Upper airway tract complications of endotracheal intubation

ABSTRACT

The gold standard in airway maintenance is translaryngeal endotracheal intubation, but this is not without its complications. Trauma to the upper airway as a result of the act of endotracheal intubation is a common event in adults undergoing procedures under general anaesthesia. Sites requiring attention during intubation include the laryngeal apparatus, the pharynx and oral cavity as well as the nasal cavity when nasopharyngeal intubation is performed. Patients can present with a range of symptoms which can make assessment and management challenging. Dysphonia, throat pain and dysphagia are the commonest presenting complaints. Patient-related factors, intubation technique and other anaesthetic-related conditions can be a cause of trauma, if not adequately considered before intubation. All patients should be carefully examined preoperatively and their past medical history obtained. Patient demographics, comorbidities, existing airway pathology and presence of reflux should be noted. Trauma prevention strategies should be in place to eliminate avoidable complications. Potential difficult airway cases should be flagged up and adequately prepared for, in anticipation of intubation difficulties that can lead to trauma. The majority of injuries will resolve spontaneously with conservative management. Persistent symptomatology, usually secondary to laryngeal injuries, requires prompt referral to an ear nose and throat specialist with an interest in laryngology for further assessment and treatment.

Approximately 3 million patients undergo surgical procedures electively or as an emergency under general anaesthesia every year in the UK. The risk of all types of serious complications from general anaesthetic has been estimated to be 10 per 1 million procedures, of which airway complications make up a significant percentage. A major anaesthesia-related complication is an infrequent event, but when such complications occur, they are associated with an airway problem in 40–70% of cases (Cook, 2018).

The 4th National Audit Project of the Royal College of Anaesthetists and Difficult Airway Society (NAP4) defined airway complications resulting in death, brain damage, emergency front of neck access, admission to high dependency or critical care unit as a major airway event. Airway complications that do not progress to a major event are more common with a reported incidence of 6% in large case series. These include hypoxia, difficult endotracheal intubation, failed mask ventilation, aspiration and laryngospasm (Huitink et al, 2017; Cook, 2018).

While major airway events are well documented in the literature, more subtle complications related to the action of intubation resulting in upper airway trauma, with or without symptoms such as dysphonia, throat pain and dysphagia, are not so well described. They can cause significant morbidity with the potential for medicolegal implications (Mendels et al, 2012). This review discusses the incidence and presentation of intubation-related injuries, and explores the causative factors including mechanism of trauma and patient-related factors. The review focuses primarily on publications from 2012 onwards. The available literature in this area primarily comprises a small number of systematic reviews (n=4, sample size 56–775), randomized trials (n=4, sample size 70–700), prospective (n=6) and retrospective studies (n=3) with sample sizes ranging from 61–31 241. Non-systematic reviews (n=11) and expert opinions (n=2) have been also included. The lack of robust evidence means that an umbrella review of the literature is needed as generalisation of individual studies' findings and suggestions can be problematic.

General factors that need to be taken into account when dealing with intubation injury are discussed based on the higher level of evidence available in the literature on each topic. Injuries to the upper airway from intubation will be divided into anatomical subunits for the purpose of discussion of incidence, presentation and site-specific management.

General causes and management strategies

Awareness of the incidence, presentation and risk factors of intubation injuries – both related to patients' characteristics but also anaesthetic conditions – is paramount for the formulation of a treatment plan. Preventative mechanisms should be in place in anticipation of a potential injury before intubation is performed. Adapting a pre-intubation protocol taking into consideration the expected duration of intubation and the patient's characteristics and comorbidities can reduce the incidence of avoidable complications (Langeron et al, 2018). Patients should be assessed post-extubation, with a particular focus on symptoms and signs related to intubation injuries, before discharge from the hospital.

General strategies for the prevention of intubation trauma are summarized below.

Miss Theofano Tikka, ST5 Ear, Nose, Throat Registrar, Department of Otolaryngology – Head and Neck Surgery, Queen Elizabeth University Hospital, Glasgow G51 4TN

Mr Omar J Hilmi, Ear, Nose, Throat Consultant, Department of Otolaryngology – Head and Neck Surgery, Queen Elizabeth University Hospital, Glasgow

Correspondence to: Miss T Tikka (theofano.tikka@gmail.com)

> A fine balance needs to be reached between maintaining the blood supply to the laryngeal mucosa and preserving endotracheal cuff pressure during intubation.

