related injuries or following attempted suicide by hanging. Whilst the fracture itself is usually of little consequence and does not require repair, its presence should alert to the possibility of severe airway injury.
D. The trachea can be avulsed from the cricoid cartilage (laryngo-tracheal separation). This occurs commonly following a clothesline-type injury. Total separation is usually rapidly fatal—the trachea retracts substernally and the larynx migrates superiorly. However with partial separation, the airway may remain patent, although it is at high risk. Undiagnosed tracheal injury may become evident by presence of massive subcutaneous emphysema. A lateral c-spine Xray may show subcutaneous emphysema and an elevated hyoid bone. To complicate matters there may also be an oesophageal or recurrent laryngeal nerve injury.
E. Surgical emphysema of the neck and face may be seen after penetrating or blast injuries. Air can be forcibly driven into the soft tissues following explosions. Rupture of any gas-containing organ or cavity can also result in this (notably the lungs, trachea and oesophagus). Emphysema can also arise following facial fractures and spread into the neck and mediastinum.
F. Carotid injury is uncommon but can result in delayed dissection or rupture. Consider this in any patient with unexplained neck pain and neurological deficit. Most patients remain asymptomatic or develop neurologic deficits shortly after injury. Symptoms include pain in the ipsilateral face or neck, followed by contralateral weakness or sensory loss. Horner's syndrome associated with pain is also characteristic of carotid artery injury. The interval between injury and neurological deficits can be within hours, or up to several months
G. Oesophageal injury is uncommon but rupture and mediastinitis may occur. These injuries present with subtle signs and symptoms including vague chest pain, odynophagia and subcutaneous emphysema at the thoracic outlet. The presence of mediastinal pneumatosis with associated pleural effusions on chest films should raise such suspicion.
H. Cervical spine injury should always be considered in any trauma case. This is discussed in the chapter on the back of the neck.
I. Whilst injuries to the glandular structures (thyroid/salivary glands) can also occur, these are rare and tend not to result in immediate problems, other than swelling and internal haemorrhage. They rarely require urgent intervention.

Penetrating trauma can also result in a wide array of injuries. These are partly dependent on the mechanism of injury (slash, stab, clothesline, projectile), the direction of penetration and the depth of the wound. Any of the following important structures may therefore be at risk.

A. Airway
B. Vascular—Carotid, subclavian, vertebral and venous
C. Nerve(s)—Hypoglossal, vagus, recurrent laryngeal, phrenic, facial, brachial plexus, spinal cord
D. Thorax—lungs, pleura, mediastinum, large vessels
E. Lymphatic—thoracic duct
F. Oesophageal/pharyngeal
G. Cervical Spine
H. Muscles (sternomastoid and prevertebral)
I. Glands—thyroid (rare)/salivary

In many patients some of these injuries may be symptom free initially, others more obvious. Up to 80% of the tracheobronchial injuries can be missed during the first 24–48 h due to their nonspecific symptoms and near normal ventilation. Over the next few days the airway can become be filled with granulation tissue and organising haematoma. Symptoms depends on whether airway stenosis or complete obstruction occurs. With stenosis recurrent chest infections can develop. Symptom complexes suggestive of specific injuries include

A. hoarseness, stridor, airway obstruction, subcutaneous emphysema, pain and haemoptysis. These suggest laryngotracheal Injury and injuries to the recurrent laryngeal nerve
B. dysphagia, odynophagia, haematemesis and subcutaneous emphysema suggest oesophageal or hypopharyngeal injury
C. shock, haematoma, diminished pulses, and hemiplegia are suggestive of vascular Injury.

These can occur in any combination.

14.1.2 Injuries to the Larynx

These are uncommon injuries, but may be seen following a localised impact directly over the larynx. Common mechanisms therefore include motor vehicle accidents, hanging/strangulation, contact sports (martial arts), clothesline and stabbing injuries. Injuries to the internal structures of the larynx can arise from foreign bodies, ingestion of caustic solutions, thermal and smoke inhalation and following surgical procedures (intubation and endoscopy).

Motor vehicle accidents are a common cause of external laryngeal trauma. Injury occurs when a person is not wearing a seat belt (or is only wearing a lap belt) and is subjected to rapid deceleration. This thrusts the hyperextended neck onto the dashboard or the steering wheel, resulting in a direct blow to its anterior structures. Clothesline injuries occur when a rider of a cycle or motorcycle strikes a horizontal object at neck level. These mechanisms of injury have a significant bearing on the likely type and severity of laryngeal trauma. Clothesline injuries are potentially

serious injuries, because they apply a huge amount of force over a relatively small area. Suicidal and homicidal strangulation also vary, with the latter being more likely to result in laryngotracheal separation and neurovascular injuries. These injuries can result in laryngeal oedema and airway obstruction many hours later, despite minimal clinical signs on presentation. The larynx is also susceptible to crushing-type trauma, which compresses it against the vertebral column. Despite its elastic structure, significant swelling and bleeding may still occur. Calcification begins during the third decade of life and affects men more than women. This increases the likelihood of fractures following trauma, which can result in comminution. The hyoid bone is also at risk and most commonly fractured following attempted strangulation. Penetrating trauma to the larynx is more likely to occur as a result of interpersonal violence. This commonly results in damage to multiple structures. As such, information about the type of weapon used is very useful.

External laryngeal trauma is often a life-threatening injury, which if not promptly recognised and treated can result in death or significant long-term morbidity. It is rare, with an incidence of about 1 in every 130,000 emergency department visits. Of those that survive, up to 25% of patients may be left with dysphonia, aspiration risk or airway stenosis. Internal laryngeal trauma can be caused by iatrogenic, thermal, caustic, or foreign body injuries. Inhalation injury occurs in about 5% of burn patients and 40% of patients following caustic ingestion. If not recognised and treated promptly, these injuries can lead to severe long-term complications. Internal laryngeal injury following short-term endotracheal intubation has also been reported to have an incidence of up to 10%. This increases significantly following long-term intubation and ventilation.

Conceptually, the larynx can be considered as a semi-rigid, box-like structure made of cartilage and fibrous tissue. It contains the vocal cords, ‘supraglottic’ and ‘subglottic’ spaces. The ‘paraglottic’ space lies between the lining mucosa and the cartilages. This space is potentially very distensible following bleeding and oedema. The cricoid cartilage is the only complete ring in the respiratory tract. Airflow through a tube varies in approximation to Poiseuille’s law (flow = $\pi Pr^4/8ln$, where P is the pressure, r is the radius of the tube, l is its length, and n is the coefficient of viscosity). Put simply, small changes in the radius (from swelling/oedema) can have profound effects on the flow of air through the larynx. This is analogous to blowing air through different size straws. This concept is important at the level of the vocal cords—here, the airway is at its narrowest and the mucosa can swell considerably.

14.1.2.1 Assessment and Initial Management

Trauma to the larynx is often associated with injuries to the cervical spine and brain, as well as injuries to the torso and elsewhere. Therefore all patients with suspected laryngeal injury should be managed according to Advanced Trauma Life Support guidelines, with specialist input into the management of the injured larynx itself. The overriding priority is establishing a safe airway with cervical spine protection. This is discussed in the chapter on the injured patient. With regards to the larynx, patients may present with

A. Pain or tenderness over the larynx.
B. Voice change or hoarseness.
C. Dysphagia or odynophagia.
D. Dyspnoea.
E. Stridor
F. Haemoptysis.
G. Ecchymosis of overlying cervical skin.
H. Subcutaneous emphysema.
I. Loss of the normal thyroid prominence
J. Deviation of the larynx.

