Cricoid pressure applied after placement of the laryngeal mask prevents gastric insufflation but inhibits ventilation

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Summary

We studied 50 patients, in a blind, crossover study, to assess if cricoid pressure applied after placement of the laryngeal mask prevented gastric insufflation without affecting ventilation. After induction of anaesthesia and neuromuscular block, a laryngeal mask was inserted and confirmed to be placed correctly. The lungs were ventilated with a maximum inflation pressure of 15 cm H2O. In the first 25 patients, expiratory volumes were measured with and without cricoid pressure (30 N). On both occasions, a free hand was placed under the patient's neck. In the next 25 patients, the effect of cricoid pressure on ventilation without support of the neck was also studied. The effect of cricoid pressure with support of the neck on gastric insufflation was then assessed using a stethoscope in all 50 patients, while the lungs were ventilated with a maximum inflation pressure of 30 cm H2O. At the end of the study, the position of the mask was re-assessed. Cricoid pressure significantly decreased mean expiratory volume ($P < 0.001$). This inhibitory effect was significantly greater when the pressure was applied without support of the neck ($P < 0.001$). Cricoid pressure significantly reduced the incidence of gastric insufflation (12 patients vs one patient; $P < 0.001$; 95 % CI for difference 10.5–33.5 %). In no patient was the mask dislodged after these procedures. Thus, although cricoid pressure applied after insertion of the laryngeal mask prevented gastric insufflation, it also decreased ventilation. The inhibitory effect of cricoid pressure on ventilation without support of the neck was greater than cricoid pressure with support of the neck. (Br. J. Anaesth. 1996; 76: 772–776)

Key words

Equipment, masks anaesthesia. Larynx, cricoid pressure.

The laryngeal mask has a potential role in patients with difficult airways. It has been used successfully to facilitate ventilation in patients in whom ventilation via a face mask, or tracheal intubation, or both, had failed [1, 2]. However, it cannot reliably prevent gastric insufflation, regurgitation or pulmonary aspiration [3, 4]. Cricoid pressure is thus necessary in patients with increased risk of pulmonary aspiration.

Cricoid pressure, when applied before insertion, impedes the correct positioning of the laryngeal mask and may prevent adequate ventilation [5–7]. Thus, it has been suggested that cricoid pressure should be released temporarily during insertion of the laryngeal mask and, when the mask has been inserted, cricoid pressure should be reapplied [5, 7].

Cricoid pressure applied after placement of the laryngeal mask effectively prevents regurgitation [8]. However, it is not known if cricoid pressure applied after placement of the laryngeal mask prevents gastric insufflation and if it affects ventilation through the mask. Therefore, in this study we examined if cricoid pressure applied after placement of the laryngeal mask effectively prevented gastric insufflation without inhibiting ventilation. It has been reported that there are differences in the various effects of cricoid pressure with and without support of the neck [7, 9]. We also studied if there was a difference in the effect on ventilation between these two methods of cricoid pressure.

Patients and methods

After obtaining approval from the local Research Ethics Committee and written informed consent, we studied 50 female patients, ASA I or II, aged 18–65 yr, undergoing elective surgery, in whom neuromuscular block was indicated. Patients were excluded if they had any pathology of the neck, upper respiratory or upper alimentary tracts, or were at risk of pulmonary aspiration of gastric contents. Patients with Mallampati class 3 [10] or class 4 [11] were also excluded.

Temazepam 20 mg was given orally as premedication. In the anaesthetic room, an electrocardiograph, pulse oximeter and arterial pressure cuff were attached. After preoxygenation, anaesthesia was induced with either thiopentone or propofol i.v. and neuromuscular block was produced with vecuronium. Neuromuscular block was confirmed with a peripheral nerve stimulator. Anaesthesia was maintained with either enflurane or isoflurane in oxygen during the study.

After neuromuscular block was achieved, pillows were replaced by a firm pad (6 cm in height). The pad was placed under the patient's occiput, but not under the neck. A size 3 or size 4 laryngeal mask was inserted using the method described in the manu-

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facturer’s instruction manual [12]. The cuff of the mask was inflated with the recommended maximum volume of air (20 and 30 ml, respectively). The breathing system was connected to the laryngeal mask.

ROUTINE ASSESSMENT OF VENTILATION VIA THE LARYNGEAL MASK

The adequacy of ventilation was assessed by manual ventilation. Ventilation was judged as adequate when the chest expanded with inflation with a satisfactory compliance. If it was not possible to ventilate the lungs adequately, one more attempt at placement of the laryngeal mask was allowed. If unsuccessful, the patient was withdrawn from the study. Any apparent airleak from the gap between the mask and pharynx was noted.