Trauma

The endotracheal tube cuff

The principle of capillary perfusion in the presence of external pressure is vital when it comes to cuffed endotracheal intubation. A fine balance needs to be reached between maintaining the blood supply to the laryngeal mucosa and preserving endotracheal cuff pressure during intubation. The effects of pressure on the laryngeal mucosa walls can be explained using the compartment syndrome paradigm. Presence of high pressure within a closed circuit results in reduced blood supply to the tissues within that compartment. The diastolic blood pressure and absolute compartment pressure need to be kept within a certain range to achieve a differential pressure that allows sustained capillary perfusion. For the laryngeal compartment, cuff pressures within 20–34 cmH_2O are considered adequate, with 25 cmH_2O being optimal. However, this does need to be assessed over time, especially in prolonged intubation, as patient factors including muscle relaxation and local oedema can affect this. Recognition of this has led to the design and development of low pressure, high-volume cuffs to reduce pressure damage, which is most commonly seen in the posterior larynx (Tsaousi et al, 2018).

Endotracheal tube characteristics

The shape, firmness and material composition of an endotracheal tube, as well as its external diameter, are factors to take into account when deciding on the optimum endotracheal intubation tube (Farrow et al, 2012; Karmakar et al, 2015). Endotracheal tube made of softer, more pliable material are available but they are more prone to compression and can provide inadequate support for ventilation. Tubes made to a specific shape and firmness while maintaining pliability are available but are seldom used because of their cost and thus lack of availability in most hospitals (Benjamin, 2018).

Emergency intubation

Difficult airway conditions are reported in 5.8% of elective intubations, being more than doubled in the emergency setting (Martin et al, 2011). Time constraints around intubation may limit assessment of patients' history and physical examination with lack of preoperative screening. Patients are frequently haemodynamically compromised and not adequately fasted. Airway complications in these settings increase 7-fold compared to elective intubations. Hypoxaemia and its sequelae make the airway tissues more susceptible to trauma which is exacerbated by multiple attempts at intubation with a reported 39% rate of airway injury associated with emergency intubations (Mort, 2007). The use of airway adjuvants is more common in the emergency setting, with bougie-guided intubation performed in more than 50% of difficult intubations in large case series (Martin et al, 2011). The Difficult Airway Society suggests that the hold-up sign or feeling of clicks has high sensitivity in confirming tracheal rather than oesophageal intubation. Nevertheless, the use of a bougie and the manoeuvres described above have been associated with trauma to the larynx, trachea, bronchi and mediastinum and are not recommended in grade 3b or 4 views (Frerk et al, 2015).

Seniority of anaesthetist

Junior anaesthetists have a higher rate of intubation-related complications with an average two-fold increase reported in the literature compared to senior residents or consultants. An independent factor for this is the number of attempts at intubation irrespective of the grade of view at laryngoscopy (Martin et al, 2011). Junior trainees have five times increased likelihood of requiring three or more attempts at intubation compared to senior anaesthetists, with complication rates increasing fivefold after the second attempt (Mort, 2004). This is likely related to direct forceful contact trauma and can be exacerbated by the use of sharp equipment such as a laryngeal bougie.

Muscle relaxants

Movements of the endotracheal tube can cause abrasions of the laryngeal mucosa, and secondary oedema and ulceration. The use of muscle relaxants during intubation reduces motion of the tube against the larynx, reducing laryngeal injuries. Nevertheless, their use varies depending on local protocols (Martin et al, 2011; Meacham and Schindler, 2015).

Extubation

Swallowing, coughing and movement against a patent endotracheal tube during extubation can result in mucosal trauma. Prompt removal of the endotracheal tube is vital to avoid laryngeal trauma when patients can maintain their own airway. Blind suction of the oral cavity, pharynx and larynx following extubation can lead to mucosal trauma and direct visualization is recommended (Popat et al, 2012). Moreover, accidental removal of tube with an inflated cuff or application of significant traction and twisting results in significant direct trauma; this has been described with the use of both an endotracheal tube and a laryngeal mask (Benjamin, 2018; Langeron et al, 2018).

