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REVIEW ARTICLE

Postoperative sore throat: cause, prevention and treatment

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Summary

Sore throat is a common postoperative complaint, occurring most often following tracheal intubation. Factors such as tracheal-tube size and cuff design have been shown to be important causative factors. Routine tracheal intubation for elective surgical procedures can result in pathological changes, trauma and nerve damage which may also account for postoperative throat symptoms. Sore throat following the use of a laryngeal mask appears to be related to the technique of insertion but the contribution of intracuff pressure remains to be clarified. It would appear, however, that high intracuff pressure is associated with nerve palsies due to neuropraxia and nerve compression. Careful insertion techniques for both the tracheal tube and laryngeal mask are of paramount importance in the prevention of airway trauma and postoperative sore throat.

Keywords *Complications*; sore throat. *Intubation, tracheal*; complications. *Equipment*; tube, tracheal, laryngeal mask.

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Sore throat is a common postoperative complaint. After tracheal intubation, the incidence of sore throat varies from 14.4% to 50% [1–8] and after laryngeal mask insertion from 5.8% to 34% [5, 9–11]. The wide variation in these figures is presumably due to different skills and techniques among anaesthetists and to differences between individual anaesthetists and patients in the definition of sore throat. It is well recognised that the method of questioning is an important determinant of the incidence of sore throat. After indirect questioning of 129 patients, only two complained of sore throat, whereas after direct questioning of 113 patients, 28 complained of sore throat [2]. This difference may be due to the fact that patients concentrate on symptoms directly related to the operative site and do not immediately associate sore throat with anaesthesia and surgery. The purpose of this article is to review the factors that may cause postoperative throat symptoms such as pain, dysphagia and hoarseness after the use of tracheal intubation, the laryngeal mask airway (LMA) or the oral (Guedel) airway, and possible methods of reducing these symptoms. Trauma that occurs in association with airway manipulation will also be discussed.

Sore throat following tracheal intubation

The highest incidence of sore throat and other airway-related symptoms tends to occur in patients who have undergone tracheal intubation. In a series of 1325 patients, there was an incidence of sore throat of 14.4% [1]. In this study, women were intubated with an 8-mm tracheal tube and men with a 9-mm tracheal tube. All tubes were lubricated with lignocaine jelly. However, the incidence of sore throat in women (17%) was significantly higher than that in men (9%) which was attributed to the tube being a tighter fit in women. Other factors that were found to be implicated were thyroid surgery (because of movement of the tube and cuff within the trachea) and the presence of a nasogastric tube. Surprisingly, multiple attempts at intubation did not increase the incidence of sore throat. Fifty per cent of patients were hoarse, 18.5% had a cough and 70.5% complained of dryness of the throat [1]. The sex difference in that study was not confirmed in a study of 242 patients who had an overall sore-throat incidence of 35% when questioned directly [2]. In neither study was any attempt made to standardise anaesthetic technique, but

details were recorded so that possible causative factors could be identified.

It has been clearly demonstrated that the use of a smaller tracheal tube reduces the incidence of sore throat, presumably because of decreased pressure at the tube–mucosal interface [6]. One hundred and one patients were assigned to two groups and received either a small or a large tube. Large tubes were 9 mm (for men) and 8.5 mm (for women), and small tubes were 7 mm (for men) and 6.5 mm (for women). No lubricants were used. The sore-throat incidence in the group intubated with the large tubes was 48%, compared with 22% in the group intubated with the small tubes. No ventilatory difficulties were experienced as a result of using a small tube. Therefore, the use of smaller tubes has the distinct advantage of reducing the incidence of postoperative sore throat.

The tracheal-tube cuff has been implicated as a cause of serious sequelae following long-term intubation. The red-rubber tube had a low-residual-volume, high-pressure cuff and the exertion of this high pressure on the tracheal mucosa was thought to be damaging. A study of blood flow in rabbit tracheal mucosa demonstrated that when a high-pressure, low-volume cuff was inflated to > 30 mmHg ($39\ cmH_2O$), the mucosa in contact with the cuff, i.e. that covering the tracheal cartilage, became ischaemic [12]. This ischaemia was thought to contribute to the occurrence of conditions such as tracheal stenosis and tracheomalacia. When a thin-walled, low-pressure, high-volume cuff was used, blood flow did not cease until intracuff pressures were in the range 80–120 mmHg. This was thought to be due to a more even distribution of pressure over the mucosa. These high-volume cuffs still allowed some perfusion of the mucosa covering the cartilages at pressures > 30 mmHg. Even so, the cautious recommendation was made that intracuff pressure should be maintained at < 20 mmHg ($26\ cmH_2O$).