In some patients, the type of stridor may indicate the location of the injury. Inspiratory stridor suggests a supraglottic or glottic obstruction (oedema or haematoma) whilst expiratory stridor generally results from obstruction in the tracheobronchial tree. Biphasic stridor (inspiratory and expiratory) implies an injury at the level of the subglottis.

A stridulous patient with respiratory distress may require an immediate tracheostomy under local anaesthesia. Endotracheal intubation should be approached with caution in suspected laryngeal injuries as this can exacerbate the injury and may not be possible due to distortion of the anatomy. In selected cases cricothyroidotomy may be helpful as a temporising measure.

Once the patient's cervical spine has been stabilised, the neck is inspected for abrasions, bruising and any wounds. It is gently palpated for crepitus, haematoma, laryngeal tenderness and any obvious distorted laryngeal anatomy (such as loss of the prominence). Open wounds should not be explored immediately. Flexible nasoendoscopy should be performed as soon as practical, depending on the patient's clinical condition and the oropharynx and hypopharynx also examined for injuries. The laryngeal mucosa is assessed for lacerations, haematomas, exposed or protruded cartilage and vocal cord movements during phonation. Impairment of movement may indicate structural damage or recurrent laryngeal nerve injury (following penetrating injuries).

14.1.2.2 Imaging

Multislice CT is now performed in most patients with neck trauma or impending airway obstruction (once the airway has been secured), or in stable patients with clinical suspicion of injury. It is important to remember that laryngeal trauma is associated with cervical spine fracture in about 10% of cases. All but the most minor of laryngeal injuries should be considered to be a distracting injury when clearing the spine.

14.1.2.3 Classification of Laryngeal Trauma and Management

Laryngeal trauma can be classified according the Schaefer-Fuhrman system.

Group 1: Minor endolaryngeal haematomas or lacerations; no detectable fracture
Group 2: Oedema, haematoma, minor mucosal disruption without exposed cartilage; nondisplaced fracture; varying degrees of airway compromise

Group 3: Massive oedema, large mucosal lacerations, exposed cartilage; displaced fracture(s); vocal cord immobility
Group 4: Same as group 3 but with severe mucosal disruption, disruption of the anterior commissure, an unstable fracture, two or more fracture lines
Group 5: Complete laryngotracheal separation

In many cases, definitive treatment must be provided within 24 h. Initial measures include steroids (to reduce oedema), antibiotics, anti-reflux medications (to minimise laryngeal inflammation), cool humidified oxygen (prevent crust formation and reduce ciliary paralysis) and voice rest. Patients should be admitted to a high-dependency unit and regularly reviewed, including serial flexible nasoendoscopy. If possible the head of the bed should be elevated to help resolve laryngeal oedema. A mixture of oxygen and helium should be available in case the patient develops respiratory problems. Many patients can be managed medically. However if there is evidence of increasing compromise to the airway, a definitive airway will be required in the form of endotracheal intubation or tracheostomy. This is decided on (i) the stability and extent of the injury to the laryngeal framework, (ii) the extent of mucosal injuries, (iii) any injury to the vibratory apparatus and (iv) the integrity of the laryngotracheal junction.

The main indications for surgical repair of the larynx are displaced, unstable, or comminuted laryngeal fractures, laryngotracheal separation or extensive mucosal disruption. Immediate exploration should be performed in patients with progressive subcutaneous or mediastinal emphysema, pneumothorax, severe dyspnoea or associated oesophageal trauma. In all other patients the optimal timing of repair is a controversial, but is usually within 12 h of presentation. Delays in repair can result in granulation tissue and scar formation which can progress to laryngeal stenosis. Cartilage fractures themselves may be repaired using miniplate fixation. These tend to heal by fibrous union but without fixation may fail to regain their original anatomic shape. Endolaryngeal stenting is controversial. The need for endolaryngeal support must be balanced against the possibility of further mucosal injury. In cases of massive laryngeal injury with significant tissue loss, partial or total laryngectomy may be indicated although this is rare.

All patients with laryngeal trauma should be followed up regularly for 12 months. Long-term morbidity may include laryngeal stenosis, dysphonia and aspiration. Patients with vocal cord paralysis should be carefully observed for recurrent laryngeal nerve recovery. If dysphonia persists with vocal cord paralysis, vocal cord medialisation procedures can be considered to improve phonation.

Schafer's classification of laryngo-tracheal trauma and management algorithm

Group	Symptoms	Signs	Management
Group 1	Minor airway symptoms	Minor hematomas Small lacerations No detectable fractures	Observation Humidified air Head of bed elevation
Group 2	Airway compromise	Oedema/hematoma Minor mucosal disruption No cartilage exposure	Tracheostomy Direct laryngoscopy Oesophagoscopy

Group	Symptoms	Signs	Management
Group 3	Airway compromise	Massive oedema Mucosal tears Exposed cartilage Vocal cord immobility	Tracheostomy Direct laryngoscopy Oesophagoscopy Exploration/repair No stent necessary
Group 4	Airway compromise	Massive oedema Mucosal tears Exposed cartilage Vocal cord immobility	Tracheostomy Direct laryngoscopy Oesophagoscopy Exploration & repair/stent required

14.1.2.4 Paediatric External Laryngeal Trauma

The neonatal larynx lies at the level of C3 and descends during the first 3 years of life to the level of C6. The paediatric larynx is smaller than the adult larynx, more elastic and the laryngeal mucosa is less firmly adherent to the cartilaginous framework. Thus, whilst the paediatric larynx is better shielded, if an injury does occur it is more likely to result in severe mucosal oedema, haematoma formation and loss of the airway. In children it is usually not possible to perform tracheotomies under local anaesthetic. The child is therefore managed along the same lines as acute epiglottitis (see the chapter on the throat).

14.1.2.5 Iatrogenic Injury

Despite major advances in endotracheal intubation, this remains the most common cause of laryngeal trauma. Injuries include pharyngeal or laryngeal lacerations, cricoarytenoid joint dislocation and damage to the lingual, hypoglossal and laryngeal nerves. It has been reported that approximately 10% of patients have signs of injury 24 h after intubation. With long term intubation the incidence of laryngotracheal injuries increases to 90%, with long-term sequelae occurring in 10% of patients. In adults, intubation can result in pressure necrosis, perichondritis, granulation tissue formation and ultimately scarring with airway narrowing. The subglottis is the narrowest part of the paediatric airway, thus most iatrogenic injuries occur here. The larynx can also be injured by a poorly placed, high tracheostomy.

14.1.2.6 Chemical and Thermal Injury

Caustic and thermal injuries can result in severe laryngeal and tracheal strictures. This is rare. The majority of injuries are caused by ingestion of alkaline substances and the larynx is involved in about half of these. Caustic ingestion is almost always accidental in children, but in adults it is almost always from attempted suicide following ingestion of large volumes of liquid. Ingestion of alkali results in necrosis of the tissues and an injury that worsens over time. Thermal injury to the larynx occurs following inhalation of superheated air. Inhalation injuries occur in about one third of burn patients. One fifth of these have extensive laryngeal injury.