Patient factors

Pre-existing pathology

A larynx with pre-existing pathology increases the risk of further damage following intubation. These can be congenital abnormalities, malignant or benign pathology or previous intubation injuries, such as the presence of laryngeal web, subglottic stenosis and laryngomalacia. It can also be a result of acute laryngeal trauma including

laryngeal fracture, caustic injury or acute inflammatory change as a result of infection or an allergic response (Mort, 2007; Pacheco Lopez et al, 2014). If any of these pathologies is suspected or encountered formal evaluation via fibreoptic laryngoscopy with or without the involvement of an ear nose and throat surgeon is recommended to evaluate the extent of the pathology and any likely consequences.

Reflux

Patients suffering from uncontrolled reflux are predisposed to laryngeal trauma because the laryngeal mucosa is already compromised. Acid reflux with laryngeal spillover causes local inflammation from exposure to pepsin, which can progress quickly to mucosa congestion, oedema and ulceration. It is also a predisposing factor for infections and delayed wound healing (Colton House et al, 2011; Benjamin, 2018). The authors did not find any literature on the possible effect of acute control of reflux at the time of intubation. Nevertheless, a systematic review on the management of post-intubation laryngeal granulomas did not identify an improvement following antireflux treatment (Rimoli et al, 2018).

Comorbidities

Systemic medical conditions can make patients vulnerable to complications during intubation. This can be related to factors that make the patient's tissues more vulnerable to injury or that make the act of intubation more complex.

Factors increasing tissue susceptibility to injury

Apart from the role of the cuff pressure, the balance of the differential perfusion equation can be altered in patients with chronic conditions causing poor capillary perfusion secondary to hypoxia and hypovolaemia. These are any condition associated with cardiac, hepatic, kidney and respiratory compromise or reduced brain activity (Mort, 2007). Special consideration should be given to patients with diabetes and vasculitic conditions that can affect tissue perfusion, with possible implications for tissue healing including the likelihood of necrosis and ulceration. Optimizing this preoperatively and care in tube selection and cuff pressure is of paramount importance in these cases.

Factors that anatomically affect intubation

Obesity, with a body mass index of more than 30 kg/m^2, has been associated with significant desaturation events which are secondary to the limited pulmonary reserve of these patients as well as body habitus challenges relating to an overcrowded oropharynx and limitations in neck extension (Combes et al, 2005).

For patients suffering from arthritis poor neck flexion and extension can limit access to the airway and increase the incidence of endotracheal tube insertion trauma or misplacement. This needs to be anticipated preoperatively (Martin et al, 2011; Langeron et al, 2018).

Patient demographics

Female gender has been suggested as a contributing factor secondary to smaller airway dimensions and fragility of the laryngeal mucosa (Darmon et al, 1992). Age extremities have been associated with a higher likelihood of hypoxaemic events which can contribute to tissue susceptibility to trauma (Mort, 2007). Vocal cord paralysis is higher in patients over 50 years of age (Kikura et al, 2007). Nevertheless, the role of age and gender as well as other patient demographics (height and weight) remains controversial (Colton House et al, 2011).