After the introduction of high-volume, low-pressure cuffs, Loeser and co-workers [13–17] extensively investigated the effect of using tracheal tubes with different cuff designs on the incidence of postoperative sore throat, and showed that the high-volume cuffs were associated with a higher incidence of sore throat because of the greater area of cuff–tracheal contact. Although the high-volume cuffs caused a greater area of damage to the tracheal mucosa, the damage was more superficial than that caused by the high-pressure cuffs [18]. A further problem with the high-volume cuffs was that if their diameter was greater than that of the trachea, the redundant material would wrinkle. These wrinkles caused deep mucosal grooves and in addition permitted a 100% incidence of aspiration of dye instilled directly above the vocal cords when the cuff was inflated to $25\ cmH_2O$ [19]. It was therefore recommended that the ideal cuff should have a diameter slightly less than that of the trachea but should be constructed of material that would allow a 10% increase in diameter over the range of inflating pressure of $20–30\ cmH_2O$. In this way, wrinkling would be avoided, allowance could be made for variation in tracheal size when obtaining a seal and intracuff pressures would not compromise the tracheal mucosa. Furthermore, the cuff should be narrow in order to minimise the cuff–tracheal contact area [20].

High-volume, low-pressure cuffs will exert high pressure on the tracheal mucosa if overinflated following tracheal intubation, or if no allowance is made for N_2O diffusion. Both high- and low-volume cuffs were shown to undergo similar changes in volume and pressure as a result of N_2O diffusion when inflated with air [21], but these changes did not occur when cuffs were inflated with the anaesthetic gas mixture [22]. In an animal study, a comparison was made between cuff inflation with either saline or air. The pressure in the air-inflation group was significantly higher than that in the saline-inflation group at 120 min and thereafter, and by 6 h the pressure in the air-inflation group was six times that in the saline-inflation group [23].

The application of high pressure to the tracheal mucosa may also contribute to the occurrence of postoperative sore throat. The Brandt Anaesthesia Tube is designed to prevent intracuff pressure from increasing above 25 mmHg ($33\ cmH_2O$), by virtue of the cuff communicating through the inflation line with a pilot balloon that is more compliant and of higher volume [24]. The incidence of postoperative sore throat in patients intubated with this new tube (15%) was significantly lower than that after intubation with a standard Mallinckrodt tube (60%). Both types of tube had similar high-volume, low-pressure cuffs, which suggests that cuff-pressure limitation may reduce the incidence of postoperative sore throat. Overinflation may further predispose the patient to postoperative sore throat by causing an increase in the cuff–tracheal contact area [25].

It has been suggested that in order to avoid these problems, the cuff seal point should be carefully determined after tracheal intubation and that the intermittent measurement and adjustment of cuff pressure should be routine clinical practice [26]. Alternatively, simple measures such as inflating the cuff with gas drawn from the breathing circuit or with saline will avoid the problem of N_2O diffusion.

Surprisingly, Loeser *et al.*'s study [17] found that the use of uncuffed tubes resulted in a significantly higher incidence of sore throat than the use of cuffed tubes, even when the patients breathed warmed and humidified gases. It was thought that this could be due to nonhumidified air being drawn across the airway mucosa during spontaneous respiration. There was a higher incidence of sore throat when all the cuffed tubes were lubricated with lignocaine ointments, as opposed to a water-soluble jelly or no

lubricant at all. However, the incidence was as high as 90% when the uncuffed tubes were lubricated with 4% lignocaine jelly, and the severity of sore throat in these patients was significantly greater. Conversely, a comparison between intubation with dry tubes or a tube lubricated with jelly containing 1% cinchocaine led the investigators to suggest that the use of lubricants containing a local anaesthetic may be beneficial [8]. Of the 248 patients in that study, 39% who were intubated with a dry tube complained of sore throat on the first postoperative day compared with 24% who were intubated with a lubricated tube, a significant difference. After the first postoperative day, the incidence decreased rapidly in both groups. A further comparison was made in 60 patients between lubrication of the tube with jelly containing cinchocaine and lubrication with the same jelly without cinchocaine [8]. The incidence of sore throat was 38% in the noncinchocaine group vs 25% in the cinchocaine group, which was not statistically significant, although it might have become so with greater numbers of patients.

