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Cricoid pressure: indications and complications

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Summary

Cricoid pressure to occlude the upper end of the oesophagus, also called the Sellick manoeuvre, may be used to decrease the risk of pulmonary aspiration of gastric contents during intubation for rapid induction of anaesthesia. Effective and safe use of the technique requires training and experience. Cricoid pressure is contraindicated in patients with suspected cricotracheal injury, active vomiting, or unstable cervical spine injuries. The technique may be particularly difficult in patients with a history of difficult intubation. The recommended pressure to prevent gastric reflux is between 30 and 40 Newtons (N, equivalent to 3–4 kg), but pressures greater than 20 N cause pain and retching in awake patients and a pressure of 40 N can distort the larynx and complicate intubation. The recommended procedure is, therefore, to induce anaesthesia and apply a pressure of about 30 N, either manually or with the cricoid yoke, to facilitate intubation. Reported complications of cricoid pressure during intubation include oesophageal rupture and exacerbation of unsuspected airway injuries.

Keywords: Sellick manoeuvre; cricoid pressure; intubation technique

Introduction

Cricoid pressure is used to temporarily occlude the upper end of the oesophagus. This manoeuvre is often used to decrease the chance of stomach contents being aspirated into the lungs during emergency anaesthetic induction and has become the standard of care during rapid sequence induction. However, few practitioners know the history of this procedure or the proper way to perform cricoid pressure. In addition, some clinicians believe the technique is ineffective and some believe it is unnecessary (1). This article reviews the history, mechanics, technique, and complications of cricoid pressure during rapid sequence induction of anaesthesia, particularly in the paediatric patient.

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History of cricoid pressure

The use of cricoid pressure for near-drowned victims was first described by Monro in 1774: 'Whether the inflation of the lungs is done by a person's mouth or bellows, the air is ready to pass by the gullet into the stomach; but this may be prevented by pressing the lower part of the larynx backwards upon the gullet. The pressure should be only on the cricoid cartilage, by which the gullet may be straitened[sic], the air's passage through the larynx is not interrupted' (2).

Cricoid pressure was revisited by Sellick in 1961 as a useful technique for preventing pulmonary

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aspiration of gastric contents in certain patients (3). He identified pulmonary aspiration as a significant problem during induction of anaesthesia in obstetric and emergency surgery patients and proposed that the risk of this complication could be decreased if the esophagus could be occluded by pressing the cricoid cartilage against the cervical vertebrae during induction of anaesthesia or positive-pressure mask ventilation. Eversince publication, the application of cricoid pressure prior to tracheal intubation is called the Sellick manoeuvre.

Mechanics of cricoid pressure

The cricoid cartilage is the only upper airway cartilaginous structure that is a complete ring. The oesophagus begins at the lower portion of the cricoid cartilage; thus pressure anteriorly will compress the oesophagus against the anterior vertebral body of the sixth cervical vertebra (C6). Application of pressure is similar in adults and children except that the child's cricoid cartilage differs from that of the adult in its smaller size, greater backward inclination of the posterior lamina, and higher position in the neck (1). Because all other cartilaginous structures in the upper airway are U-shaped, mistakenly exerting pressure on another cartilage, typically the tracheal or thyroid cartilage, will be at best ineffective and may lead to upper airway damage or intubation difficulties.

Intra-oesophageal/intragastric pressures

After Sellick's publication, Fanning (4) was the first to report on the intra-oesophageal/intragastric pressures required to overcome deliberate cricoid pressure. In the five cadavers Fanning studied, cricoid compression withstood intra-oesophageal pressures of at least 50 cm H_2O (mmHg) and often considerably more. Fanning proposed from these findings that properly applied cricoid pressure could overcome intragastric pressures associated with fasting (up to 18 cm H_2O), delayed gastric emptying (<50 cm H_2O), eructation (>20 cm H_2O), and fasciculations caused by administration of succinylcholine (>40 cm H_2O). However, vomiting, which creates oesophageal pressures greater than 60 cm H_2O, could overcome cricoid pressure, leading to regurgitation and pulmonary aspiration.

Using Fanning's techniques, Salem and colleagues studied cricoid pressure in eight paediatric cadavers and found that firm cricoid pressure maintained at 100 cm H_2O prevented reflux of saline from the oesophagus to the pharynx (5). In addition, the authors showed that cricoid pressure is effective even in the presence of a nasogastric (NG) tube.