After successful insertion, a bite-block (a wad of gauze) was inserted and both the laryngeal mask and the bite-block were fixed to the patient’s face with tape. The lungs were subsequently inflated using the ventilator (Siemens Servo-C) with a setting of square waveform in the pressure control mode. An inspiratory–expiratory ratio of 1:3 was used and the pressure was initially set to 15 cm H₂O.

ASSESSMENT OF INITIAL POSITION OF THE LARYNGEAL MASK

The position of the laryngeal mask was assessed using a fibreoptic bronchoscope, as described previously [7]. The mask was arbitrarily considered to be placed correctly when all of the following criteria were fulfilled: (1) the skin overlying both the thyroid and cricoid cartilages bulged mildly during inflation of the cuff; (2) neither the mask nor the tube was twisted; (3) the glottis was seen through the fibrescope; and (4) neither the tip of the mask nor the oesophagus was seen through the fibrescope [13].

EFFECT OF CRICOID PRESSURE ON VENTILATION VOLUME

In a random, crossover design, we assessed the adequacy of ventilation with and without cricoid pressure. In the first 25 patients, we studied the effect of cricoid pressure which was applied with a free hand placed under the patient’s neck (i.e. bimanual cricoid pressure). On one occasion, cricoid pressure was applied with a cricoid yoke [7], at a force of 30 N [14]; on the other occasion, the yoke was placed on the cricoid cartilage, but pressure was not applied (sham pressure). The order of the test pressures was randomized by tossing a coin.

The investigator assessing ventilation volumes and the presence of gastric insufflation (see below) was blind to the application of cricoid pressure by placing a screen between the patient and the investigator. The other investigator, who applied a test pressure on cricoid cartilage, was also blind as to the volumes of ventilation and the presence of gastric insufflation. Expiratory volumes, as a reflection of ventilation volumes, were recorded from the sixth to the 10th breaths and mean values were calculated.

We found that cricoid pressure inhibited ventilation through the laryngeal mask in the first 25 patients (see results). Therefore, we studied another 25 patients to determine if there was a difference in the inhibitory effect on ventilation between two different methods of cricoid pressure. Three different methods were used in this part of the study: sham pressure, cricoid pressure with support of the neck (bimanual method) and cricoid pressure without support of the neck (single-handed method). These three test pressures were applied in turn. The order was randomized by choosing a card without replacement from three cards indicating the three test pressures. Expiratory volumes were recorded from the sixth to the 10th breaths for each circumstance.

EFFECT OF CRICOID PRESSURE ON GASTRIC INSUFFLATION

After assessment of the effect of cricoid pressure on ventilation through the laryngeal mask, we studied the effect of cricoid pressure on gastric insufflation in all 50 patients. The inflation pressure was increased from 15 to 30 cm H₂O. On one occasion, cricoid pressure was applied bimanually and on the other occasion, no pressure was applied. In each of the two occasions, the presence of gastric insufflation was assessed by auscultation over the epigastrium. The lungs were inflated for a maximum of five times for each situation. Lawes, Campbell and Mercer [15] have shown that a volume of gas, as little as 5 ml, entering the stomach from the oesophagus can be detected. We also confirmed that “bubbling” sounds were detected reliably by a stethoscope placed over the epigastrium during insufflation of 5 ml of air through a nasogastric tube into the stomach. Any apparent air leak from the gap between the laryngeal mask and the pharynx was also noted.

ASSESSMENT OF FINAL POSITION OF THE LARYNGEAL MASK

At the end of the procedure, the position of the laryngeal mask was re-assessed using a fibreoptic bronchoscope to examine if the mask had been dislodged by application of cricoid pressure and ventilation with an inflation pressure of 30 cm H₂O.

MEASUREMENTS AND STATISTICAL ANALYSIS

Ventilation volumes and the presence of gastric insufflation were recorded. The mean expired tidal volume between the sixth and 10th breath was calculated. Normal plots (plots of normal scores) showed that the data for the differences in expiratory volumes between the different test pressures were not normally distributed. The non-parametric Wilcoxon signed rank sum test was therefore used to compare mean expiratory volumes in patients in whom only bimanual and sham pressures were used. In patients in whom all three test pressures were used, Friedman’s non-parametric two-way analysis of variance was used to compare mean expiratory volumes. If this proved significant, the Wilcoxon
Results

Routine Assessment of Ventilation via the Laryngeal Mask

The laryngeal mask was placed easily at the first attempt and ventilation was considered adequate in all patients who were included in the study. In one other patient, however, placement of the mask failed after two attempts and thus this patient was withdrawn from the study. A size 4 mask was used in 44 and a size 3 in the remaining six patients. There was no detectable air leak from the gap between the laryngeal mask and the pharynx in any patient when the lungs were ventilated with a maximum inflation pressure of 15 cm H2O.

