Effect of cricoid pressure on insertion of and ventilation through the cuffed oropharyngeal airway

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We have assessed the effect of cricoid pressure on insertion of and ventilation through the cuffed oropharyngeal airway (COPA) in 53 patients, in a double-blind, randomized study. Two anaesthetists assessed adequacy of ventilation in anaesthetized and paralysed patients at the same time but using different methods. The first assessed ventilation clinically, by observing synchronized chest expansion with gentle manual ventilation and the second noted measurements of tidal volume (VT) and peak inspiratory pressure (PIP). Five mask ventilated breaths ('baseline') were assessed as above. Patients were then allocated randomly to receive cricoid pressure (group A, n=28) or no cricoid pressure (group B, n=25). Five further mask ventilated breaths ('after manoeuvre') were again assessed. A COPA was then inserted and five further breaths ('after COPA') were assessed. A COPA was inserted at the first attempt in all patients except for one in group A who required two attempts. COPA placement was difficult in one patient in group B who had a small distance between the incisor teeth. Ventilation was clinically 'adequate' in all patients except for one in the cricoid pressure group. There were no significant differences in measured VT or PIP between 'baseline' and 'after manoeuvre' breaths. Significant differences in VT and PIP were found after COPA insertion in the group that received cricoid pressure, with a mean decrease in VT of 108 ml (P=0.0049) and a mean increase in PIP of 5.2 cm H₂O (P=0.0111).

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If rapid sequence induction of anaesthesia fails, it is important to prevent regurgitation and aspiration of gastric contents while maintaining oxygenation of the patient. Since it was first described by Sellick in 1961,1 cricoid pressure is standard practice to prevent regurgitation in these situations. Oxygenation may be maintained in the presence of continuous cricoid pressure by face mask with or without a Guedel airway, although cricoid pressure can reduce tidal volume and may cause upper airway obstruction.2 The laryngeal mask airway (LMA) has also been used in such a situation. However, cricoid pressure impedes proper placement3 or may reduce ease of insertion of the LMA.4 In one study, placement of the LMA was achieved at the first attempt in only 15% of patients.5 This is because the tip of the LMA lies behind the cricoid cartilage.6 7 Cricoid pressure can impede ventilation through the LMA.8 It has been recommended that the LMA should not be used when the patient’s lungs can be ventilated with a face mask after failed rapid sequence induction.3 5

We do not know if the cuffed oropharyngeal airway (COPA) has been used when rapid sequence induction and intubation have failed, although a case of successful airway management after failed face mask ventilation has been reported.9 The COPA is a modification of the Guedel airway which allows manual ventilation by directly connecting to the breathing system. It has a distal cuff which provides a seal in the upper pharynx behind the base of the tongue. Because the airway tip lies above the larynx, we hypothesized that continuous cricoid pressure would not interfere with placement of the COPA, and that ventilation of patients’ lungs through it should be possible. In this study, we have examined the effect of cricoid pressure on insertion of and subsequent ventilation through the COPA.

Patients and methods

After obtaining approval from the Local Ethics Committee and written informed consent, we studied 53 ASA I or II patients, aged 20–70 yr, undergoing elective gynaecological surgery with tracheal intubation (Table 1). Patients with any pathology of neck or upper respiratory tract, or who were considered at risk of aspiration of gastric contents...
were excluded. Patients were premedicated with temazepam 20 mg orally. The ECG and oxygen saturation were monitored continuously, arterial pressure was recorded non-invasively and a peripheral nerve stimulator was used to monitor neuromuscular block.

At the start of the operating session and before each anaesthetic, the anaesthetic nurse practised cricoid pressure by applying force with fingers on a weighing scale to obtain a reading of 3 kg. The patient was placed in the Magill intubating position. After preoxygenation, anaesthesia was induced with midazolam 2.5 mg, fentanyl 1.5 μg kg⁻¹ and propofol 1.5–2.5 mg kg⁻¹. Rocuronium 0.6 mg kg⁻¹ was administered and the patient’s lungs were ventilated manually by mask with 1.2% isoflurane in oxygen. A Datex-Engström spirometry monitor (Helsinki, Finland) incorporating a D-lite reusable sensor was used to measure expired tidal volume (VT) and peak inspiratory pressure (PIP).

Two anaesthetists took part in the study. The first undertook mask ventilation, insertion of a COPA and clinically assessed chest ventilation as ‘adequate’ or ‘inadequate’ by observing expansion of the chest with gentle bag ventilation. Ventilation was judged adequate if chest expansion was obvious. The second anaesthetist recorded VT and PIP from the monitor. The anaesthetists made their recordings simultaneously for the same breaths, but did not communicate each others findings. After confirming that neuromuscular block was complete, three sets of readings for five breaths each were recorded, as described below.