All patients with caustic or thermal laryngeal injuries should be admitted for airway observation. The full extent of airway compromise may not be evident until 24 h after the injury. Once an inhalation injury is diagnosed, a multidisciplinary

team consisting of otolaryngologists, respiratory physicians and respiratory therapists should be involved. The first priority is the provision of a safe and secure airway, followed by cardiovascular resuscitation using standard burn protocols. The role of endotracheal intubation is controversial due to the risks of iatrogenic glottic and tracheal stenosis. The upper aerodigestive tract should be evaluated regularly with flexible nasolaryngoscopy. In cases of caustic injury, the entire upper aerodigestive tract should be irrigated to remove any residual substances. If microlaryngoscopy, tracheobronchoscopy, or oesophagoscopy, are required these should be undertaken within 24 h of injury. After this time, oedema and ulceration are more marked and instrumentation becomes more difficult. Treatment is dependent on the nature and extent of the injuries and the development of scarring.

14.1.3 Tracheal Injuries

These injuries tend to occur following clothesline-type mechanisms, such as a blow to the front of an extended neck, falls or an impact with the handlebars of a cycle during braking. Blunt trauma directly to the trachea usually compresses the trachea against the cervical spine. This results in temporary deformation of the tracheal cartilage and soft tissue lacerations. This injury is rare because of the flexibility and mobility of the trachea, and the protection provided by the mandible, manubrium and clavicles. Because the trachea is closely associated with the major vessels, nerves, larynx, and oesophagus, injury to these structures is also frequently present. Injury to the thyroid although uncommon should also be suspected.

Owing to the serious nature of this injury, many patients die before reaching hospital. However if there is no major vascular injury, there may be sufficient time for the patient to be transferred from the scene of the injury. Symptoms of tracheal injury may be easily overlooked, especially if the patient has other serious injuries. Important symptoms include anterior neck pain (particularly when swallowing or moving the neck), dyspnoea and cyanosis (also made worse on moving the neck), dry cough, haemoptysis, hoarseness, and dysphagia. Surgical emphysema is a very worrying sign, suggesting a tear somewhere in the lumen of trachea (or any air containing structure). There may also be extensive bruising and vocal cord paralysis with aphonia. It is important to remember that emphysema can extend into the chest resulting in pneumothorax and pneumomediastinum on a chest x-ray. With partial tracheal disruption, the trachea may appear to be normally positioned. Although significantly damaged there may be a false passage within the surrounding soft tissues which allows a low level of (ineffective) ventilation. The severity of the injury may therefore not be obvious, and initially there may be no dyspnea. Any positive pressure ventilation (during anaesthesia) will then result in the sudden onset of massive emphysema.

If the airway is patent, the most important part of the initial assessment is to determine whether tracheal disruption is partial or complete. Features of partial tracheal rupture include gradually worsening dyspnoea, haemoptysis, hoarseness,

and subcutaneous emphysema. In complete tracheal disruption, the skin of the anterior neck moves in and out during respiration and a gap in the trachea may be felt beneath the skin. With closed injuries it is important to obtain a neck and chest X-ray, or if the patient is stable a CT scan. Bronchoscopy in stable patients will determine the precise location and extent of injury. The first priority is to maintain the patency of the airway, if necessary with intubation or tracheostomy. However these need to be undertaken with extreme caution as they can further to displace any tears resulting in total loss of the airway. Early repair of these injuries is usually indicated.

14.1.4 Hyoid Bone Fracture (Garrotter's Throat)

These are rare. However with the increasing popularity of martial arts the incidence has increased slightly. Both striking and choking techniques are common mechanisms of injury. Fracture of the hyoid is also associated with strangulation. The rarity of this injury is due to protection from the mandible and the hyoid's mobility. Age has also been suggested as another protective factor. Prior to fusion, the elastic cartilaginous structures of the hyoid may offer protective mobility from injury. The average age of hyoid bone fracture has been reported to be between 15 and 55 with an average age of 35. Patients typically present with sharp anterior neck pain and tenderness, aggravated by talking, coughing and swallowing. Changes in the voice may also occur. Dyspnoea, stridor and crepitus are occasionally seen. Rarely the sharp ends of the hyoid lacerate adjacent structures resulting in haemoptysis, subcutaneous emphysema and even and external carotid artery pseudoaneurysm. Diagnosis can usually be made on plain film radiography (lateral C Spine) or CT scan. Fractures occur mostly in the body or the greater cornua of the hyoid. Management involves observation for 48–72 h. Further treatment is dependant on whether or not there is perforation of the laryngeal or pharyngeal mucosa. Usually, the fracture itself does not require repair. A soft diet and analgesia help with pain control. If the larynx or pharynx are perforated removal of the fractured bone and suturing may be indicated. The prognosis for uncomplicated fractures is generally good, even if there is non-union (Fig. 14.1).

14.2 Oesophageal Injuries

Oesophageal injuries are uncommon in trauma, representing only 0.1% of all trauma admissions following penetrating injury. Because they are rarely seen, these injuries are the most frequently missed injuries in the neck. Most occur in association with airway injuries because of their close relationship. Blunt oesophageal perforation is even less common and tends to involve the cervical oesophagus. Isolated oesophageal trauma following external trauma to the neck is very unusual, but can occur as a result of barotrauma (around the dehiscence of Killian—see the chapter on the Throat) and following injury from the thyroid cartilage. Iatrogenic injuries

Fig. 14.1 Uncomplicated fracture of the hyoid bone with intact airway managed conservatively

following intubation and oesophagoscopy can also occur. Whatever the cause, early diagnosis is crucial as spillage of oral and gastric contents can result in mediastinitis, abscess formation and even death.

Although there are no pathognomonic signs for oesophageal injury, crepitus and surgical emphysema are often seen following rupture of the oesophagus, hypopharynx and larynx. Other features include severe chest or lower neck pain, dysphagia, odynophagia and blood in the saliva. Dyspnea, hoarseness, stridor, dry cough, neck pain and tenderness suggest airway involvement. Patients who present late may show signs of sepsis. A systemic inflammatory response usually develops within 24–48 h after perforation. This quickly develops into a severe bacterial and chemical mediastinitis and may result in cardiorespiratory collapse and multiple organ failure (MOF). Patients with suspected oesophageal perforation should therefore be admitted and investigated urgently. Physical examination is unreliable and plain radiographs or CT of the neck and chest may demonstrate surgical emphysema, pneumomediastinum or pneumothorax. Panendoscopy or contrast swallow studies using water soluble contrast are then indicated, according to local protocols.

Conservative management consists of nil by mouth status, broad-spectrum antibiotics and either enteral nutrition via a nasogastric tube (passed under radiological

guidance) or parenteral nutrition. Patients may initially need to be managed on an ICU. Proton pump inhibitors (PPIs) should also be prescribed. However, if the patient presents late and has evidence of a mediastinal collection then exploration and drainage of any pus is indicated. Various clips and stents have been devised in the management of oesophageal perforation, but their role is still unclear. The prognosis of traumatic injury is favourable, if treated early.