Force of cricoid pressure

In the 1990s, the focus of studies addressing cricoid pressure shifted from measuring gastric and esophageal pressures that lead to regurgitation to the amount of force on the cricoid cartilage (measured in Newtons) required to prevent pulmonary aspiration. Ten Newtons (N) are equal to 1 kg of force.

In 1992, Vanner and Pryle found that 30 N of pressure on the cricoid prevented regurgitation of saline in all 10 cadavers with oesophageal pressures up to 40 mmHg (6) and Vanner *et al.* found that 40 N of cricoid pressure created an upper esophageal pressure of greater than 38 mmHg in 24 anaesthetized adults (7). Vanner and colleagues found that pregnant supine patients or patients treated with succinylcholine rarely generate intragastric pressures of greater than 35 mmHg (8). Based on these studies, the recommended amount of cricoid pressure to prevent reflux is between 30 and 40 N. However, awake patients experience pain, coughing, and retching with pressures greater than 20 N, so pressures greater than 20 N should be applied only after loss of consciousness (7,9). Furthermore, although 40 N is effective in preventing aspiration, it can cause laryngeal distortion, impeding intubation. Therefore, 30 N is the commonly recommended force to exert on the cricoid cartilage (10).

Technique for cricoid pressure for anaesthesia induction

The performance of rapid-sequence induction is similar in children and adults. The first step is to establish intravenous access while the patient is awake. In patients with intestinal obstruction or evidence of ileus, the stomach should be decompressed with an NG or orogastric (OG) tube before anaesthesia induction. The NG or OG tube can remain in place during induction, because its presence does not

reduce the efficacy of cricoid pressure as long as an adequate mask seal can be maintained. By leaving the gastric tube open to atmospheric pressure it is possible to vent liquid and gas remaining in the stomach (11).

Preoxygenation for 2–7 min with 100% oxygen is commonly recommended. Monitoring of expired oxygen and nitrogen concentrations should be started. Then, depending on the patient's clinical condition, propofol, thiopental, ketamine, or etomidate may be used for rapid sequence induction. Succinylcholine or rocuronium are the muscle relaxants most frequently indicated.

Contraindications to cricoid pressure

There are several contraindications to the use of cricoid pressure, including suspected cricotracheal injury, active vomiting, and unstable cervical spine injuries (12). In addition, use of cricoid pressure may make intubation even more difficult in patients with a history of difficult intubation. It is also important to realize that effective cricoid pressure in the failed intubation/easy mask ventilation scenario for greater than 10 min by only one assistant would appear to be an unreasonable expectation (Meek et al. 1998).

Application of cricoid pressure

Before induction of anaesthesia the cricoid ring should be identified and gently palpated. Cricoid pressure should begin before the patient is fully asleep, with 10 N of pressure, increasing to 30 N when loss of consciousness is established.

Once relaxation has occurred and prior to intubation, ill neonates or patients with limited respiratory reserve may be gently ventilated. Moynihan and colleagues showed that appropriate application of cricoid pressure in infants and young children was effective against gastric gas insufflation during mask ventilation with up to 40 cm H_2O peak inspiratory pressure (14). In older children oxygenation is usually maintained without ventilation until successful intubation, when cricoid pressure is released and ventilation is begun. However, if tracheal intubation is difficult, manual ventilation is begun with 100% oxygen. An oral airway may also be required.

If ventilation is difficult, the amount of cricoid pressure should be reduced, and if difficulty persists, cricoid pressure should be released (11).

Prevalence and risk factors for pulmonary aspiration during intubation

Because cricoid pressure is used during intubation to reduce the risk of pulmonary aspiration, it is important to understand the prevalence and risk factors for this complication. Warner and colleagues evaluated the prevalence of pulmonary aspiration in the perioperative period in a retrospective review of paediatric patients anaesthetized at the Mayo Clinic between 1985 and 1997 (15). Of the 63 180 infants and children who underwent general anaesthesia, 24 (0.04%) had evidence of pulmonary aspiration. Most of these patients aspirated before placement of the endotracheal tube. Seven of the 24 patients aspirated during anaesthesia for elective procedures and the remaining 17 patients during administration of anaesthesia for emergency surgery. These authors implied that cricoid pressure was applied in all cases, with an aspiration rate for elective procedures of 1 : 4544 and for emergency procedures a rate of 1 : 373. No respiratory symptoms developed in 15 of the 24 patients who aspirated gastric contents. Of the nine patients who developed symptoms, all did so during the first 2 h. Three children required mechanical ventilation, but no child died. Borland and colleagues also had no deaths in their study of paediatric pulmonary aspiration (16).