The effect of the application of laryngotracheal lignocaine spray on postoperative sore throat has also been investigated [3]. In the study group, after induction of anaesthesia and 2 min of mask ventilation, the lignocaine spray was applied to the epiglottis, vocal cords and trachea. Mask ventilation was then continued for a further 2 min prior to intubation. Subjects in the control group were intubated after 4 min of ventilation, with no application of spray. The incidence of sore throat was 29.2% in the study group and 19.6% in the control group. Although this difference was not statistically significant, it was concluded that the application of lignocaine spray could not be recommended for routine use; it was further suggested that the lignocaine may be irritating or damaging to the tracheal mucosa. However, it should be noted that subjects in the study group underwent two laryngoscopies whereas those in the control group had only one.

Lubrication with 1% hydrocortisone was also found to increase the incidence of sore throat from 50% to 90%, when compared with KY jelly [7].

There is no study therefore that categorically demonstrates that the use of lubricating jelly containing a local anaesthetic is beneficial in the reduction of postoperative sore throat after tracheal intubation. The application of lignocaine spray before intubation appears to increase the incidence of sore throat, as a result of either mucosal irritation or repeated laryngoscopy.

The role of suxamethonium in the aetiology of postoperative sore throat is unclear. It has been suggested that suxamethonium, which is known to cause postoperative skeletal muscle pain, could also lead to pain in the striated pharyngeal muscles, causing sore throat. In a study of 83 women undergoing dilatation and curettage who did not undergo tracheal intubation, the effect of administration of suxamethonium was examined [27]. Patients who received suxamethonium, either as a bolus or by infusion, had a significantly higher incidence of sore throat, hoarseness and myalgia 24–30 h postoperatively. Precurarisation did not have any effect on these symptoms despite significantly reducing the incidence of muscle fasciculation. Although the patients did not undergo intubation, did not have oral airways inserted and were not suctioned, 20 patients had a nasopharyngeal airway inserted. The highest incidence of airway use occurred in those given a bolus of suxamethonium and the incidence of sore throat in these patients was higher than in the other groups. However, it could not be confirmed statistically that the use of the nasopharyngeal airways contributed to the higher incidence of sore throat in patients receiving suxamethonium. These findings have not been confirmed by other investigators. Fifty-eight patients who were undergoing gynaecological laparotomy were given either pancuronium or suxamethonium with precurarisation after induction of anaesthesia [4]. All of these patients underwent orotracheal intubation and one in whom intubation was deemed to have been traumatic was excluded from the final analysis. The postoperative sore throat incidence was 14% in the group that received suxamethonium as compared with 17% in the group that did not. Because airway management was standardised in this study, it would appear that suxamethonium does not increase the incidence of postoperative sore throat.

In summary, the use of smaller tracheal tubes with cuffs that have a small area of contact with the tracheal mucosa will reduce the incidence of postoperative sore throat. Careful control of intracuff pressure may be beneficial even for short-term intubation, and consideration should be given to using either the anaesthetic gas mixture or saline to inflate the cuff. Lubricants containing local anaesthetic agents are not useful and may actually increase sore throat incidence (Table 1).

Sore throat and the laryngeal mask airway

As with the tracheal tube, the reported incidence of sore throat after use of the LMA varies widely, possibly because of differences in insertion skills and techniques, lubricants and cuff pressure that may or may not be controlled.

The standard technique of insertion of the LMA recommended by the manufacturer and the inventor [28] is that before insertion, the laryngeal mask should be tightly deflated so that it forms a flat, oval disk with the rim facing away from the aperture. The distal edge of the rim should be smooth and flat to facilitate insertion. The back of the mask should be lubricated just before insertion so

Table 1 Means of reducing of the incidence of postoperative throat symptoms.