14.2.1 Blunt Injuries

Blunt cerebrovascular injury (BCVI) is often occult and asymptomatic. Therefore rapid screening is usually required. It occurs in about 1% of patients following blunt force trauma, commonly motor vehicle collisions, assaults, falls and hanging. BCVI may also follow unaccustomed physical exercise such as bodybuilding or car pushing. Cases have even been reported following chiropractic manipulation, 'headbanging', prolonged telephone usage (with flexion of the neck) and child-birth. Both carotid and vertebral artery injuries can occur as a result of stretching and tearing of the intima following rapid extension or flexion of the neck, torsional force or direct impact. The internal carotid artery is thought to stretch over the lateral masses of the third and fourth cervical vertebrae. Dissection can then occur as blood passes through the tear in the vessel wall. As the intramural clot expands it blocks the lumen of the artery. It can also weaken the subadventitial tissues, resulting in a dissecting aneurysm. Similarly, the vertebral artery is vulnerable to stretch following fractures of the transverse process of the cervical vertebrae that involve the foramen transversum. This may then undergo thrombosis, dissection, spasm or aneurysm formation.

Patients may present with non-specific symptoms such as headache, neck pain, Horner's syndrome, cranial nerve palsies, a cervical bruit and brain or spinal cord ischaemia. In others there may be no obvious signs, particularly if there are distracting injuries or the patient is intubated. A high index of suspicion is therefore necessary based on the mechanism of injury. Initial investigations include CT Angiography of the neck. Magnetic resonance imaging (MRI) and magnetic resonance angiography (MRA) can provide further information regarding intraluminal obstruction (double lumen and string sign—a thin string of intravenous contrast material is seen distal to a stenosis), blood flow, length of any dissection, arterial wall thickness and the age of any haematoma. MRI of the brain will show early signs of ischaemic infarction.

Management of these injuries is currently controversial and includes anticoagulation if there are no contraindications. Endovascular techniques have a limited role in the management of aneurysms. Indications for stenting include an enlarging pseudo-aneurysm, progressive dissection and surgically inaccessible symptomatic lesions. Surgery may be indicated in patients with reversible neurological deficits secondary to vascular occlusion. Low level injuries sited at the thoracic outlet can be very problematic because these involve large vessels which are difficult to

expose. Unstable patients should be taken immediately to theatres. Stable patients should have urgent imaging to define the site and extent of the injury.

14.2.2 Hanging and Strangulation

These terms are often used interchangeably, but strictly speaking are different. Hanging can be considered as judicial (or 'complete'—where the victim is fully suspended), or non-judicial ('incomplete'—where some part of the body is still in contact with the ground). Another classification is based on the location of the ligature knot. 'Typical' hanging refers to the knot being placed in the midline, directly under the occiput. This results in a higher likelihood of arterial occlusion. 'Atypical' hanging refers to all other knot placements. Strangulation can be manual, ligature or postural (as a result of the victim's own body weight compressing the anterior neck against a firm object).

Judicial hanging is designed to result in a high cervical fracture (i.e. "hangman's fracture", through both pedicles of C2), with complete cord transection and (hopefully) instantaneous death. Attempted suicides however tend to result in venous congestion, with stasis of cerebral blood flow and eventual unconsciousness. Compression of the airway does not usually play a significant role. Once the person is limp, the ligature can tighten further, resulting in arterial occlusion and brain death. Vagal reflexes arising from the carotid body may also cause fatal dysrhythmias. Pulmonary complications are frequently associated with survivors. These include pulmonary oedema, bronchopneumonia and acute respiratory distress syndrome (ARDS). Pulmonary oedema can be centrally mediated (neurogenic) or post-obstructive (following significant negative intrapleural pressure). Neurogenic pulmonary oedema is often associated with a very poor prognosis.

Clinical features may include the presence of ligature marks, fingernail scratches, abrasions, and contusions around the neck. Tardieu's spots are petechial haemorrhages in the conjunctiva, mucous membranes, and skin above the ligature marks. These have important implications in forensic medicine and occur following rupture of the capillaries. Laryngeal injuries may also occur, with fractures of the thyroid cartilage seen in about half of non-judicial hanging deaths. Fractures of the hyoid bone occur in 20%. Cricoid fractures are more commonly seen following manual strangulation. Vascular injury can result in delayed carotid artery dissection or thrombus formation. This is uncommon. Cervical spine fractures, subluxations and cord injury are all uncommon, but seen in non-judicial hangings.

Resuscitation is indicated even if the patient is unconscious. The initial Glasgow Coma Scale score is not predictive of outcome. All patients should be assumed to have cerebral oedema and raised intracranial pressure. Imaging should be undertaken in all unconscious patients and those with unexplained neurologic deficits. Following head CT and neck CTA, ventilatory support is provided as necessary. Positive end expiratory pressure prevents pulmonary oedema. Induction of mild hypothermia has also been reported to provide some benefit.

14.3 Penetrating Neck Injuries

Penetrating neck injuries can follow low or high energy projectiles. Historically these have carried a high mortality rate and frequently required mandatory neck exploration. However management has evolved over the last few decades, largely as a result of improvements in imaging and endoscopic techniques. Selective neck exploration is now undertaken in most low-velocity penetrating injuries. However these injuries can be deceptive and therefore need careful assessment. Involvement of the airway, vascular, gastrointestinal, skeletal and CNS can all occur, depending on the location and mechanism of injury. Almost half will involve vascular structures. Patients with zone I injuries (at the base of the neck) are at the highest risk. Spinal cord injuries and thrombosis of the carotid arteries account for around 50% of all deaths from penetrating neck injury.

14.3.1 The Zones of the Neck

This concept applies more to vascular trauma, but is applicable to all forms of penetrating neck injury. The neck is divided into 3 zones.

Zone I—the base of the neck to the cricoid cartilage. Structures within this zone include (i) the proximal common carotid arteries, (ii) Vertebral and subclavian arteries, (iii) Subclavian, innominate, and jugular veins, (iv) Trachea, (v) Recurrent laryngeal and vagus nerves, (vi) oesophagus and (vii) Thoracic duct.

Zone II—this is between the cricoid cartilage and the angle of mandible. Structures within this zone include (i) Carotid arteries, (ii) Jugular and vertebral veins, (iii) pharynx, and larynx, (iv) Proximal trachea, (v) Recurrent laryngeal and vagal nerves and (vi) Spinal cord.

Zone III—this is located above the angle of the mandible. Structures within this zone include (i) Extracranial carotid and vertebral arteries, (ii) Jugular veins, (iii) Spinal cord (iv) Cranial nerves IX–XII and (v) Sympathetic trunk (Fig. 14.2).

It is important to remember that the zone of injury only refers to the site of entry. With higher energy injuries, the wound may pass into another zone, cross the midline or pass even further into the face, cranium, or chest. In a stable patient with a suspected vascular injury in zone I or III, vascular imaging is essential. These are difficult sites to surgically explore. CT angiography or angiography are usually undertaken. Zone II injuries may also require CT angiography, MRI angiography, oesophagoscopy, bronchoscopy, contrast swallow, USS, or angiography depending on the injuries suspected. However zone II is easier to access surgically and in the presence of an expanding haematoma with tracheal deviation and impending airway compromise, immediate surgical exploration maybe undertaken. Endovascular techniques such as stenting have also been reported to be effective in selected cases, thereby avoiding surgery.