Assessment of Initial Position of the Laryngeal Mask

During inflation of the mask, the tissue overlying both the thyroid and cricoid cartilages bulged. The glottis was always seen directly below the grille of the laryngeal mask when the position of the mask was assessed using a fibreoptic bronchoscope. Neither the mask nor the tube was twisted; neither the tip of the mask nor the oesophagus was seen in any patient. Therefore, the position of the mask was judged as correct in all patients.

Effect of Cricoid Pressure on Ventilation Volume

In the first 25 patients, median expiratory volume was 733 (range 438–1413) ml when no pressure was applied to the cricoid cartilage. Bimanual cricoid pressure decreased the expiratory volume to 501 (169–1133) ml, and this inhibitory effect was significant \( P < 0.001 \) (95% CI for difference 93–223 ml) (fig. 1).

In the second 25 patients, in whom the effects of both single-handed and bimanual cricoid pressures were studied, Friedman's two-way analysis of variance showed that mean expiratory volume was significantly different between the three test pressures \( P < 0.001 \). The inhibitory effect of single-handed cricoid pressure was significantly greater than that of bimanual cricoid pressure \( (P < 0.001) \) (95% CI for difference 88–290 ml) (fig. 1).

Effect of Cricoid Pressure on Gastric Insufflation

When inflation pressure was increased from 15 to 30 cm H2O, gastric insufflation was detected in 12 of 50 patients (24%) when no pressure was applied on the cricoid cartilage. In contrast, when bimanual cricoid pressure was applied, insufflation occurred in only one of 50 patients (2%); it occurred under both circumstances in this patient. Bimanual cricoid pressure thus decreased the incidence of gastric insufflation by 22% \( (P < 0.001) \) (95% CI 10.5–33.5%).

At a maximum inflation pressure of 30 cm H2O, air leaked from a gap between the laryngeal mask and the pharynx in 23 patients (46%) when no (sham) pressure was applied and in 26 patients (52%) when bimanual cricoid pressure was applied.

Assessment of Final Position of the Laryngeal Mask

At the end of the procedure, the position of the laryngeal mask was re-assessed. The position had not changed in any patient.

Discussion

Effect of Cricoid Pressure on Ventilation

Cricoid pressure significantly decreased ventilation volumes through the laryngeal mask. The cumulative frequency of the expiratory volume per unit body weight (fig. 2) showed that the proportion of patients at a certain expiratory volume was always greater when cricoid pressure was applied compared with sham pressure. In addition, the proportion was also always greater when single-handed cricoid pressure was applied compared with bimanual cricoid pres-
Cricoid pressure and the laryngeal mask

Figure 2. Cumulative frequency of mean expiratory volume (calculated from the sixth to the 10th breaths) when either no (—), bimanual (⋯⋯) or single-handed (——) cricoid pressure was applied. The data for no pressure and bimanual cricoid pressure are for 50 patients, whereas those for single-handed cricoid pressure are for the last 25 patients.

Figure 2. Cumulative frequency of mean expiratory volume (calculated from the sixth to the 10th breaths) when either no (—), bimanual (⋯⋯) or single-handed (——) cricoid pressure was applied. The data for no pressure and bimanual cricoid pressure are for 50 patients, whereas those for single-handed cricoid pressure are for the last 25 patients.

Cricoid pressure is more likely to be inadequate when cricoid pressure is applied and, in particular, when it is applied without support of the neck (single-handed cricoid pressure). For example, if we arbitrarily consider that ventilation was adequate when the expiratory volume was greater than 8 ml kg⁻¹, ventilation was adequate in most patients when no pressure was applied. In contrast, it was adequate in about 50% of patients when bimanual cricoid pressure was applied and in only 14% of patients when single-handed cricoid pressure was applied.

Several differences in the various effects of cricoid pressure with and without support of the neck have been reported [7, 9]. Cricoid pressure without support of the neck tends to flex the head on the neck. In contrast, support of the neck minimizes such flexion [9]. It has been claimed that flexion of the head on the neck may make both ventilation through the face mask and tracheal intubation more difficult [7, 9]. In addition, single-handed cricoid pressure prevents placement of, and ventilation through, the laryngeal mask more often than bimanual cricoid pressure [7]. The findings in this study confirm that support of the neck may reduce the untoward effects associated with cricoid pressure.

We assessed ventilation while the lungs were ventilated by a pressure control mode with a maximum inflation pressure of 15 cm H₂O. We used this mode as we considered that in clinical practice, ventilation would usually be controlled by squeezing the reservoir bag, feeling the compliance of the lungs. We also considered that we would not inflate the lungs with an inflation pressure greater than 15–20 cm H₂O to minimize air leak around the laryngeal mask. It is, however, not clear if cricoid pressure decreases ventilation volumes when the lungs are ventilated by a volume-controlled mode.

