Cricoid pressure impedes placement of the laryngeal mask airway

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Summary
We have studied 22 patients to examine whether or not cricoid pressure affects ventilation of the lungs via the laryngeal mask and its correct positioning. In a randomized, crossover design, the laryngeal mask was inserted with or without cricoid pressure applied with a standardized force of 30 N using a cricoid yoke. A standardized pillow (6 cm in height) was placed under the patient's occiput, but the neck was not supported. Ventilation of the lungs via the laryngeal mask was adequate in all patients when no cricoid pressure was applied, but in only three of 22 patients when cricoid pressure was applied (P < 0.001; 95% confidence interval (CI) 0.72–1.0). The mask was positioned correctly in 18 patients when no pressure was applied, and in none after application of cricoid pressure (P < 0.001; 95% CI 0.66–0.98). We had planned to study, in an additional 20 patients, the effect of cricoid pressure without a pillow under the occiput; placement of the mask, however, was difficult even when cricoid pressure was not applied and there was a high incidence of bleeding from the oropharynx. We thus abandoned that part of the study after eight patients. In those eight patients, the success rate of ventilation via the laryngeal mask was lower when cricoid pressure was applied compared with bimanual cricoid pressure [6, 7].

Inability to ventilate the lungs of a patient after failed tracheal intubation is a cause of significant morbidity. The laryngeal mask has been used successfully in patients in whom tracheal intubation or manual ventilation via a face mask has failed [1, 2]. Application of cricoid pressure is mandatory if the laryngeal mask is used in anaesthetized patients with an increased risk of pulmonary aspiration of gastric contents.

Cricoid pressure applied before placement of the laryngeal mask prevents the distal part of the mask from occupying its correct position, as cricoid pressure compresses both the hypopharynx and the oesophagus [3, 4]. The success rate of adequate ventilation via the laryngeal mask, however, is inconclusive [4–7].

One of the reasons for the discrepancies in previous studies is the difference in the methods of cricoid pressure. When cricoid pressure was applied while the patient's neck was supported by a hand (bimanual method), placement of the mask was impeded [4, 5], whereas cricoid pressure applied without support of the neck (single-handed method) did not impede placement [6, 7].

When cricoid pressure is applied while the neck is supported either by a hand (bimanual method) or a "cuboid" (a pad which supports the neck), flexion of the head on the neck is prevented [8]. In contrast, when it is applied without support of the neck, the head tends to flex on the neck [8]. The view of the glottis at laryngoscopy deteriorates with flexion of the head. Flexion of the head may also, in theory, make placement of the mask more difficult, because correct placement is achieved best when the patient's head and neck are positioned in the "sniffing position" [9]. Previous results are not consistent with this theory, because the success rate of placement was higher when single-handed cricoid pressure was applied [6, 7] compared with bimanual cricoid pressure [4, 5].

Another possible reason is that the force applied was too weak in the studies which showed no difference in the success rate of placement of the mask with and without cricoid pressure [6, 7]. In no study, however, was the force standardized.

The aim of this study was to examine whether or not cricoid pressure without support of the neck (single-handed method) impedes placement of the laryngeal mask when a standardized force, which is sufficient to prevent regurgitation, is applied while a standardized pillow of optimal height is in place under the occiput.

Patients and methods
We studied 22 patients (ASA I or II) for whom neuromuscular block was required as part of the anaesthetic procedure for elective surgery. Patients with any pathology of the neck or upper respiratory tract, or at risk of pulmonary aspiration of gastric contents were excluded, as were those with Mallampati class III [10] or class IV, described by...
Samsoon and Young [11]. The local Ethics Committee approved the study and written informed consent was obtained from all patients.

Temazepam 20 mg was given orally as premedication. After preoxygenation of the lungs, anaesthesia was induced with propofol and neuromuscular block produced with vecuronium. Anaesthesia was maintained using nitrous oxide with either enflurane or isoflurane in oxygen. Adequacy of neuromuscular block was confirmed with a peripheral nerve stimulator.

In a random crossover fashion, the laryngeal mask was inserted while cricoid pressure was applied on one occasion and with no pressure (sham pressure) applied on the other occasion. The order was randomized by tossing a coin. The adequacy of ventilation via the laryngeal mask and its position were examined only in patients in whom ventilation via a face mask had been adequate after application of either cricoid or sham pressure. One of two anaesthetists (K.B., R.S.V.) applied cricoid pressure with a cricoid yoke without supporting the neck (single-handed cricoid pressure). The cricoid yoke, which was produced at our university, uses a spring to produce a standardized force. It had a concave contact surface and the ridge was 2 cm wide based on the width of the fingers. The force produced by the cricoid yoke was adjusted to 30 N [12]. A force transducer confirmed that the yoke could reproduce the force within an error of 5%. Sham pressure was applied by placing the yoke on the cricoid cartilage without force. An investigator inserting the mask (T.A.) was blind as to whether or not cricoid pressure was being applied, by covering the patient's neck, the assistant's hand and the yoke with a drape.