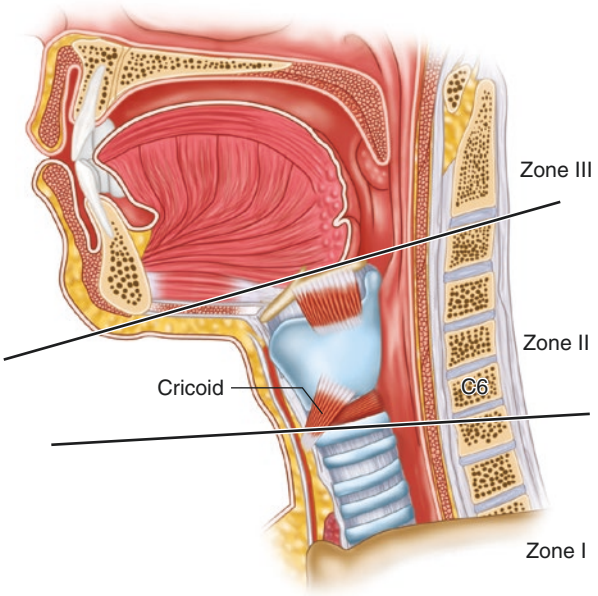

Fig. 14.2 Zone of the neck

Patients can present with a multitude of symptoms and signs, depending upon the structures that have been damaged. However they can also present with minimal findings. Symptoms and signs include

A. Airway injury—Dyspnoea, haemoptysis, surgical emphysema, stridor, hoarseness, and dysphonia. Injury to the recurrent laryngeal nerve will lead to vocal cord paralysis
B. Vascular injury—"Hard signs" include (i) a bruit or thrill—this suggests an arteriovenous fistula (ii) Expanding or pulsatile haematoma (iii) Pulsatile or severe haemorrhage and (iv) Pulse deficit. The anatomical site itself is not considered to be a high-risk feature. "Soft signs" include (i) Hypotension and shock (ii) non-growing, nonpulsatile haematoma and (iii) Neurologic deficit that develops over a few hours—this suggests ischaemia.
C. Gastrointestinal tract injury—Surgical emphysema, crepitus, dysphagia, odynophagia, drooling, and haematemesis.
D. Thoracic Duct Injury. These are seen following penetrating injuries in Zone I or II on the left side. They are rare and represent less than 1% of all penetrating neck injuries. Signs include leakage of milky fluid from the wound, or a soft swelling in the root of the neck. Most injuries are discovered during exploratory surgery. Occasionally injuries may present late with a chylothorax.

E. Glandular wounds (Thyroid, parathyroid and salivary glands), are reported rarely. Leakage of clear fluid from upper neck wounds may suggest saliva.
F. Nerve injury—Injury to accessory nerve will result in ipsilateral shoulder weakness, injury to greater auricular nerve will lead to hypoaesthesia over the ipsilateral ear. With upward directed wounds to the side of the neck, the facial nerve or its lower branches can be transected. Injuries to the Brachial plexus are discussed in the chapter on the back of the neck.

Investigations are tailored towards the suspected injuries. In the vast majority of cases the first line of investigation is CT, including CT angiography. This has the advantage of being rapid and providing an accurate overview of the entire neck and help determine if there has been an injury to any structures within the neck. This can be especially useful when considering pharyngoesophageal injuries. Conventional angiography, although often perceived as the "gold standard" is limited solely to the assessment of the carotid vessels and their branches. Duplex ultrasonography is non-invasive, convenient and relatively inexpensive, but its sensitivity in detecting vascular injury is highly operator dependent. Multidetector helical CT angiography has therefore now largely replaced all these other modalities in stable patients. CT may also identify injuries to the larynx, trachea, brachial plexus, thyroid and cervical spine. However it cannot be used to confidently exclude oesophageal injury. Oesophagoscopy is therefore often required in suspected pharyngo-oesophageal injuries. This may be combined with contrast-enhanced studies. Further evaluation of any airway injury often requires fibre-optic visualisation. Although MR angiography can be used to delineate blunt carotid and vertebral artery injuries, its use in penetrating trauma is limited because of the potential presence of metallic foreign bodies.

Management requires the expertise of several disciplines. The initial approach is always along the lines of ATLS as detailed elsewhere. Airway injuries can quickly obstruct and may require endotracheal intubation or a surgical airway. Haemorrhage should be controlled with direct pressure only. Pharyngeal packing for severe oral bleeding may also be necessary. This will require the patient to be intubated even if the airway is self maintained. Intravenous access should be established on the side opposite to the injury to avoid potential extravasation of fluids. Emergency thoracotomy may be indicated for patients with zone I injuries who have refractory shock.

Spinal immobilisation should also not be forgotten and should be put in place following airway and haemorrhage control. Depending on the clinical picture, surgical exploration of the neck may be required either immediately or following investigation with CT. CT should also include the chest. Penetrating injuries can sometimes extend to great depths, injuring structures that would perhaps not normally be considered. This can include the apices of the lungs and contents of the mediastinum. The GCS, pupils and upper limbs should also be carefully examined. In those patients not requiring immediate surgery, entry and exit wounds need to be carefully assessed. Superficial wounds should be closed only if the depth is clearly visualised. If in doubt wait until it has been assessed by an appropriate specialist. If there is any concern about internal jugular vein injury (and possible air embolism) the patient should be placed in the Trendelenburg position (table tipped head down by 15–30°).

14.3.2 Key Points to Remember

A. Airway management is the first priority. Approximately 10% of patients present with airway problems
B. Cricothyroidotomy, tracheostomy or endotracheal intubation may be required early.
C. To avoid air embolism, the patient should be supine or in Trendelenburg's position.
D. Direct pressure only should be used to control active haemorrhage from the neck. Probing open neck wounds deep to the platysma should be avoided.
E. Intravenous access should be placed on the opposite side in Zone I injuries
F. Prophylactic antibiotics, tetanus toxoid and nasogastric tube placement should be considered.
G. Radiological imaging can not reliably rule out oesophageal injury.
H. Remember to carry out a thorough neurologic examination and assess the upper limbs.
I. Transcervical wounds are associated with a high mobility and mortality. The most common injury is vascular, followed by spinal cord, although anterior injuries often involve the viscera of the neck.

14.3.3 Tracheostomy

A tracheostomy is an artificial opening made in the trachea through the front of the neck. This may be created surgically with a scalpel, or percutaneously. A tracheostomy tube is then placed through this opening. This may be temporary or permanent. The tracheostomy enables air to enter the lungs directly, bypassing the nose, pharynx and larynx. It also provides easy access to the trachea and bronchial tree for suctioning. Tracheostomy is not generally considered to be an emergency procedure by non-head and neck specialists. If emergency surgical access to the airway is required a surgical cricothyroidotomy is usually recommended, using a scalpel/bougie technique (see the chapter on the injured patient). Nevertheless, in experienced hands an emergency tracheostomy may provide urgent access. Tracheostomies are more commonly undertaken in the critical care setting. They are often placed in patients requiring long term ventilation, or to facilitate weaning from ventilation. Indications for tracheostomy therefore include

(i) To bypass upper airway obstruction, for example by a foreign body or acute swelling of the soft tissues (infection, anaphylaxis, angioedema). In this scenario a short-term tracheostomy is required. More lasting damage to the upper airway (for example from chemical or inhalation burns) may require long-term tracheostomy.
(ii) Prevention of aspiration and airway protection. Some patients may be unable to maintain an airway independently. This may occur following injury or diseases affecting cranial nerves V, VII, IX, X or XII, damage to the brain stem,

or in patients with very low levels of consciousness. This places the airway at risk from aspiration of food, drink and saliva. In these patients tracheostomy may be short- or long-term, using a cuffed tube

(iii) Assist with tracheo-bronchial toileting (suctioning). Sometimes the patient's bronchial secretions cannot be cleared normally—they are too thick, or the patient cannot cough effectively.