The first anaesthetist delivered five breaths by mask (‘baseline’). Patients were allocated randomly to one of two groups by computer-generated random numbers. Patients in group A received bimanual cricoid pressure, while those in group B did not. Cricoid pressure was applied by a right-handed nurse standing on the right side of the patient with the left hand supporting the neck from behind. A green drape was used on the neck as a screen to blind the anaesthetists as to whether or not cricoid pressure was being applied, but allowed a clear, unobstructed view of the chest. Even when cricoid pressure was not applied, the hands of the anaesthetic nurse were similarly positioned under cover of the screen. The first anaesthetist removed his hand and face mask from the patient’s face after delivering the five ‘baseline’ breaths and replaced it only after the anaesthetic nurse had started the ‘manoeuvre’ under cover of the drapes, ensuring that he remained blind to the manoeuvre. After this, five further mask ventilated breaths were measured (‘after manoeuvre’). Direct laryngoscopy was then performed and the laryngeal view recorded according to the criteria of Cormack and Lehane.11 After this, a pre-selected, lubricated COPA was inserted. The size of the device was determined by a method described previously.12 After COPA insertion, five further breaths were evaluated (‘after COPA’). The size, time for insertion (from start of insertion to inflation of the cuff of the COPA), number of attempts at insertion and any other problems were recorded. The device was replaced with the next biggest size if there was a big leak despite cuff inflation with up to 10 ml more than that recommended by the manufacturer or if chest expansion was not considered clinically adequate. If at any time oxygen saturation decreased to less than 95%, the study was discontinued and ventilation then labelled as ‘failed’. At the end of the study, the anaesthetic nurse immediately revaluated blindly, the force used for cricoid pressure on a weighing scale.

We considered that a reduction of tidal volume by 100 ml would be clinically significant. In a small pilot study and in other published work,2 the SD of tidal volume during manual ventilation through a COPA was estimated as 120 ml. Using a nomogram for power calculations, at least 25 patients were required in each group for a power of 0.8 at the 5% significance level.

**Statistical analysis**

Data were analysed using Stat View for Windows version 4.53 (Abacus Concepts Inc., California, USA). Data concerning COPA insertion were analysed using an unpaired t test. Inter-patient variability in VT and PIP was analysed using two-way analysis of variance (ANOVA). Analysis of the effects of cricoid pressure on VT and PIP before and after COPA insertion was performed by ANOVA using the median value of each of the five observations.

**Results**

There were no differences between the two groups in the time required for COPA insertion or the force applied for cricoid pressure (Table 2).

The COPA was inserted at the first attempt in all patients, with the exception of one patient in group A (cricoid group) who required two attempts. There were no difficulties in introducing the COPA into the mouth, turning it through 180° to point the tip caudad, placing it down to its final position or strapping and inflation in any patient except for one in group B (no cricoid pressure). This patient had a

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**Table 1** Patient characteristics (mean (SD or range) or median [range]) in groups A (cricoid pressure) and B (no cricoid pressure)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Group A (n = 28)</th>
<th>Group B (n = 25)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yr)</td>
<td>40.6 (26–65)</td>
<td>37.2 (24–68)</td>
</tr>
<tr>
<td>Height (m)</td>
<td>1.61 (0.06)</td>
<td>1.64 (0.06)</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>69.5 (16.1)</td>
<td>69.5 (9.9)</td>
</tr>
<tr>
<td>Body mass index (kg m⁻²)</td>
<td>26.7 (6.2)</td>
<td>26.2 (4.0)</td>
</tr>
<tr>
<td>Mallampati score</td>
<td>2 (1–4)</td>
<td>1 (1–4)</td>
</tr>
<tr>
<td>Cormack and Lehane score</td>
<td>1 [1–3]</td>
<td>2 [1–3]</td>
</tr>
</tbody>
</table>

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**Table 2** COPA insertion and cricoid pressure data (mean (SD)) in groups A (cricoid pressure) and B (no cricoid pressure). No significant differences

<table>
<thead>
<tr>
<th>Variable</th>
<th>Group A (n = 28)</th>
<th>Group B (n = 25)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insertion time (s)</td>
<td>25 (12)</td>
<td>22 (5)</td>
</tr>
<tr>
<td>Force at cricoid cartilage (kg)</td>
<td>3.24 (0.42)</td>
<td>3.15 (0.35)</td>
</tr>
</tbody>
</table>
Cricoid pressure and the cuffed oropharyngeal airway

![Box and whisker plots of median expired tidal volume for baseline, after manoeuvre and after COPA set of breaths.](image1)

Fig 1 Box and whisker plots of median expired tidal volume for ‘baseline’, ‘after manoeuvre’ and ‘after COPA’ set of breaths. The box indicates the lower and upper quartiles (25 and 75 percentiles) and the central line is the median; the points on the whiskers next to central line represent 95% CI; and the bars at the end of the ‘whiskers’ are 10% and 90% values.