ADEQUACY OF VENTILATION VIA A FACE MASK

When the patient was paralysed, the pillows were removed and a firm pad pillow (6 cm in height) was placed under the patient's occiput, but not under the neck. Cricoid pressure was applied on one occasion and no pressure was applied on the other occasion. Adequacy of ventilation via a face mask was assessed after application of either cricoid or sham pressure. Ventilation was judged to be adequate when the chest expanded with satisfactory compliance during inflations via the face mask. If it was not possible to ventilate adequately via the face mask, the patients were excluded from the study.

ADEQUACY OF VENTILATION VIA THE LARYNGEAL MASK

In patients in whom ventilation via a face mask had been adequate after application of a test pressure, the investigator attempted to extend the patient's head on the neck and to place either a size 3 or 4 laryngeal mask using the insertion method described in the manufacturer's instruction manual [9]. The cuff was inflated with the recommended maximum volume of air (20 and 30 ml, respectively) [9]. Only one attempt at placement was allowed for each set of circumstances. The laryngeal mask was then connected to the breathing system and adequacy of ventilation assessed.

POSITION OF THE LARYNGEAL MASK

After assessment of the adequacy of ventilation, a fibropptic bronchoscope was passed through the laryngeal mask. The view of the larynx through the bronchoscope with its tip positioned at the level of the grille of the mask was categorized by the "blinded" observer: A = glottis, but not the tip of the epiglottis seen; B = glottis and tip of the epiglottis seen; B = epiglottis pressed downward; B = epiglottis not pressed downward, but glottis not seen; and F = failure of placement. The position of the mask was judged arbitrarily as correct when the category was A and as suboptimal when the category was B, B or B [4, 13]. We referred to the categories by a letter code instead of a number code in this study (in our previous study [4], we used 4, 3, 2, 1, 0) to clarify that there was no obvious ordering in the category [3]. If the upper part of the oesophagus was seen in the bowl of the mask, the mask was considered to be placed in the suboptimal position.

EFFECT OF THE ABSENCE OF THE PILLOW

In another group of patients, we examined adequacy of ventilation via the laryngeal mask and its position with and without single-handed cricoid pressure without any pillow, that is with the patient's occiput lying directly on the trolley.

SAFETY MANAGEMENT

If arterial haemoglobin oxygen saturation ($SpO_2$) decreased to less than 95%, the procedure was abandoned immediately and appropriate treatment was given. The patient was excluded from the study.

STATISTICAL ANALYSIS AND PATIENT CHARACTERISTICS

Fisher's exact test was used to compare the success rates of adequate ventilation via the laryngeal mask and its correct positioning. Confidence intervals were also calculated.

The success rate of adequate ventilation via the laryngeal mask without cricoid pressure has been reported as 95–100% [4, 6]. We considered that a clinically important difference in the success rate would be 25%. Fifty patients would be required to detect this difference with a power of 0.8–0.9 [14]. Our previous results, however, showed a difference of 45% in the success rate of adequate ventilation with and without bimanual cricoid pressure. We hypothesized that the difference should be greater than 45% when single-handed cricoid pressure was used. Therefore, 20 patients would be sufficient to detect a difference of 45% with a power of 0.8–0.9 [14]. $P < 0.05$ was considered significant.

We had planned to study the effect of cricoid pressure without a pillow in an additional 20 patients. We stopped the study after eight patients because of the high incidence of bleeding from the oropharynx.

We studied 22 patients, aged 23–66 yr, weight 65–90 kg, and with Mallampati class I and II (17 and five patients, respectively). We studied the effect of
Cricoid pressure and the laryngeal mask

Cricoid pressure without the use of the pillow in another eight patients, aged 32–67 yr, weight 52–76 kg, and with Mallampati class I and II (five and three patients, respectively).

Results

ADEQUACY OF VENTILATION VIA A FACE MASK

Ventilation via a face mask became difficult when cricoid pressure was applied in three patients, who were excluded from the study. The lungs could be ventilated via a face mask after application of test pressure in all 22 patients included in this study, although a Guedel airway was sometimes required when cricoid pressure was applied because of flexion of the head on the neck.