(iv) Elimination of dead space to improve respiratory insufficiency (respiratory, cardiac or neurological disease)

(v) When long-term ventilation is required. Prolonged endotracheal intubation can damage the soft tissues of the pharynx and trachea, resulting in mucosal ulceration, laryngeal stenosis and granulomas. Patients need to be sedated so it reduces their ability to communicate. It also increases the work of breathing by extending the dead space. Tracheostomy reduces these problems and can help in the process of weaning from artificial ventilation.

(vi) Following extensive subcutaneous emphysema from a ruptured lung or viscus in a ventilated patient (under positive air pressure). This air needs to 'escape'. If not allowed, it will continue to collect, resulting in cardiac tamponade and tension pneumothorax.

(vii) In extensive head and neck procedures

Whilst there are no absolute contraindications to tracheostomy, anatomical factors such as a high-riding innominate artery, or a thyroid mass or goitre may affect the choice of technique (percutaneous vs. surgical).

14.3.4 Surgical Technique

In essence, the tracheostomy tube is placed via a small skin incision, midway between the cricoid cartilage and the suprasternal notch, through an opening (fenestration) between the second and fourth tracheal rings. The skin incision can be either horizontal or vertical, depending on the surgeon's preference. Once this has been made the deeper soft tissues are separated, at all times keeping to the mid-line of the neck. Successful tracheostomy requires a good understanding of anatomy, careful dissection through the correct tissue planes and meticulous haemostasis. As the strap muscles are separated the thyroid isthmus often comes into view and may restrict access to the trachea. This may need to be ligated and divided. Since the thyroid is such a highly vascular organ, carelessness at this stage can result in significant bleeding post-operatively and a return to theatre. Once the anterior part of the trachea is reached, the overlying fibrous tissues are cleared and the anterior wall is opened (using a vertical slit, small window, or superior based 'Bjork' flap). The endotracheal tube is then withdrawn and the tracheostomy tube inserted into the tracheal lumen under direct vision (Fig. 14.3). If the tube is cuffed, this should be checked prior to commencing the tracheotomy—now would not be a good time to find out the cuff has a hole in it. In non-urgent cases a fibre-optic light source in the trachea can assist in the dissection. Passing a scope through the tracheostomy tube

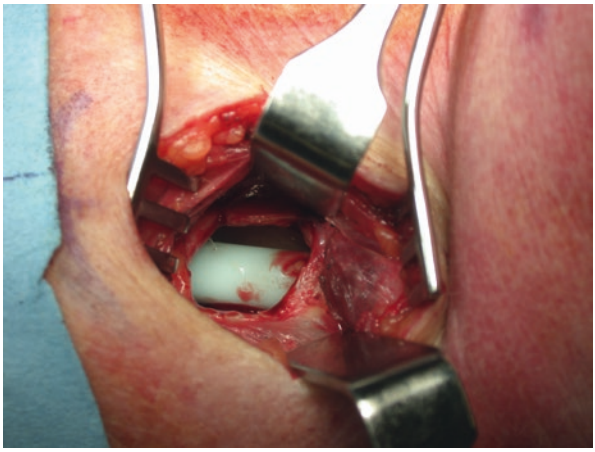

Fig. 14.3 Tracheostomy fenestration being made and endotracheal tube seen in situ

once it has been placed can also confirm its correct position. Once the tube is in place, the cuff is gently inflated and the anaesthetist confirms good gas exchange. The flanges are then sutured to skin and securely fastened around neck with tapes. The wound is then closed, but not airtight. It is important that air can escape through the wound if positive pressure ventilation is applied. Although the tracheostomy tube may be cuffed, this is not completely airtight and air under pressure can leak out of the hole in the trachea, into the surrounding soft tissues. If this occurs under the sufficient pressure the air can then track down into the mediastinum with a risk of cardiac tamponade and pneumothorax. Sutures should be removed at 7 days post operatively. The first tracheostomy change should take place 7–21 days after the initial operation, depending on local protocol and the status of the patient.

14.3.5 Types of Tracheostomy

Tracheostomies may be temporary, long term or permanent. They may also be classified by the method of insertion—surgical or percutaneous.

Temporary This is placed in patients requiring short term respiratory support, or when they cannot maintain patency of their own airway. Facial trauma and large abscesses often require a temporary tracheostomy to facilitate repair and recovery. Tracheostomy may also be required in patients with head and neck cancers prior to definitive treatment (surgery or chemoradiotherapy), in anticipation of post operative airway oedema. The tracheostomy tubes are removed when airway obstruction resolves.

Long Term/Permanent This is usually placed in patients that require long term ventilation or have an incompetent larynx. This can occur in some head injury and

severe stroke patients, who are unable to maintain their airway and clear secretions because of the neurological deficit.

Percutaneous Tracheostomy This is the most commonly used technique in critical care, as it is simple, quick and can be performed at the bedside. It uses the Seldinger technique, similar to the technique used in central vascular access. The procedure involves the insertion of a needle through a small incision in the midline of the neck, into the trachea, through which a guide-wire is passed. The needle is then removed, leaving the wire in situ and the tract is gradually enlarged by inserting a series of dilators over the wire, until the stoma is large enough to fit a suitably sized tube. Percutaneous tracheostomy insertion should be performed under tracheoscopy guidance—a flexible endoscope is passed via the endotracheal tube to visualise the needle and dilators entering the trachea. This should ensure correct placement and avoid inadvertent pre/paratracheal insertion, or posterior tracheal wall laceration. Incorrect placement of the tracheostomy tube can lead to loss of the airway, surgical emphysema, pneumothorax, tracheo-oesophageal fistula and potential death.

14.3.6 Tracheostomy Care

The essential aspects of care are:

Maintain Airway This is especially important for first 48 h to prevent accidental dislodgement of tube. Ensure the tracheostomy tube is sutured to the neck skin, clean the inner cannula daily.

Infection Control The presence of the tracheostomy tube, retained secretions and stoma in a debilitated and often immunocompromised patient, all increase the risk of infection. It is therefore important that adequate infection control procedures are in place when caring for these patients (Alcohol gel, handwashing, gloves, sterile equipment etc.). For further advice contact the infection control team.

Humidification This prevents tracheal crusting and mucous plugs. Since tracheostomies bypass the normal processes of humidification, filtration and warming of inspired gases, this can result in increased viscosity of mucus secretions, depressed ciliary function and reduced mucocilary transport. Retained thick secretions can then become infected and result in atelectasis. Overtime obstruction of the airways and tracheostomy tube blockage can occur. Humification reduces this and allows more effective expulsion and suction of secretions. It is also important to ensure the patient is adequately hydrated. Tracheal humidification can be provided by a heated humidifier or Heat and Moisture Exchanger (HME) or a Tracheostomy bib filter.

Heated humidification delivers gas at body temperature saturated with water. The temperature is set at 37 °C delivering a temperature ranging from 36.5 °C to 37.5 °C at the tracheostomy site.

Tracheostomy Bibs These consist of a specialised foam that traps the moisture in the expired air. On inspiration the foam moistens and warms the air that passes into the airway. These are changed daily or more frequently as required.

