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Respiration and the Airway

Overinflation of the cuff and pressure on the neck reduce the preventive effect of supraglottic airways on pulmonary aspiration: an experimental study in human cadavers

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Abstract

Background: The oesophageal leak pressure is defined as the pressure which breaks the seal between the cuff of a supraglottic airway and the peri-cuff mucosa, allowing penetration of fluid into the pharynx and the oral cavity. As a consequence, a decrease in this variable increases the risk of reflux and can lead to pulmonary aspiration. The aim of this study was to analyse the effects of cuff overinflation and pressure on the neck on the oesophageal leak pressure of seven supraglottic airways.
Methods: Three laryngeal masks, two laryngeal tubes, and two oesophageal–tracheal tubes were tested in an experimental setting. In five human cadavers, we simulated a sudden increase in oesophageal pressure. To measure baseline values (control), we used an intracuff pressure as recommended by the manufacturer. The first intervention included overinflation of the cuff by applying twice the amount of pressure recommended. A second intervention was defined as external pressure on the neck.
Results: The oesophageal leak pressure was decreased for laryngeal masks (control, 28 cm H_2O; overinflation, 9 cm H_2O; pressure on the neck, 8 cm H_2O; $P<0.01$) and for laryngeal tubes (control, 68 cm H_2O; overinflation, 37 cm H_2O; pressure on the neck, 39 cm H_2O; $P<0.01$) and was unaffected for oesophageal–tracheal tubes (control, 126 cm H_2O; overinflation/pressure on the neck, 130 cm H_2O; n.s.).
Conclusions: Cuff overinflation and pressure on the neck can enhance the risk of gastro-oesophageal reflux when using supraglottic airways. Therefore, both manoeuvres should be avoided in clinical practice.

Key words: laryngeal masks; models, anatomical; respiratory aspiration

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Editor's key points

- Gastropharyngeal reflux can occur during the use of a supraglottic airway, but it is not known whether or not the overinflation of the cuff or pressure on the neck affect the risk of reflux.
- In a cadaver model, the effect of overinflation of the cuff or pressure on the neck on the sealing effect on gastropharyngeal reflux was assessed during the use of one of seven supraglottic airways.
- Overinflation of the cuff or pressure on the neck increases the risk of reflux during the use of the laryngeal masks or the laryngeal tube.

Using supraglottic airways, there is no complete protection against gastric insufflation, gastro-oesophageal reflux, or subsequent pulmonary aspiration.[1] Given that the risk of aspiration is always present in prehospital airway management and during general anaesthesia, it is of clinical importance to identify factors that impair the sealing capabilities of supraglottic airways.[2–4]

Using a cadaver model, our group has shown in previous studies that there are some major differences between the individual supraglottic airways with regard to sealing capabilities during sudden increases in oesophageal pressure.[5–7] It seems that oesophageal–tracheal dual-lumen tubes can prevent reflux better than laryngeal tubes or laryngeal masks.[6] Although some information is available regarding the capability of each supraglottic airway to prevent reflux, only little is known about the impact of manoeuvres that are used in clinical conditions to optimize the airway position, such as cuff overinflation or pressure on the neck. Although it has been shown in supraglottic airways that cuff overinflation can lead to postoperative morbidity and to impairment of its primary function, the airway seal, overinflation of the cuff is still a frequent phenomenon in clinical practice.[8] One reason for this might be the incorrect assumption that air leakage around the blocked cuff is avoidable by this manipulation. Several clinical studies have shown that overinflation of the cuff increases, rather than decreases, the air leakage around the device.[9 10] The application of external pressure on the neck after placement of supraglottic airways has been reported to prevent gastric insufflation.[11] However, it remains an open question as to whether or not the risk of gastro-oesophageal reflux is influenced by these manoeuvres, which are mainly performed by paramedics and emergency physicians.[12]

In the present study, therefore, we examined the hypothesis that cuff overinflation and external pressure on the neck can change the sealing capabilities of supraglottic airways during sudden increases in oesophageal pressure. In this regard, differences between individual airway devices were expected.

Methods

Cadaver model

The study was approved by the local Ethics Committee of the Charité University Hospital – Universitätsmedizin Berlin (trial registry number: EA1/195/06). Given that it is impossible to determine the protection from aspiration afforded by airway devices in clinical conditions in patients, we used an experimental setting based on investigations in human cadavers. Five unfixed human bodies (three female, two male) were dissected within 24 h after their natural death. The mean age at death was 82 yr (range, 77–88 yr).

The bodies were prepared to provide exposure of the trachea and the oesophagus in the neck. The distal end of the trachea was connected to a test lung for respirators and secured by a suture. The distal end of the exposed oesophagus was connected to a vertical flexible tube with a diameter of 2 cm and a height of 130 cm, using a tight suture. By filling this flexible tube with water, orally directed oesophageal pressure was simulated and precisely measured using a centimetre division scale applied on the outside of the tube.

The oesophageal leak pressure, or as synonymously mentioned, regurgitation pressure, was first described by Brimacombe and Keller.[13] They have shown that the oesophageal leak pressure is a suitable measure to assess the risk of reflux and pulmonary aspiration.[13–15] Oesophageal leak pressure was defined as the pressure which breaks the seal between cuff and peri-cuff mucosa, allowing penetration of water into the oral cavity and the pharynx.

After placement of the supraglottic airway, the tube was completely filled with water to a level of 130 cm (resulting pressure, 130 cm H_2O) while the oesophageal tube was clamped. After removal of the clamp, the height of the water column remaining after 60 s was measured. The water that penetrated the barrier between the oesophagus and hypopharynx was collected, but we did not differentiate reflux and pulmonary aspiration in this experimental approach. Figure 1 shows a schematic illustration of the experimental procedure.

All devices were applied in a randomized sequence using a computerized random-number generator.

Airway devices

Devices with an oesophageal drainage tube were tested with a closed drainage lumen. The study was carried out using laryngeal mask airways (Classic Laryngeal Mask Airway™, Laryngeal Mask Airway ProSeal™, and Intubating Laryngeal Mask Airway Fastrach™), laryngeal tubes (Laryngeal Tube™ and Laryngeal Tube LTS II™), and oesophageal–tracheal dual-lumen tubes (Easytube™ and Combitube™). The sizes of the supraglottic airways were selected for the bodies to establish a representative seal (Classic Laryngeal Mask Airway, Laryngeal Mask Airway ProSeal, Intubating Laryngeal Mask Airway Fastrach, Laryngeal Tube, and Laryngeal Tube LTS II, size 4 or 5; Combitube and Easytube 37 or 41 Charrière).

The Combitube and Easytube were inserted into the oesophagus using distal tube placement. All devices were inserted by the same experienced anaesthetist (>1000 extraglottic airway device applications). The correct placement of all supraglottic airway devices was evaluated by performing the following tests. Initially, sufficient ventilation of the test lung was checked by delivering 10 consecutive breaths (maximal inspiratory pressure, 15 cm H_2O). A correct position was assumed when there was no audible air leakage during this manoeuvre and the pressure could be maintained. Thereafter, a constant airway pressure was built up by pressing the ventilation bag with 15 cm H_2O for 60 s without any pressure loss and no detectable bubbles in the water column, indicating an oesophageal leak.

In devices with an incorporated oesophageal drainage tube, the correct position of the oesophageal point was verified by inserting a gastric tube through the oesophageal lumen and moving it forward until it became visible at the oesophageal end. As the last step, the correct position was checked by means of fibreoptic pharyngoscopy. If necessary, the position of the extraglottic airway was corrected or the size changed until all baseline tests performed were passed.