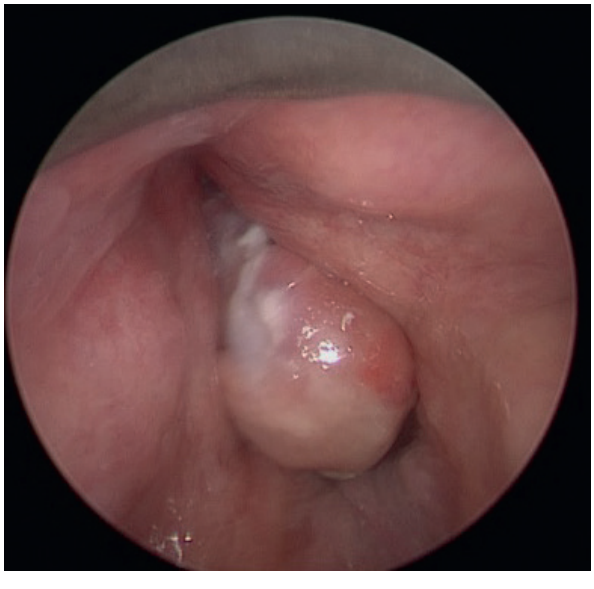
Laryngeal injuries

Incidence

Pacheco Lopez et al (2014) reviewed the literature on the incidence of postoperative laryngeal injuries and found significant variation, with reported rates from 0% up to 97% even after a short period of intubation. The large variation in the reported incidence is explained by the heterogeneous group of patients included in the review and the inclusion of both emergency and elective procedures of variable duration of intubation. Additionally, the use of different subjective and/or objective assessments of the laryngeal status with a lack of pre-intubation laryngeal assessment in some of the included studies adds to the wide range of reported trauma.

A systematic literature review by Mendels et al (2012), looking particularly at post-intubation laryngeal injuries in the elective setting after short-term anaesthetic (a period of anaesthesia of less than 5 hours' duration), identified only a few studies that performed an assessment of vocal cord state and voice quality before intubation for direct postoperative comparisons. Laryngeal injuries varied significantly from 0–42% within the first 24 hours dropping to 2.7–22.2% 72 hours following intubation. This rate dropped further to 0–5.6% when patients were assessed more than 3 days postoperatively. The most common injuries were vocal cord haematoma, thickening and granuloma (*Figure 1*),

Figure 1. Laryngeal granuloma.



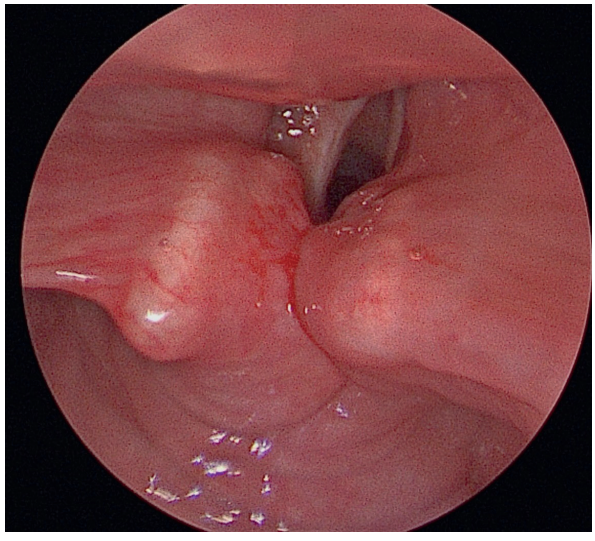


Figure 2. Arytenoid subluxation.

but arytenoid dislocation, subluxation (*Figure 2*) and vocal cord paralysis are also reported (Mendels et al, 2012). Vocal cord paralysis is an uncommon post-intubation complication with an average estimated incidence of 5 per 10 000 intubations, and bilateral vocal cord paralysis is an even rarer event. These injuries are usually transient and resolve spontaneously (Kikura et al, 2007). The exact mechanism of such injuries remains unknown.

Presentation

The most frequently occurring clinical symptoms reported post-extubation are dysphonia (76%), throat pain (76%) and dysphagia (49%) (Brodsky et al, 2018). Nevertheless, patients can present with a range of symptoms including odynophagia (pain on swallowing food and fluids) and respiratory distress. Most symptoms regress within the first 24 hours after extubation, with simple analgesia for symptomatic relief. Objective and subjective assessments of dysphonia have revealed an incidence ranging from 28–47% immediately after the operation to an average of 18% 24 hours postoperatively. On further assessment 3 days or more later the incidence of hoarseness is reduced to 6.1–12.5%. Patients' surveys have also shown a significant symptomatic improvement with 29% of reported symptoms still present after day 1, dropping to an average of 11% at day 3 and 0.8% at day 7 post extubation (Mendels et al, 2012).