We used a firm pad to standardize the position of the patient’s head and neck. Soft pillows are usually used to support the head and neck during induction of anaesthesia in the UK. This support of the neck by pillows may lessen the inhibitory effect of single-handed cricoid pressure on ventilation.

It has been recommended that cricoid pressure should be released temporarily during placement of the laryngeal mask and that it is re-applied immediately after placement of the mask [5, 7, 13]. From the results of this study we recommend that the patient’s neck should be supported when cricoid pressure is applied after placement of the laryngeal mask to minimize the decrease in ventilation through the laryngeal mask.

Gastric Insufflation

Cricoid pressure significantly decreases the degree of gastric insufflation while the lungs are ventilated via a face mask in both adults [15, 17, 18] and children [19–21]. We found that cricoid pressure was effective in preventing gastric insufflation even when the laryngeal mask was in place.

When the lungs were ventilated at a maximum inflation pressure of 30 cm H₂O (without cricoid pressure), gastric insufflation occurred in 24% of patients, whereas air leaked from the gap between the mask and the pharynx in 46% of patients. In a previous study, where a similar method of ventilation was used, the incidences of gastric insufflation and air leak were 35.4% and 96%, respectively, when the lungs were ventilated with an inflation pressure of 30 cm H₂O [3].

One possible reason for these differences between this and previous studies [3] is the difference in the size of the laryngeal mask. In the previous study, a size 3 laryngeal mask was used in females and a size 4 in males [3], whereas in this study, we used a size 4 in most female patients. Thus the incidence of both gastric insufflation and air leak might have been lower in this study because of a “better fit” mask. Brain states that a size 4 mask should be used in adults (both males and females) of average size, and a size 3 mask in small adults [12], although there is no study to confirm this recommendation. Our study may support the claim that the use of the size 4 mask is better than the size 3 mask in females of average size.

The incidence of apparent air leak from a gap between the laryngeal mask and the pharynx was greater than that of gastric insufflation. This finding is consistent with previous results [3]. The higher incidence of air leak around the laryngeal mask may indicate that the mask acts as a pressure-limiting (“pop-off”) valve and reduces both the incidence and degree of gastric insufflation. When a face mask is used, gastric insufflation usually occurs at about 30 cm H₂O [15, 17, 21]. Thus the incidence of gastric insufflation is lower when the laryngeal mask is used compared with a face mask.

Cricoid Pressure During Cardiopulmonary Resuscitation

The laryngeal mask may be useful as an initial method of airway management during resuscitation until a person competent in tracheal intubation is available [22]. Although application of cricoid pressure during cardiopulmonary resuscitation has been
advocated, it is not performed widely [23]. It is recommended that the airway should be maintained by two people when a face mask is used, one holding the mask and the patient’s jaw and the other ventilating the lungs [24, 25]. Thus a third person may be required to apply cricoid pressure, which might be impractical. When the laryngeal mask is used, it may be practical to apply cricoid pressure, as one person can maintain both a patent airway and adequate ventilation and the second person can apply cricoid pressure.

In this study, although cricoid pressure decreased the incidence of gastric insufflation, it also inhibited ventilation through the laryngeal mask. It has been claimed from results of a multi-hospital study that the incidence of both gastric insufflation and regurgitation during cardiopulmonary resuscitation may be lower when the laryngeal mask is used compared with a face mask, even when cricoid pressure is not applied [22]. It is not clear if cricoid pressure would improve clinical outcome when the laryngeal mask is used during cardiopulmonary resuscitation.

**POSITION OF THE LARYNGEAL MASK**

The position of the laryngeal mask had not changed in any patient at the end of the experimental procedures. Thus application of cricoid pressure and ventilation of the lungs with an inflation pressure of 30 cm H2O for a short duration after placement of the laryngeal mask did not usually dislodge the mask, when the mask was placed and fixed correctly to the patient’s face. This finding is consistent with a previous observation [26]. However, it is not certain if cricoid pressure or ventilation with a high inflation pressure for a long duration would dislodge the mask. Dislodgement could be more likely to occur if the mask is not placed or fixed correctly. There is, however, no evidence to support these possibilities.

In summary, we have shown that although cricoid pressure applied after correct placement of the laryngeal mask significantly decreases the incidence of gastric insufflation, it also decreases the adequacy of ventilation. We also have shown that the inhibitory effect on ventilation by cricoid pressure without supporting the neck is greater than cricoid pressure with support of the neck. The patient’s neck should thus be supported when cricoid pressure is applied after successful placement of the laryngeal mask.

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**References**