Pulmonary Toileting Tracheostomy tubes usually require regular suctioning for the first few days. However, suctioning should not be excessive as this can lead to trauma in the tracheal lumen and granulation tissue formation. The patient should first be assessed for signs of sputum in the airways. If the patient can cough secretions into the top of the tracheostomy tube these can be can be removed with a clean yankauer sucker. For deeper secretions an appropriately sized catheter is required. Under sterile conditions, this should be inserted without suction, to the carina to stimulate a cough and then withdraw applying continuous suction. This should take no longer than 10–15 s and ideally no more than three times in any one session.

Care of the Inner Cannula This may vary from hospital to hospital. Some tracheostomy specialist recommend that inner cannulae are regularly inspected to prevent narrowing and blockage of the tube. This should be done at least four hourly at first, but this may be required more or less frequently dependant on the quantity and thickness of the patients secretions. Disposable inner cannulae should be discarded if soiled and a new one inserted. Non disposable inner cannulae should be cleaned according to the manufacturers' instructions.

Skin Care Care of the stoma is commenced in the immediate post-operative period, and is ongoing. Daily cleaning of the stoma is recommended using 0.9% sterile saline solution.

Secretions can ooze out of the stoma site resulting in wetness around the tracheostomy site. This can cause irritation to the skin with maceration and excoriation. The wound site should be assessed at least once every 24 h (including the back of the neck where the tape is passed). If there are signs of wetness or irritation a barrier cream may be applied. If the wound is infected advice should be sought from the wound care team for complicated wounds. Appropriate dressings should prevent skin breakdown around the stoma.

Check Cuff Pressure Cuff pressure should be less than capillary perfusion pressure (<25 cm H_2O) to prevent pressure necrosis and subsequent subglottic stenosis, tracheal-innominate artery erosion and tracheomalacia.

Feeding Impairment in laryngeal function may pose an increased risk of aspiration during oral intake. Swallowing and protective reflexes may be affected by a number of mechanisms.

(i) Reduced elevation of the larynx
(ii) Tracheal irritation
(iii) Reduced laryngeal closure
(iv) Compression of the oesophagus by the tracheostomy tube cuff
(v) Reduced subglottal air pressure with reduction or elimination of airflow through the glottis
(vi) Poor reflexive cough
(vii) Poor co-ordination of glottic closure
(viii) Reduced laryngeal sensitivity
(ix) wasting of the laryngeal muscles

Not all patients with tracheostomies will have swallowing problems, but it can be difficult to ingest solid food when the cuff is inflated. If there are no concerns regarding aspiration, the cuff can be deflated to facilitate oral feeding. Assessment of swallowing function by a SLT is required prior to the commencement of oral feeding in patients, identified as being at risk of dysphagia. Fiberoptic Endoscopic Evaluation of Swallowing (FEES) and Videofluoroscopy may be required to assess the pharyngeal and laryngeal anatomy and physiology before, partially during, and after the swallow.

Oral Hygiene Patients that cannot eat and drink should be encouraged or assisted to maintain their oral hygiene by using a toothbrush and toothpaste and intermittently swilling their mouths with water or chlorhexidine. Patients should have a daily assessment of their oral mucosa for infections, or ulceration. A swab should be taken of any suspicious areas.

When transferring patients, appropriately trained personnel should be with them at all times. Mobile humidification should be available. Although tracheostomies provide direct access to the lower respiratory tract for suctioning, many patients find it difficult to produce an effective 'explosive' cough, to clear secretions from the lungs. They can however be taught to expectorate, by 'huffing' with the diaphragm. With a cooperative and well humidified patient, very little suction is required. Most patients can effectively clear their lungs on their own.

14.3.7 Decannulation

Tracheotomy tubes should be removed as soon as possible (especially in children) to prevent long-term sequelae (notably tracheal ulceration, subglottic stenosis and tracheomalacia). Decannulation can take place following successful weaning and

with MDT agreement. Prior to decannulation, patients may undergo downsizing and a trial of capping, but this is not always necessary. Flexible nasendoscopy can also evaluate airway patency and ensure there is no obstruction. The patient should be able to manage their own secretions, not be aspirating oropharyngeal secretions and be able to cough up bronchial secretions. Once the tube is removed an airtight dressing is placed to seal the stoma. This usually heals without complications. Sometimes a tracheocutaneous fistula may persist especially in immunocompromised or poorly nourished patients. This can be corrected with a surgical closure if necessary.

14.3.8 Types of Tracheostomy Tubes

The main components of a tracheostomy tube are essentially the same between different designs. The tube shaft is arc shaped and can be either a single tube (cannula) or dual cannula, with an inner and outer tube. It may have a cuff to provide an airtight seal and enable positive pressure ventilation and reduce the risk of aspiration. For ease of insertion it is supplied with an obturator. A neck flange helps secure the tube to the skin of the neck. Short term tracheostomy tubes have a connector to allow attachment to ventilatory equipment. Long term tracheostomy tubes are more low profile to be more discreet. Tubes are usually described by (i) the presence or absence of a cuff at the end (cuffed/non cuffed), (ii) the presence or absence of an inner cannula (single/double lumen), or (iii) the presence or absence of a window in the side wall (fenestrated/non fenestrated). They can also be made from different materials and be different sizes and lengths.

When placing a tracheostomy, the length and diameter of the trachea can vary and are chosen on the basis of the patient's body habitus (neck size especially). These should be selected according to the diameter and length of the tube, rather than the manufacturer's "size", which is not standardised between models nor manufacturers. The outer diameter of the tube should be about 2/3 to 3/4 of the tracheal diameter. As a general rule, for most adult females an outer diameter of 10 mm is appropriate, whilst an outer diameter of 11 mm is suitable for most adult males. The longer and thinner the inner diameter of the tube the greater the work of breathing will be (like sucking through different size straws). The ideal length of a tube is such that its tip lies a few centimeters above the carina. If it is too short it may accidentally fall out or partially obstruct, if it is too long it may lead to discomfort and coughing. Laryngectomy stomas will not usually need a tube, unless the patient needs oxygen, suctioning, respiratory support or protection of their lungs from aspiration. It is essential that staff know the type of tube in place and if the patient has a tracheostomy or laryngectomy patient. This should be clearly documented in the patient's notes and on a sign above the patient's bed.

14.3.8.1 Cuffed Tubes

Cuffed tubes have a soft balloon around the distal end which can be inflated to seal the airway. These are necessary when positive pressure ventilation is required or

where airway protection is required to minimise aspiration (although cuffed tubes are not a complete barrier). If the tracheostomy tube lumen is occluded with the cuff inflated, the patient will not be able to breathe.

14.3.8.2 Non-cuffed Tubes

These allow much more air flow into the pharynx as there is more space between the external circumference of the tube and the tracheal lumen. They tend to be used in patients who only require suction to clear secretions or when weaning patients prior to decannulation. These tubes will not facilitate positive pressure ventilation as the gas will escape around the tube. Patients must have an effective cough and gag reflex to prevent aspiration.

14.3.8.3 Fenestrated Tubes

Fenestrated tubes have an opening on the outer cannula, which allows air to pass through the patient's oropharynx as well as the stoma. This allows the patient to phonate. If necessary, the fenestration can be occluded with an non-fenestrated inner tube. Fenestrations increase the risk of aspiration. Suctioning should only be performed with the non-fenestrated inner cannula in situ. This ensures correct placement of the suction catheter.