ADEQUACY OF VENTILATION VIA THE LARYNGEAL MASK

Placement of the laryngeal mask was easy and adequate ventilation was always obtained via the mask when no cricoid pressure was applied (fig. 1). In contrast, when cricoid pressure was applied, it was often difficult to extend the head on the neck and to open the mouth, although both the mask and the index finger could be inserted into the oropharynx in all patients. Ventilation was adequate in only three of these 22 patients. Cricoid pressure, therefore, significantly decreased the success rate of adequate ventilation via the laryngeal mask ($P < 0.001; 95\% \text{ CI} 0.72$–1.0) (fig. 1).

POSITION OF THE LARYNGEAL MASK

When the mask was placed without cricoid pressure, the glottis was always seen directly below the grille of the mask and the position was judged as correct in 82\% of patients. In contrast, the mask was not in the correct position in any of the three patients in whom ventilation was adequate after application of cricoid pressure (fig. 1, table 1). Cricoid pressure thus significantly impeded correct placement of the laryngeal mask ($P < 0.001; 95\% \text{ CI} 0.66$–0.98).

In those patients in whom ventilation was not adequate after application of cricoid pressure, the glottis was seen in only one patient. In this patient, ventilation was not adequate despite a non-obstructed glottis and the tip of the epiglottis being seen. The reason for the failure was a marked airleak. The view in this patient was categorized as F according to the definition. The masks were occasionally not in far enough and only the base of the tongue was seen in almost all patients.

EFFECT OF THE ABSENCE OF THE PILLOW

Placement of the mask was difficult without a pillow, regardless of the presence or absence of cricoid pressure, because the index finger sometimes could not drive the mask fully into position. The epiglottis was sometimes impacting upon or pressed down by the mask (table 2). Bleeding from the oropharynx was observed in three of the additional eight patients, and thus we stopped the study. In these eight patients, when cricoid pressure was applied without the pillow in place, ventilation was adequate in only one patient and the position was correct in none (table 2).

Discussion

We have shown that cricoid pressure applied with sufficient force without support of the neck (single-handed method) impeded placement of and adequate ventilation of the lungs via the laryngeal mask. In our previous study, we showed that cricoid pressure while the patient's neck was supported (bimanual...
method) prevented adequate ventilation in 40% of patients at the first attempt and 50% at the second attempt at placement [4]. In the current study, we found that the success rate of adequate ventilation was much lower when cricoid pressure was applied without support of the patient's neck (single-handed method) than the bimanual method, although we did not compare these results directly. These results are consistent with the theories that cricoid pressure should impede the distal part of the mask from occupying the hypopharynx and that the success rate of placement of the mask should be more difficult when the head is flexed on the neck by the single-handed method than when the head is extended (“sniffing position”) by the bimanual method [3].

Differences in the methods of cricoid pressure have been proposed as the reasons for the discrepancies in the effect of cricoid pressure on placement of the mask [4, 15]. In earlier studies, bimanual cricoid pressure impeded placement of the mask [4, 5], whereas single-handed cricoid pressure did not [6, 7]. There are two possible differences between the methods: the efficacy of cricoid pressure and the position of patient's head and neck. In all studies, pillows were placed under the patient’s occiput (Blogg E. C., Berry A., personal communication, 1994) [3, 7]. We used a standardized pillow of 6 cm in height, because it provides the optimal position for the view of the glottis at laryngoscopy [16]. When a pillow is placed under the patient's occiput and cricoid pressure is applied without support of the neck, the head tends to flex on the neck. Bimanual cricoid pressure is designed to improve the view of the glottis at laryngoscopy by preventing flexion of the head, rather than to improve the efficacy of cricoid pressure [3, 8]. Vanner and colleagues have shown that when a force greater than 15 N is used, there is no difference in the efficacy of cricoid pressure between the different positions of the patient's head and neck [17]. Thus, if the reason for the discrepancies is because of the difference in the methods of cricoid pressure, the position of the head and neck, rather than the efficacy of cricoid pressure, should be the major reason.

The high success rate of placement of the mask reported when single-handed cricoid pressure was applied [6, 7] is not consistent with the theory that cricoid pressure should impede the distal part of the mask from occupying the hypopharynx and that placement should be more difficult when single-handed cricoid pressure is used compared with the bimanual method. In the current study, where single-handed cricoid pressure with sufficient force was applied, extension of the head on the neck and opening of the mouth were often difficult. The final positioning of the mask by the index finger was also often difficult not only because of the cricoid pressure but also because of flexion of the head on the neck. The mask was obviously not placed deep enough when cricoid pressure was applied, as the base of the tongue was frequently observed through the fibrescope. Placement was also difficult in the presence of cricoid pressure when the pillow was not placed under the occiput. Thus, it is unlikely that the difference in the position of the patient's head and neck caused by the difference in the methods of cricoid pressure is the main reason for the discrepancies among the studies.