Prolonged intubation is associated with chronic laryngeal changes that can manifest with persistent hoarseness, breathlessness and aspiration. The most common injuries are arytenoid erythema and interarytenoid oedema (95% and 97% respectively) followed by vocal cord erythema and oedema (66% and 89% respectively). Other injuries include vocal cord ulcers, granulomas and immobility (Colton House et al, 2011). The incidence of subglottic stenosis (*Figure 3*) ranges from 1% to 21%. Tracheomalacia has been reported, as have other rare complications such as tracheoinnomate artery fistulas and tracheo-oesophageal fistulas (Colton House et al, 2011; Pacheco Lopez et al, 2014).

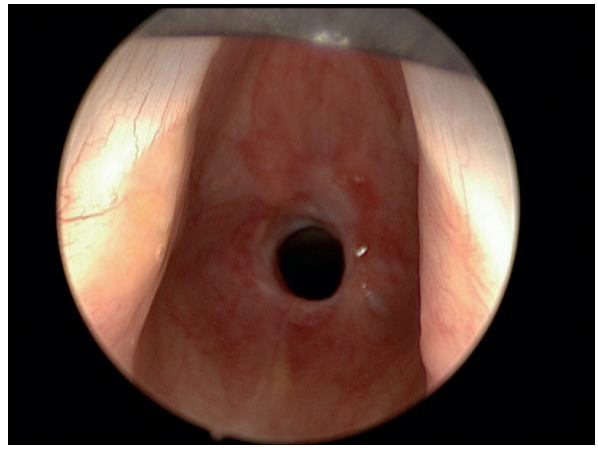


Figure 3. Subglottic stenosis.

Classification

There have been several attempts to classify intubation-related laryngeal injuries over the years. Nevertheless, there is no universally accepted grading or classification system. This makes comparisons difficult across studies and limits the generalisability of the outcomes. The most well-known classification systems are summarized in *Table 1*.

Prevention

The endotracheal tube size must be carefully selected based on the patient's age, gender and individual characteristics (Farrow et al, 2012; Karmakar et al, 2015). For prolonged intubation, an endotracheal tube made of synthetic material and with smooth edges is preferred. The material should have low porosity and be thermoplastic to disperse pressure throughout the tube surface. During extubation, if the first attempt has been unsuccessful, a short course of steroids may be helpful in controlling topical inflammation, and tube downsizing should be considered before definite extubation (Benjamin, 2018).

The endotracheal tube cuff pressure must be regularly assessed during intubation and should not reach pressures greater than 34 cmH_2O, as this threshold is associated with mucosal ischaemia and subsequent trauma (Tsaousi et al, 2018). Thin walled cuffs, allowing higher volumes under lower pressure, are preferable reducing the incidence of mucosal trauma, but high volume cuffs have been associated with post-intubation sore throat (Farrow et al, 2012). When a laryngeal mask airway is used, similar considerations to the endotracheal tube apply when deciding the appropriate tube size. A cuff pressure of more than 60 cmH_2O must be avoided, and the pressure should be checked every 30 minutes when nitrous oxide is used, as this can cause increased cuff pressures. Extreme neck positions must be avoided (Bick et al, 2014).

Optimization of treatable conditions before intubation is essential for prevention of complications. Rigorous treatment of reflux is essential and, if possible, optimization of pulmonary and cardiac function before intubation. Elective procedures should be delayed until patients have recovered from acute infection, particularly involving

the respiratory tract. Diabetic patients should have well-controlled blood sugar levels and be adequately hydrated before intubation. Temporomandibular and atlanto-axial joint status should be assessed in anticipation of difficult intubation secondary to densification of joint collagen structures (Cheisson et al, 2018).

When an anatomically complex airway is identified during preoperative assessment (such as subglottic stenosis or laryngeal trauma) these cases should be discussed with an ear nose and throat specialist and joint intubation should be considered. Adequate pre-oxygenation and the availability and knowledge of use of videolaryngoscopy, and use of fibreoptic intubation and other intubation means should be considered. The anaesthetic agents used must allow quick return of spontaneous ventilation in case of failure of intubation. Propofol and sevoflurane are the anaesthetics of choice. The addition of muscle relaxants is recommended, unless contraindicated. Short-acting muscle relaxants agents are preferred or agents that can be rapidly reversed (Langeron et al, 2018) when dealing with an anatomically complex airway.