14.3.9 Non-cuffed, Fenestrated Tube

These tubes are common in patients discharged from critical care.

14.3.9.1 Non-cuffed Tube, Non-fenestrated

Most of the air flows into lungs via the tube. However some air leaks past the tube into pharynx and mouth.

14.3.9.2 Single Lumen Tubes

These are less complicated than double cannula tubes and are usually temporary. The tubes can be cuffed or uncuffed. The large inner diameter allows better ventilation when the cuff is inflated. However, if they become occluded with secretions, they need to be changed. These tubes are not commonly used, as tube blockage cannot be managed easily.

14.3.9.3 Double Lumen Tubes

These have an outer cannula to keep the airway open and an inner cannula which acts as a removable lining to facilitate cleaning of the tube. Some inner cannula are disposable, others must be cleaned and re-inserted. This type of tube is the safest outside the critical care environment, although the inner cannula must be regularly cleaned.

14.3.9.4 Adjustable Flange Tubes

These tubes are used in patients who have abnormally large necks (very large girth/obese, oedema, following surgery). The flange can be adjusted to alter the length of

the tube. Care must be taken that the tube is not so long that the inferior end extends into one of the bronchi. This should be checked using an endoscope.

14.3.9.5 Mini Tracheostomy

A mini tracheostomy involves the insertion of a small 4 mm non-cuffed tracheostomy tube. It is sometimes used to facilitate removal of secretions. However it does not protect the airway from aspiration and cannot provide a definitive airway.

14.3.9.6 Speaking Valves

These are one-way valves that fit over the end of the tracheostomy. They allow the patient to breathe in through the tracheostomy, but not out. Expired air therefore passes up through the larynx and out of the mouth. This can allow the patient to talk. As air cannot flow out through the tracheostomy, these valves can be dangerous in patients that have upper airway obstruction. Speaking valves should be used with a fenestrated tube or uncuffed tube.

14.3.10 Complications of a Tracheostomy

Tracheostomy generally has a relatively low incidence of complications and most of these can be avoided by meticulous surgical technique and postoperative care. Some complications can be serious and sometimes fatal. The most common serious complications are haemorrhage, tube obstruction and tube displacement. Others include

Pneumothorax
Surgical emphysema
Tracheal stenosis (Figs. 14.4 and 14.5)
Ulceration, and/or necrosis of trachea with granulation tissue
Tracheal-innominate artery erosion
Subglottic stenosis
Vocal cord paralysis (the recurrent laryngeal nerve runs alongside the trachea)
Chest infection
Tracheo-oesophageal fistula
Scarring
Tracheocutaneous fistula

14.3.10.1 Blocked Tracheostomy Tube

Inserting a tracheostomy bypasses the natural clearance and humidification mechanisms, such that the lungs will receive cool, dry air. This reduces the function of the cilia and their ability to clear secretions. The patient may also be unable to cough. Secretions can collect resulting in blockage with thick, dry material. This can be minimised with humidification, tracheal suction and inner tube care. If there is a suspicion the tracheostomy tube is blocked, the inner cannula should be removed in the first instance. A suction catheter or preferably an endoscope should be passed into the tracheostomy tube to evaluate if there is a blockage.

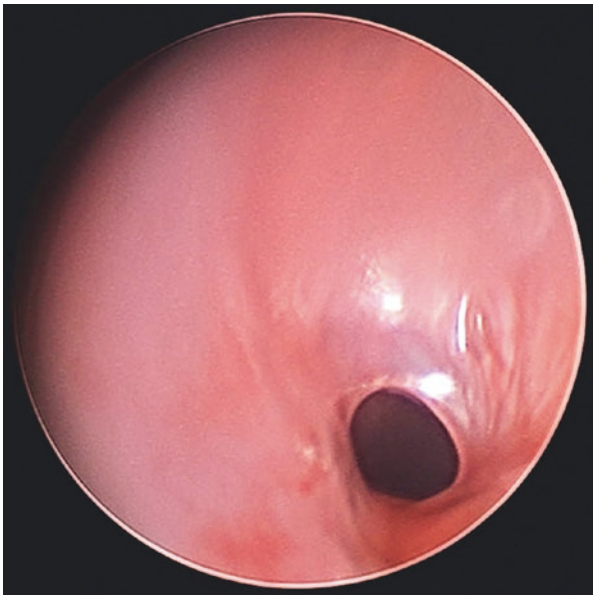

Fig. 14.4 Severe tracheal stenosis

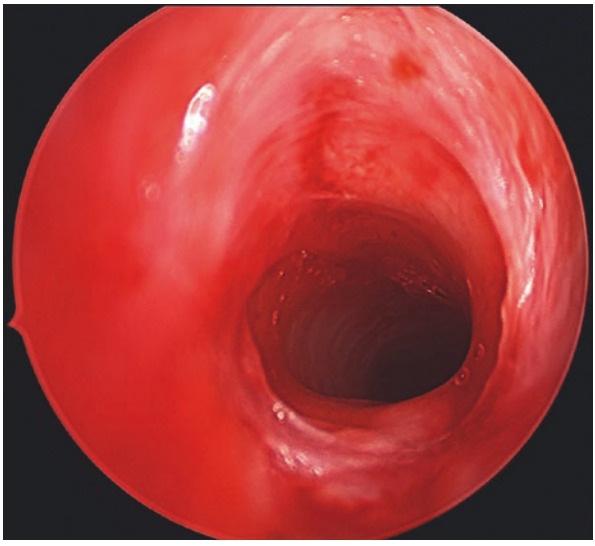

Fig. 14.5 Mild tracheal stenosis

14.3.10.2 Displaced Tracheostomy Tube

Tubes can sometimes become dislodged out of the trachea, into the surrounding soft tissues of the neck. Partial displacement is more dangerous as it is not always obvious that there is a problem. Clues suggestive of displacement include

(i) Respiratory distress
(ii) The patient suddenly becomes unable to talk
(iii) Pain at the tracheostomy site
(iv) The development of surgical emphysema
(v) Frequent need to inflate the cuff to prevent air leak
(vi) Suction catheters will not pass easily into the trachea
(vii) Increasing ventilator support or increasing oxygen requirements

Tracheal displacement is a medical emergency. Anaesthetic and otolaryngology/maxillofacial support should be sought immediately. In these cases oxygen should be administered via both face mask and via the tracheostomy, and oxygen saturation monitoring commenced. If present, the inner cannula should be removed and an attempt made to pass a flexible suction catheter. If passing the suction catheter is difficult or the patient is having difficulty breathing still, endoscopy should be performed to ascertain if the tube is in the correct position (i.e. can the carina be viewed). If it is displaced, the tracheostomy tube must be replaced and preferably with endoscopic guidance. If this is not possible endotracheal intubation may need to be undertaken depending on the clinical status of the patient. In the tube is clearly causing the obstruction and cannot be repositioned this may need to be removed completely.

14.3.11 Paediatric Tracheostomy

This differs from adult tracheostomy and is associated with a higher rate of complications. In children the trachea is more mobile, making it susceptible to deviation and displacement during surgery. The common carotid arteries are also more medial in paediatric patients and therefore at greater risk of injury during surgical tracheostomy. The size of the tracheal tube must be accurately matched—these are non cuffed and rely on a good fit for an effective seal.