Another possible explanation for the discrepancies in earlier studies is the difference in the force of cricoid pressure. If the force is too weak, the mask might be wedged into the hypopharynx. In none of the studies, however, was the force of cricoid pressure standardized. We applied a standardized force of 30 N using a cricoid yoke in this study as Vanner and colleagues have shown that cricoid pressure with this force effectively prevents regurgitation in cadavers and also in patients [12, 17]. Ansermino and Blogg had abandoned the use of a cricoid yoke because the yoke tended to deviate the larynx laterally [5]. We were able to overcome this problem by using a yoke with a concave-shaped ridge and by simultaneously stabilizing the larynx with the fingers.

The force of cricoid pressure was insufficient in one of the reports, where single-handed cricoid pressure did not impede placement of the mask [18], as the oesophagus was seen in the bowl of the mask in 10% of patients. When cricoid pressure is applied correctly, it should not be possible to see the oesophagus with a fibrescope passed through the laryngeal mask, as cricoid pressure compresses the hypopharynx and also the upper end of the oesophagus. We believe therefore that the discrepancies in studies in the success rates of placement of the laryngeal mask are caused by differences in the force of cricoid pressure and that single-handed cricoid pressure also impedes placement when sufficient force is applied.

It is unlikely that our technique in placement of the mask was suboptimal, because we used the insertion method described in the manufacturer's instruction manual [9]. In addition, when cricoid pressure was not applied with a pillow under the patient's occiput, we could always obtain adequate ventilation via the laryngeal mask and could place the mask correctly in most patients. Cricoid pressure with a force of 30 N did not prevent adequate ventilation via the face mask in any patient in this study. Failure to obtain adequate ventilation via the laryngeal mask while cricoid pressure was applied, therefore, was neither caused by possible suboptimal technique nor by cricoid pressure itself.

The size of the laryngeal mask used in this study might not have been appropriate. We selected size 4 for males and either size 3 or 4 for females based on the size of the patients. We routinely inflated the cuff with the recommended maximum volume of air, because we considered that inflation volumes would not be adjusted after urgent placement in patients in whom tracheal intubation has failed. Nevertheless, we believe that the results are valid, because ventilation via the laryngeal mask was always adequate and the position correct in the majority of patients when cricoid pressure was not applied.

When a pillow was not placed under the occiput, placement of the mask was more difficult even without cricoid pressure, although adequate ventilation was usually obtained. This difficulty was mainly because the index finger sometimes could not
drive the mask fully into the correct position. The success rate of adequate ventilation through the laryngeal mask without pillows (and without cricoid pressure) in our study (75%) was lower than that in previous studies [19, 20]. The reasons for these discrepancies are unclear. When cricoid pressure was applied, ventilation was almost always inadequate.

We intended that the investigator who placed the mask should be blind to the presence or absence of cricoid pressure, but the blinding was not perfect. In our previous study, where bimanual cricoid pressure was applied, the position of the patient’s head and neck was similar with and without cricoid pressure, and the investigator experienced no difficulty in ventilating the lungs via a face mask and in opening the mouth after application of cricoid pressure. The investigator was thus blinded effectively when the patient’s neck was covered with a drape [4]. In the current study, however, this was not effectively so, because when cricoid pressure was applied, extension of the head and opening of the mouth were often more difficult and a Guedel airway was sometimes required.

Fibrescopy cannot reliably confirm the correct position of the laryngeal mask [13]. It may be considered that the mask is in the correct position when the skin overlying both the thyroid and cricoid cartilages bulges slightly, and neither the tip of the mask nor the upper end of the oesophagus is seen through the fibrescope [21]. Bulging in the neck, however, could not be assessed in this study, because the patient’s neck was covered by a drape. Therefore, the correct position of the mask could not be confirmed in this study design. We assessed the position of the mask only by the view of the larynx through the fibrescope, and thus judged arbitrarily that the mask was in the correct position when only the glottis, but not the tip of the epiglottis, was seen (category A). We did not study the degree of misplacement as it is difficult to assess by fibrescopy only [3, 13].

Our current study supports the view that in patients with an increased risk of pulmonary aspiration, the laryngeal mask should not be used when the patient’s lungs can be ventilated via the face mask after failed tracheal intubation [4]. In addition, we recommend from these data that cricoid pressure should be released temporarily during placement of the mask, although this temporary release can be associated with an increased risk of pulmonary aspiration. When the mask has been placed, cricoid pressure should be reapplied immediately.

In conclusion, we have shown that cricoid pressure without support of the neck (single-handed method) impeded correct placement and ventilation via the laryngeal mask when sufficient force was applied. We believe that cricoid pressure impedes placement of the mask regardless of the method of application, and that the reason for the discrepancies among the earlier studies is because of the difference in the force of cricoid pressure.

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References