General principles	After tracheal intubation	After LMA insertion
Experience of anaesthetist	Smaller tracheal tube	Correct size of LMA
Adequate anaesthesia/ relaxation of patient	Minimal cuff–tracheal contact area	?Inflation of cuff before insertion/ use of insertion aid
Careful technique	Monitoring and adjustment of intracuff pressure	Use of KY jelly/saline lubricant
Soft suction catheters	Avoidance of local anaesthetic/steroid lubricants	Minimisation of intracuff pressure

that it does not dry out. Suitable lubricants include saline, water and water-based gels, but gels containing a local anaesthetic have also been used. This standard technique was compared with three other methods: insertion with the cuff semi-inflated; insertion with the cuff fully inflated; and back-to-front insertion with the cuff fully deflated, followed by rotation of the LMA through 180° as with a Guedel airway [29]. The standard technique was found to be the most successful according to position obtained (as assessed with a fibreoptic bronchoscope) and function.

Several studies have evaluated insertion techniques, lubricants and the effect of cuff-pressure limitation in terms of ease of insertion of the LMA, pharyngeal trauma and postoperative throat symptoms. The use of a special insertion aid which was designed to avoid pharyngeal trauma by preventing the tip of the LMA from folding back, reduced the incidence of trauma, defined by the presence of blood on the LMA after removal, from 22% to 4% [9]. In addition, the incidence of sore throat was reduced from 28.5% to 18%, an incidence not significantly different from that after anaesthesia with only a facemask.

In a study of 200 patients, insertion of the LMA by means of the standard technique, the mask being fully deflated before insertion and then inflated with enough air to obtain an adequate seal after placement, was compared with insertion of the LMA already fully inflated with the recommended volume of air [11]. All masks were lubricated with a water-based lubricant. Both techniques had a high success rate (> 94%). Significantly fewer LMAs had blood on them after removal when they had been inserted already inflated, 0% compared with 15.3%, and the incidence of sore throat was also significantly reduced from 21.4% to 4.1%. This difference may have been due to the presentation of a softer leading edge to the posterior pharyngeal wall. It was further suggested that cuff pressure was not a factor in the causation of sore throat, because the group in which pressures were likely to be highest, i.e. the group that had the LMA inserted already fully inflated, had the lower incidence. Therefore, the occurrence of pharyngeal trauma and hence the incidence of postoperative sore throat can be reduced either by the use of an insertion aid or by inflation of the LMA cuff before insertion.

There is conflicting evidence as to whether limitation of pressure exerted on the pharyngeal mucosa by the LMA cuff reduces throat symptoms. A study in which the effect of high and low intracuff pressures on laryngopharyngeal discomfort was compared concluded that cuff pressure was not a factor in the causation of sore throat [30]. Extremes of pressure were chosen and maintained by a microprocessor-controlled monitor, with the laryngeal mask cuff being inflated to either 30 mmHg (39.5 cmH_2O) or 180 mmHg (237 cmH_2O). The volumes of air used to obtain these pressures were not specified. There was no significant difference in the incidence of sore throat, hoarseness or dysphagia between the two groups. Fifty per cent of patients in the low-pressure group and 42% in the high-pressure group had a throat-related complaint, but this percentage decreased rapidly in both groups over the next 2 days. There was also no difference in the quality of airway obtained or in the occurrence of air leak. Dysphagia was the most common complaint in both groups and was still present in 20% of patients in each group the day after surgery. However, it is unlikely that the high pressure was transmitted directly to the pharyngeal mucosa: the elastic of the cuff must have been stretched excessively, so a proportion of the pressure measured would have been due to elastic recoil.

The effect of cuff pressure limitation on sore-throat incidence was studied in patients receiving positive pressure ventilation [31]. In the control group, LMA cuff pressures were monitored but not adjusted, and they increased significantly during the first 60 min of anaesthesia as a result of N_2O diffusion. Minimising cuff pressure led to significantly lower pressures after insertion and reduced sore-throat incidence from 8% to 0%. It has been demonstrated that it is possible to reduce the intracuff pressure to 22 mmHg (29 cmH_2O) in spontaneously breathing patients without affecting tidal ventilation [32], but it has been argued that this pressure may be too low to provide a minimum leak pressure (airway pressure at which leaks occur around the LMA) of 10 cmH_2O. This leak pressure has been recommended in spontaneously breathing patients in order to protect the larynx from oropharyngeal secretions [33].