Treatment

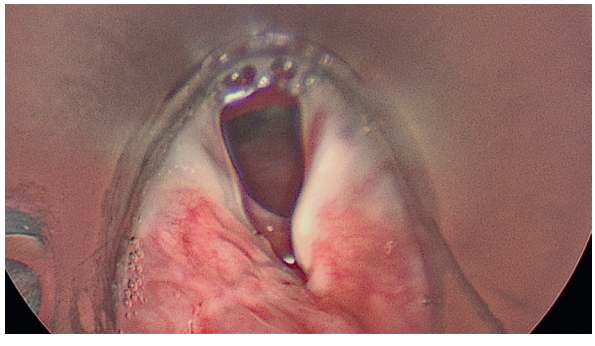
When an injury has already occurred, the only investigation is direct inspection of the larynx by the ear nose and throat surgeon. This is recommended in the acute setting, when there is airway compromise, usually secondary to vocal cord paralysis or trauma to the cartilaginous or mucosal laryngeal framework. Bilateral vocal cord paralysis may require an emergency tracheostomy. Realignment of a dislocated arytenoid can be attempted, but the success of this manoeuvre is questionable. Laryngeal haematoma may require drainage depending on the severity and airway compromise (Benjamin, 2018).

Early removal of granulation tissue has been described in the literature but can also lead to more aggressive scar formation (*Figure 4*). Removal of bilateral granulation can cause scar fusion and creation of webs and adhesions. Granulation tissue and ulceration formed in the first days to week after intubation can be divided before organized scar tissue develops. Further treatment may be required with close monitoring for recurrence (Benjamin, 2018). Mature scars causing stenosis can be divided using cold steel or laser dissection and/or balloon dilatation. Topical mitomycin can be applied to slow down topical inflammatory response with regrowth of scar tissue. Severe cases not responding to the above treatment may be candidates for laryngotracheal reconstruction including posterior cricoid split, grafts, resection of scarred segment, arytenoidectomy or vocal cord lateralisation depending on the type of pathology (Pacheco Lopez et al, 2014; Benjamin, 2018).

Table 1. Classifications of intubation injuries

Fan et al (1983)	1. Normal–mild (interarytenoid ulceration, vocal fold granuloma)		
	2. Moderate (bulky granulomas, pseudomembranes)		
	3. Severe (subglottic stenosis or membranes (*Figure 3*), tracheal stenosis, vocal cord paralysis)		
Colice at al (1989)	1. Normal		
	2. Mild (erythema or mucosal ulceration without lumen size reduction)		
	3. Moderate (erythema, mucosal ulceration or oedema with reduction of lumen size)		
	4. Severe (erythema or mucosal ulceration or oedema with reduction of lumen size by more than 50%)		
Mendels et al (2012)	Vocal cord lesion causing impaired vibratory movement	Epithelial	Inflammation
			Pigmentation
		Lamina propria	Reinke's space oedema
			Haematoma
			Scar (*Figure 4*) or laceration
		Arytenoid	Granuloma
	Movement disorder of vocal cord	Paralysis	
		Cricoarytenoid joint disorder or subluxation (*Figure 2*)	
Benjamin (2018)	General description	■ Early non-specific changes ■ Oedema ■ Granulation tissue ■ Ulceration ■ Miscellaneous injuries: arytenoid dislocation, vocal cord bleeding, vocal cord laceration, damage to intrinsic muscles, airway perforation	
	Specific intubation injuries	■ Tongues of granulation tissue ■ Ulcerated troughs ■ Healed furrows ■ Healed fibrous nodule ■ Granuloma (*Figure 1*) ■ Interarytenoid adhesion ■ Posterior glottic stenosis or scarring (*Figure 4*) ■ Subglottic stenosis (*Figure 3*) ■ Complete obstruction ■ Ductal retention cyst ■ Vocal cord paralysis ■ Dislocation of arytenoid (*Figure 2*)	

Figure 4. Posterior glottic scarring.



> Endoscopic assessment of the nasal cavity before intubation can help identify the most patent side for tube insertion.