![Box and whisker plots of median peak inspiratory pressure for baseline, after manoeuvre and after COPA set of breaths.](image2)

Fig 2 Box and whisker plots of median peak inspiratory pressure for ‘baseline’, ‘after manoeuvre’ and ‘after COPA’ set of breaths. The box indicates the lower and upper quartiles (25 and 75 percentiles) and the central line is the median; the points on the whiskers next to central line represent the 95% CI; and the bars at the end of the ‘whiskers’ are 10% and 90% values.

narrow inter-incisor distance, a Mallampati class IV airway and a Cormack and Lehane view of 3 at laryngoscopy. When the device was in place, ventilation was judged clinically to be adequate. In all patients, the lungs were ventilated adequately, as assessed clinically, except in one patient in group A. Oxygen saturation in this patient decreased to less than 95% and ventilation was labelled failed.

In three patients in group A, an audible leak persisted after inflation of the COPA cuff with 10 ml more than that recommended by the manufacturer. In all of these patients, the next biggest size COPA was inserted successfully and ventilation was judged as adequate. There were no significant intra-patient differences between the five observations for Vt or PIP for each patient (ANOVA). Median values for each set of five observations are displayed as box and whisker plots in Figures 1 and 2. There were no significant differences for Vt or PIP between ‘baseline’ and ‘after manoeuvre’ sets of mask ventilated breaths in both groups. After a COPA was inserted, Vt decreased and PIP increased significantly, by mean values of 108 ml (P=0.0049) and 5.2 cm H2O (P=0.0111), respectively, in those who received cricoid pressure.

Discussion

Different airway devices, including the Guedel airway and LMA, have been tried to facilitate ventilation in the presence of cricoid pressure. However, none has proved to be entirely satisfactory in meeting the criteria of successful insertion and maintenance of adequate ventilation in the presence of continuous cricoid pressure. In our study, we have shown that a COPA can be inserted successfully in the presence of continuous cricoid pressure. Successful insertion of a COPA was achieved at the first attempt in all patients except for one in the cricoid pressure group who required two attempts. In this patient, the COPA slipped out after cuff inflation and was reinserted successfully.

Allman reported significant reductions in tidal volume and increased airway pressure in patients whose lungs were ventilated by mask (with or without a Guedel airway) when continuous cricoid pressure was applied. We found no significant changes in tidal volume or airway pressures with mask ventilation before and after application of cricoid pressure. We did not use a Guedel airway to assist mask ventilation. In Allman’s study, cricoid pressure was not standardized and an excessive force during its application could have been responsible for the increase in airway pressures and upper airway obstruction. We standardized the force applied, as described by Vanner and colleagues, and then observed its effect on mask ventilation and on the use of the COPA. Two anaesthetic nurses who work routinely in the obstetric theatres took part in the study. They conscientiously practised cricoid pressure by producing a force of 3 kg equivalent to 30 Newtons on a weighing scale before each case and revalidated it each time afterwards by reproducing the same force with an independent observer recording the reading on the scale. This may explain why none of our patients had airway obstruction.

Although single-handed cricoid pressure is as effective as bimanual pressure, we used bimanual cricoid pressure in our study. During our pilot study we found that single-handed cricoid pressure interfered with extension of the head and neck, opening of the mouth, turning the COPA in the mouth through 180° and placing it in its final position; insertion was easier and ventilation successful when bimanual cricoid pressure was applied. Bimanual cricoid pressure is recommended during rapid sequence induction.

Placement of the LMA and subsequent ventilation have been shown to be impaired by cricoid pressure. Some recommend that cricoid pressure should be released transiently to facilitate insertion, but this may allow regurgitation and aspiration. Subsequent ventilation may also be difficult when cricoid pressure is reapplied. Cricoid pressure is less likely to interfere with placement of a COPA and ventilation through it. We assessed ventilation
clinically by observing chest expansion when the lungs were ventilated manually and simultaneously recorded $V_t$ and PIP for the same breaths. Ventilation appeared adequate in all patients except for one in the cricoid pressure group. This patient’s lungs could not be ventilated after insertion of a COPA because of a major leak that could not be prevented by further cuff inflation. Before the anaesthetist could change the device, oxygen saturation decreased rapidly to less than 95% and therefore the study was discontinued and ventilation labelled as failed.

The significant reduction in tidal volume recorded after insertion of a COPA in patients who received cricoid pressure could have been caused by a leak around the cuff of the device, which we did not measure. PIP increased significantly after COPA insertion only in the group that received cricoid pressure.

Using fibroptic visualization, Brimacombe suggested that the anterior tilt of the larynx caused by cricoid pressure can approximate the vocal cords and thus some degree of airway obstruction. We are unable to offer an explanation for the increase in PIP as we did not investigate this using a fibroptic scope.

In summary, we have shown that placement of a COPA and clinically effective ventilation through it is possible in the presence of continuous cricoid pressure. We are however, unable to recommend its routine clinical use in a failed rapid sequence induction scenario until further work is undertaken to explain the changes in tidal volume and airway pressures.

Acknowledgement
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