In a study of 120 patients who were anaesthetised with the use of a laryngeal mask, lubrication of the LMA with

2% lignocaine gel was compared with lubrication with saline [10]. The incidence of sore throat was not reduced by the lignocaine, but the incidence of postoperative complications (hoarseness, tongue paraesthesiae, nausea and vomiting) may have been increased; therefore, 2% lignocaine was thought to be an unsuitable lubricant. The overall incidence of sore throat was extremely low (5.8%) and was attributed to the limitation of LMA cuff pressure to 60 cmH_2O. It was suggested that limitation of cuff pressure may also reduce the incidence of problems during emergence from anaesthesia.

In summary, there is increasing evidence that it may be advantageous to adopt an alternative technique of LMA insertion, inflation of the LMA cuff before insertion, to reduce pharyngeal trauma and postoperative sore throat. A high success rate was obtained when the LMA was inserted already fully inflated, but it is possible that partial inflation may have similar benefits. Lubrication of the LMA with gels containing a local anaesthetic before insertion did not reduce the incidence of sore throat [27]; the use of saline or KY jelly is preferred. However, the issue of whether limitation of intracuff pressure is beneficial in reducing sore throat remains unresolved. Reduction of intracuff pressure is certainly possible without adversely affecting spontaneous tidal ventilation, but it may be necessary to maintain the pressure above a certain level to protect the larynx from contamination with oropharyngeal secretions [33].

Direct comparison of symptoms following use of the LMA and the tracheal tube

A small number of studies have been published in which direct comparisons were made between the LMA and the tracheal tube with reference to intra-operative use and postoperative throat complaints. One such study divided the blanket term 'sore throat' into several, more precise symptoms: sore throat (continuous throat pain), dysphonia (voice changes), dysphagia and pharyngeal dryness [34]. There was no significant difference in the overall incidence of throat complaints, but the pattern of complaints differed. On the evening of surgery and on the first postoperative day, significantly more patients in the tracheal tube group complained of dysphonia, whereas significantly more patients in the LMA group complained of dysphagia. A similar number of patients in each group complained of pharyngeal dryness (tube, 75%; LMA, 61%). It was concluded that the LMA may not be superior with regard to minor laryngopharyngeal morbidity. However, a significant reduction in the incidence of postoperative sore throat from 45% to 34% with LMA use, as opposed to the tracheal tube, was demonstrated in a study of ambulatory surgical patients [5].

Sore throat and the Guedel airway

The incidence of postoperative sore throat after anaesthesia with a facemask and oral plastic airway, using warmed, humidified anaesthetic gases, was 15–22% [16, 17]. In a study of 88 patients, the incidence of sore throat in those who were anaesthetised with or without a Guedel airway was compared [35]. The overall incidence of sore throat was 4.5%, and there was no significant difference between the groups. The overall incidence of all throat complaints, including dry throat, was 20%, but again there was no significant difference between the two groups.

In 203 patients undergoing tracheal intubation, a comparison was made between the use of the Guedel airway and a gauze bite block [36]. Once again, the incidence of sore throat was not significantly different between the two groups. However, the investigators also noted whether blood was present on the airway instruments, e.g. the laryngoscope and the suction catheter, at any time. The incidence of sore throat in patients in whom blood was present on the airway instruments was 64.5% compared with 30.9%, which suggests that pharyngeal trauma is a significant factor in postoperative sore throat. Because the incidence of blood on the laryngoscope blade was low, it was concluded that pharyngeal trauma was associated with suctioning at the end of the procedure. The suction catheters that were used had a stiff, pointed tip that was not vented, and there was therefore the potential for high negative pressures to be exerted on the airway mucosa. Careful suctioning was recommended.

In summary, the use of an oropharyngeal airway does not appear to increase the incidence of sore throat. This is possibly due to the fact that the airway does not come into contact with the posterior pharyngeal wall. It should be noted that damage to the pharyngeal mucosa may still occur after emergence from anaesthesia as a result of suctioning by means of stiff, nonvented suction catheters. The use of soft suction catheters may be beneficial.