Oral cavity and oropharyngeal injuries

Incidence

Injuries to the oral cavity and oropharynx are frequently encountered during orotracheal intubation. This can be as a result of the direct action of the laryngoscope or tube or direct trauma by use of adjunctive instruments such as bougies or stylets used in difficult cases. The most commonly reported injury is soft tissue trauma to the tongue (36%), followed by the lower lips (22%), upper lips (7%) and oral and oropharyngeal mucosa (2%) (Mourão et al, 2015). Dental injuries are usually secondary to direct pressure to the maxillary incisors with the laryngoscope blade with an average reported incidence of 1:1000 endotracheal intubations. Previous dental work is a major risk factor, accounting for 40% of sustained injuries. A Mallampati score of 3 results in blade to tooth contact in more than 90% of intubations (Sahni, 2016).

The advent of the videolaryngoscope may offer superior visualization of the laryngeal inlet but the potential to ignore the oropharynx predisposes to injuries here, with a reported incidence of 1% for minor injuries and 0.3% for more serious injuries (Cooper, 2007).

Presentation

The majority of soft tissue injuries are considered minor, with superficial abrasions resulting in post-intubation mucosal bleeding, bruising and ulcer which the patient experiences with throat pain, irritation and discomfort and rarely odyno-dysphagia. This can last for several days but usually resolves within the first 12–24 hours post-extubation with conservative management (Pacheco Lopez et al, 2014).

Classification

No universal classification system exists for grading soft tissue injuries to the oral cavity and oropharynx. Nevertheless, Mourão et al (2015) suggested a grading system for oral cavity injuries based on the area of injury (oral mucosa, lower lip, upper lip, tongue) and a severity index from none to grade 3 for mild (scratches, bruises, echymosis, cut), medium (deep soft tissue plane injuries but no requiring treatment) and major severity injuries (deep soft tissue injures requiring treatment) respectively.

Prevention

Preoperatively, the anaesthetist should establish the dental status, with particular focus on the presence of loose teeth, crowns, veneers, bridges or other orthodontic appliances. The degree of mouth opening should also be assessed, including assessment the temporomandibular joint. Careful use of the laryngoscope, avoiding the use of the upper incisors as a fulcrum, and consideration of the oral cavity and pharyngeal structures during intubation, extubation and suctioning will reduce contact trauma.

Treatment

If an injury occurs, it usually heals with conservative management. Painkillers will suffice in the majority of cases for symptomatic control. Rarely, deep mucosal injuries occur that require primary closure following a referral to the oral and maxillofacial or ear nose and throat specialists. Injury to teeth will require a dental referral for assessment and possible reconstruction (Yasny, 2009; Mourão et al, 2015).

Nasal cavity and nasopharyngeal injuries

Incidence

Injuries to the nasal cavity and nasopharynx have a reported incidence of 29–96% following nasotracheal intubation.

Presentation

Injuries to the nasal cavity and nasopharynx usually manifest with minor epistaxis, although uncontrolled epistaxis has been documented.

Classification

The commonest injuries are superficial mucosa trauma of the septum and inferior turbinate but mucosal injuries can also occur in the nasopharynx and lateral nasal wall. Rare events of turbinate avulsion and septal haematoma are also reported (Tong et al, 2018).

Prevention

Endoscopic assessment of the nasal cavity before intubation can help identify the most patent side for tube insertion. Use of lubricants and nasal decongestants can reduce contact trauma. Injuries usually heal with conservative management, including nasal lubricants and humidification.

Treatment

Persistent epistaxis may require cauterisation or insertion of nasal packing and a septal haematoma will need incision and drainage. Referral to the ear nose and throat team for further assessment is essential at that point for definitive management (Pacheco Lopez et al, 2014; Tong et al, 2018).

Special case: the professional singer

Professional singers require particularly careful management on the occasion of airway trauma following intubation. Additional information about this management is available online at www.bjhm.co.uk.

Conclusions

Clinically significant intubation trauma is rare. While it can represent a technical failure in terms of tube type or positioning, patient-related factors have a significant role

in the development of long-term complications and so perioperative optimization of these factors is paramount in securing a good patient outcome. Even significant trauma, if recognized and managed appropriately, will heal with little or no long-term consequence if patient factors are suitably corrected. **BJHM**

Conflict of interest: none.