Injuries resulting from tracheal intubation

Complications of tracheal intubation can be classified as immediate, early and late [37]. A full discussion of these complications is beyond the scope of this review. It is well recognised that prolonged intubation can have serious consequences, but it is less well recognised that uneventful intubation for routine surgical procedures can also cause pathological changes that may provide an organic basis for patients' postoperative throat symptoms (Table 2).

Post-mortem specimens of larynx and trachea, removed from patients who were intubated as part of a resuscitation attempt, were stained with methylene blue to determine the extent of epithelial damage occurring as a result of

Table 2 Pathological changes secondary to intubation.

Epithelial loss
Glottic haematoma
Glottic oedema
Submucosal tears
Contact ulcer granuloma

both the intubation itself and the presence of the tracheal tube [38]. Trauma was extensive in all ten specimens examined. Laryngeal trauma most commonly occurred posteriorly over the cricoid plate and also over the vocal processes of the arytenoids, as a result of forces exerted by the rigid tubes. Damage was greatest in those patients who had been intubated the longest. There was evidence of trauma over the cartilaginous rings of the trachea, tending to occur only along the anterior tracheal wall; this trauma presumably resulted from the insertion or removal of the tube. Some of the specimens had an area of annular trauma coinciding with the area of cuff contact. Microscopically, epithelial loss was seen, with damage to the submucosa in some cases. A separate series of 99 autopsy specimens demonstrated focal or complete loss of mucosal epithelium even if the patient had been intubated for as short a time as 1 h. Furthermore, there was no significant repair of epithelium or stroma as long as the tube was in place [39].

One hundred patients, all of whom had undergone intubation, were examined by indirect laryngoscopy postoperatively [40]. Sixty of the patients had evidence of airway trauma. Most of the injuries sustained were intralaryngeal and included vocal cord and glottic congestion, a 'crushed' epiglottis and a small number of submucosal tears. None were considered to be serious and no permanent damage resulted.

Indirect laryngoscopic examination of 475 patients who had been intubated for elective surgery demonstrated that a small proportion of patients (6.3%) had traumatic lesions of the larynx or hypopharynx [41]. Most of these injuries were glottic haematomas, with the left cord being affected more often than the right, possibly because of the fact that the tube was turned to the left by the anaesthetist during intubation. The injuries resolved within 4 weeks and were thought to be due to inadequate relaxation of patients during intubation or to poor or careless technique. More patients in the injured group complained of sore throat and hoarseness, although the difference was not significant. In this series, two cases of vocal-cord paralysis occurred, one of which lasted for at least 2 months. This injury was thought to have resulted from high intracuff pressures causing neuropraxia of the recurrent laryngeal nerve where it lies between the cricoid and arytenoid cartilages. Although unilateral vocal-cord paralysis usually causes only hoarseness, bilateral vocal-cord paralysis after short-term intubation [42] may cause complete airway obstruction, necessitating tracheostomy. Possible causes include neuropraxia due to high intracuff pressure and nerve demyelination due to gas sterilisation of the tubes. Decreased elasticity of the trachea and surrounding tissues in older people may also increase the likelihood of damage occurring during laryngoscopy and intubation.

In a study of 200 patients in which intubation with a standard polyvinylchloride (PVC) tube was compared with that with a tube shaped to conform to the anatomy of the airway, patients underwent indirect laryngoscopy 5 days postoperatively [43]. Similar numbers of patients in each group had pathological changes (32% in the standard PVC group, 23% in the study group), but lesions were seen more frequently in the interarytenoid and subglottic area when the standard PVC tube was used. This was presumably due to the elastic recoil of the PVC tube, which exerted more pressure against the posterior wall of the larynx, as in the post-mortem studies. Although these lesions were only superficial ulcerations of the mucous membrane comprising less than one-third of the circumference of the airway, it was thought that they would constitute a very efficient barrier against mucus flow. Also, significantly more patients in the standard PVC group complained of laryngeal irritation, difficulties in coughing and sore throat. It was noted, however, that many lesions may have improved or healed in the 5-day period before laryngoscopy.

Contact-ulcer granuloma is the most common late complication of tracheal intubation and should be suspected if the patient complains of prolonged hoarseness. In a series of 167 intubated patients, 54 (32%) complained of hoarseness, but in most cases the symptoms lasted less than 5 days. Two patients in whom hoarseness persisted for 54 and 99 days, respectively, were found to have vocal-cord granulomata [44]. The site of the granuloma was usually at the tip of the vocal processes of the arytenoid cartilages, due to, among other things, their incessant movement [45]. Further risk factors included clamping of the cords onto the tube during intubation and when the depth of anaesthesia was lightened, and hooking of the arytenoid by the open end of the tube. Another possible contributory factor was that the tubes used were re-usable, and may have become roughened during repeated cleaning. It was suggested that the incidence of contact-ulcer granuloma could be reduced by prevention of trauma at intubation, and by resting the voice should contact ulceration occur, to prevent granuloma formation.

Both pharyngeal and oesophageal perforation have been reported following repeated attempts at intubation using a rigid stylet [46]. Although in both cases it was not known whether the tip of the stylet protruded beyond the lumen

of the tube, it is logical to assume that the use of this intubation aid will predispose to trauma if it does protrude and if it is used blindly and with excessive force. Laceration of the left mainstem bronchus is believed to have been caused when a stylet was used with an old Mallinckrodt Broncho-Cath [47].

Pressure on the cricoid cartilage is known to make intubation more difficult in some cases by moving the larynx away from the midline and also, if applied incorrectly, by causing obstruction of the trachea. Increased difficulty with intubation predisposes to airway trauma. Fracture of the cricoid cartilage itself has been reported following rapid sequence induction, which, on extubation, resulted in marked inspiratory stridor, hypoxia and cardiorespiratory arrest [48]. The patient had a previous history of trauma to the larynx that may have predisposed to cricoid cartilage fracture. Although pressures applied to the cricoid cartilage vary widely, even among experienced personnel, and are difficult to measure, it is unlikely that even high pressure could fracture a normal cricoid cartilage.

In summary, extensive damage to the laryngeal and tracheal epithelia occurs as a result of tracheal intubation, even with an intubation period as short as 1 h. Haematoma of the left vocal cord is the most common injury seen on indirect laryngoscopy. Optimisation of intubating conditions and careful technique are necessary to minimise airway trauma. Overinflation of the tracheal tube cuff has been associated with recurrent laryngeal nerve palsy and should be avoided.

Injuries resulting from LMA insertion

Because LMA insertion is a blind technique, is easy to learn and has a high first-time success rate, there is less awareness of the serious injury that can occur to airway structures, even with apparently uneventful use of this device. Various types of nerve injury, arytenoid dislocation and epiglottitis have been described in association with the LMA [49–56]. These injuries are summarised in Table 3.

In a very small study comparing the effects of the LMA and the tracheal tube on vocal function [57], patients underwent indirect stroboscopic laryngoscopy 18–24 h postoperatively. Seven of 11 patients in whom a LMA had been used had no pathological changes. The most common change in the remaining four patients was pharyngeal erythema. A significantly greater number of patients in the tracheal tube group believed that throat and voice parameters had deteriorated than in the LMA group.

Table 3 Airway complications following LMA insertion.

Pharyngeal erythema
Nerve palsies
Recurrent laryngeal
Hypoglossal
Lingual
Arytenoid dislocation
Epiglottitis
Uvular bruising

Several cases of vocal-cord palsy have been reported following apparently uneventful anaesthesia with the LMA. One young patient returned to hospital 2 days postoperatively, complaining of hoarseness that had been present ever since his anaesthetic [49]. Nasopharyngeal laryngoscopy revealed a left vocal-cord palsy with inability of the right cord to compensate; normal vocal function returned within 3 weeks. Two patients who complained of sore throat, dysphagia and hoarseness postoperatively were found to have unilateral recurrent laryngeal nerve palsies with associated laryngeal incompetence, resulting in aspiration in one case; symptoms lasted for up to 6 months [50]. The consensus of opinion is that recurrent laryngeal nerve palsy is due to neuropraxia from cuff pressure on the nerve at the point at which it lies unprotected at the lower level of the piriform fossa. Transient bilateral vocal-cord palsy has also been described, with full recovery 40 min postoperatively [51]. However, this may have been due to lignocaine diffusion, because the LMA had been lubricated with 2% lignocaine jelly.