KEY POINTS

- Endotracheal intubation trauma is common, more so in the emergency situation.
- Failure to recognize intubation trauma can lead to short- and long-term complications that can manifest in a wide range of symptoms.
- Patient factors and anaesthetic conditions can play an important role in the development of complications.
- Anticipation and prevention of avoidable complications is the cornerstone of the management of intubation trauma.
- Identification of significant injuries and prompt referral to an ear nose and throat specialist with an interest in laryngology is recommended for definitive treatment.

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Special case: the professional singer

Even subtle trauma can greatly affect functional voice outcomes for professional singers. The laryngeal posture and dynamics in this group of patients are highly sensitive to even minor changes to the vocal cord and laryngeal framework. Sensorimotor changes secondary to even minimal trauma from intubation can cause altered vocal techniques and suboptimal phonation that could result in further trauma and vocal pathology (Loucks et al, 1998; Meacham and Schindler, 2015).

It has been suggested that every professional singer undergoing intubation should be managed by a multidisciplinary team comprising a speech and language therapist, a teacher of singing with specialization in voice disorder, a senior anaesthetist and an ear nose and throat surgeon with specialization in laryngology. The patient should be carefully counselled about possible complications following intubation including an in-depth discussion about realistic expectation of voice quality immediately after and for the first days after intubation. A member of the team can be assigned to coordinate the patient's counselling, including education on pre-intubation and post-intubation voice hygiene (Loucks et al, 1998).

A meeting with the anaesthetists before the day of intubation is important, to allow time for discussion of different anaesthetic methods available and their associated risks and benefits. A laryngeal mask airway could be used as a first option in this group of patients, or alternatively an endotracheal tube with a smaller diameter and of softer composition. Videolaryngoscopy should be available during intubation and the use of continuous humidification gases is advisable during ventilation. Muscle relaxants should be administered, and anticholinergics avoided as they can cause trauma secondary to dry mucosa. Intraoperative steroids should be considered to decrease oedema, unless contraindicated, as well as reflux prophylaxis (Meacham and Schindler, 2015).

Aside of the usual patient examination and past medical history assessment, these patients should undergo a complete vocal cord assessment before intubation to establish and record the voice performance using objective and subjective measurements. Post-extubation bedside voice assessment and flexible laryngoscopy with documentation of findings should be performed, and post-intubation voice hygiene initiated. This includes rigorous hydration and humidification, vocal rest for at least 24 hours and minimization of postoperative nausea and vomiting with appropriate use of antiemetics.

It is recommended that the singer should not perform for at least 1 week after intubation, preferably up to 1 month, to allow complete recovery, particularly when trauma has occurred. Review of the patient a month later is critical, with a repeat full voice assessment and comparison of pre- and postoperative voice measurements, laryngoscopy as well as evaluation of patient satisfaction. All findings should be meticulously documented and saved for future reference (Loucks et al, 1998; Meacham and Schindler, 2015).

The above information is based on expert opinion, with no available studies to date. Considerations for the elective and emergency setting are outlined in *Table 2*.

Table 2. Endotracheal intubation considerations for the professional singer

Preoperatively	Elective setting	Vocal cord assessment (subjective and objective measures)
		Attendance in multidisciplinary meeting with the presence of ear nose and throat laryngologist, speech therapist, teacher of singing and senior anaesthetist (counselling, discussion of risks and voice expectations)
	Emergency setting	If patient is haemodynamically stable, discuss voice expectations as part of anaesthetic assessment
		If patient unstable, then proceed to intra-operation management suggestions
Intraoperatively		Consider videolaryngoscopy during intubation
		Consider use of laryngeal mask airway or small size endotracheal tube
		Continuous humidification
		Muscle relaxants
		Steroids
		Reflux prophylaxis
		Deep extubation
Postoperatively		Bedside voice assessment by speech therapist
		Flexible endoscopy by laryngologist
		Hydration, humidification and voice rest (at least 24 hours)
		Antiemetics and antireflux prophylaxis
		Early clinic review (not later than a month postoperatively)

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