Paralysis of the hypoglossal nerve has also occurred following use of the LMA. In one case, the LMA was inserted without difficulty, but 4 h postoperatively the patient complained of difficulty swallowing and slurred speech [52]. Examination revealed a unilateral 12th cranial nerve paralysis that resolved 8 days postoperatively. This patient had received warfarin and had an International Normalised Ratio (INR) of 1.7 before surgery, and it was postulated that the LMA had traumatised an area of the hypopharynx, resulting in bruising and consequent neuropraxia of the 12th nerve. In another case, however, the patient suffered from severe rheumatoid arthritis and there was some difficulty with LMA insertion [53]. After induction of anaesthesia, she was rotated into the right lateral position. The following day, the patient complained of difficulty swallowing and on examination her tongue was found to deviate to the right. A diagnosis was made of paralysis of the right 12th cranial nerve, which resolved within 1 week. Compression of the nerve between the LMA cuff and the hyoid bone was thought to be the cause of this injury, the compression being exacerbated by the position of the patient. Prolonged lingual nerve paralysis resulting in loss of taste sensation has also been associated with uneventful LMA use and again was thought to be secondary to neuropraxia [54].

Two cases of arytenoid dislocation resulting from LMA insertion have been reported [50, 55]. These were most

likely to have been due to direct trauma on insertion, but it has also been suggested that folding back of the tip of the LMA on insertion may cause lifting of the arytenoid. Symptoms were sore throat and hoarseness. One patient was treated conservatively with speech therapy and the other underwent mechanical reduction supplemented by botulinum toxin injection.

The LMA has been implicated as a cause of a case of epiglottitis which developed within 12 h of LMA use [56]. Although other causes for the epiglottitis could not be definitely excluded, lateral neck radiographs taken after recovery revealed that the epiglottis was posteriorly placed with an increased curvature. This abnormality may have made it more susceptible to damage because of its more prominent position. Trauma to the uvula after LMA use, with consequent severe bruising and postoperative sore throat, has also been reported [58].

In summary, care should be taken during insertion of the LMA to avoid undue trauma to structures of the airway. Special care is required in patients who are receiving anticoagulants. As with the tracheal-tube cuff, reducing the likelihood of neuropraxia may be another reason to consider minimisation of LMA intracuff pressures.

Treatment of postoperative throat symptoms

In most cases, postoperative throat complaints resolve spontaneously without specific treatment. In moderate to severe cases it may be beneficial to treat pain and dysphagia with a gargle containing a drug such as benzydamine hydrochloride, which is approved for the symptomatic treatment of acute sore throat pain [59]. Benzydamine hydrochloride is a topical nonsteroidal anti-inflammatory agent that also has local anaesthetic activity. It has an alkaline pH, which means that it becomes concentrated in inflamed tissue and has minimal systemic absorption.

Because it is not routine practice to examine the larynx after the use of airway instruments, most macroscopic injuries are likely to remain undiscovered. The most common injury is haematoma of the left vocal cord, there is no specific treatment for this but it tends to resolve spontaneously [41]. Laceration of the mucosa of the vocal cord may be treated by means of laryngeal microsurgery to remove the torn mucosa [60], although the injury does not usually cause an anatomical or functional disorder. Penetrating injuries caused by the laryngoscope blade, the airway or the patient's own teeth may require treatment with topical antibiotics [61].

Conclusion

Symptoms of postoperative throat discomfort such as sore throat, hoarseness and dysphagia are common, and are associated with trauma to the larynx and the pharynx. Careful airway management technique is therefore essential. Appropriate sizes of tracheal tube and LMA should be chosen. Lubricants containing local anaesthetics do not appear to be beneficial and may actually be harmful, having been implicated as a cause of bilateral recurrent laryngeal nerve palsy. Tracheal-tube cuffs that have minimal contact with the tracheal mucosa should be used, and monitoring and limitation of tracheal tube and LMA cuff pressures should be considered, both to reduce the incidence of postoperative sore throat and to minimise the risk of neuropraxia.

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