The most frequent predisposing factors to aspiration in the Mayo Clinic study were bowel obstruction and ileus. The link between these factors and aspiration was stronger in younger children: 10 of 11 children under 3 years who aspirated had bowel obstruction or ileus while only two of 13 children over 3 years with these problems aspirated. The authors speculate that the higher prevalence of aspiration in younger children could be because of inability to apply cricoid pressure properly in this age group. However, these authors did not describe their procedure for rapid sequence induction and they applied cricoid pressure during inhalation induction in patients who required rapid sequence induction. It is, therefore, difficult to assess the efficacy of cricoid pressure in this study. Outcome

studies in infants using prescribed airway techniques during emergency intubation are needed to adequately assess the utility of cricoid pressure.

Applying cricoid pressure correctly

Cricoid pressure must be applied correctly to be safe and effective. Meek and colleagues evaluated the cricoid pressure technique of 135 anaesthetic assistants attending an annual conference of British operating department assistants (17). Initially, only one-third of subjects quoted the correct force recommended for cricoid pressure and when each subject's technique was tested using an airway model. There was large variation in the amount of pressure applied. However, simple instruction in the correct technique for applying cricoid pressure significantly improved performance.

Another study tested 102 perioperative nurses regarding the recommended amount of force that should be applied to the cricoid cartilage (18). Only 5% of the subjects identified the correct amount of force to apply during cricoid pressure; 78.5% underestimated the recommended force and 16.5% overestimated it. In addition, there was no correlation between the amount of force participants believed they should apply and the amount they applied to an airway model. Another finding of this study was that a sizeable proportion of the subjects misidentified the cricoid cartilage and mistakenly applied pressure to the thyroid cartilage.

The inadequacies in technique identified in these studies could result clinically in aspiration, distortion, or obstruction of the airway. It would appear that all who are called on to perform cricoid pressure should receive formal instruction with ongoing review of their competence in identifying the cricoid cartilage and applying the proper amount of force to safely prevent aspiration during intubation.

The cricoid yoke

To help clinicians apply the proper amount of pressure to the cricoid, Lawes *et al*. developed the cricoid yoke (19). This instrument applies measured, consistent pressure over the cricoid. Using this instrument and models of the airway, individuals with no previous experience in the application of cricoid pressure were able to achieve as good results as experienced anaesthesia staff using proper technique without the instrument. The yoke was also found as effective as properly performed cricoid pressure in preventing regurgitation in 57 healthy women undergoing general anaesthesia for elective caesarian section (19). In this study, 14 of the patients had anatomical conditions that made intubation challenging. Anatomical displacement of the larynx to the left or right was the most common distortion seen. A reduction of the anteroposterior diameter was the second most common distortion hindering tracheal intubation; decreasing the force applied to the cricoid cartilage facilitated intubation in these latter cases.

The cricoid yoke study demonstrated some advantages of the yoke over manual application of cricoid pressure. Cricoid pressure can distort the airway even when performed by experienced personnel, resulting in difficult intubation and ventilation (10,20–22). Use of the cricoid yoke avoids excessive force or compression of the wrong anatomical site that are the most common causes of airway difficulties. Furthermore, the cricoid relocates the assistant's hands away from the handle of the laryngoscope, which is a particular advantage when the patient has a short, thick neck, large breasts, or both. Use of the cricoid yoke in the study by Lawes and colleagues was associated with no laryngeal distortion, even in these high-risk patients.

Managing the 'can't intubate, can't ventilate' situation

Palmer and Ball found that cricoid pressure forces over 30 N, especially in women, led to distortion of the airway (10) and they caution against maintaining sustained cricoid pressure if failed ventilation follows failed intubation. They recommend managing this 'can't intubate, can't ventilate' situation by decreasing or releasing cricoid pressure and/or reevaluating the location where pressure is being applied.

Complications of cricoid pressure

In the last decade, several reports have been published discussing complications secondary to the use of cricoid pressure. Ralph and Wareham reported oesophageal rupture in an 81-year-old woman who began vomiting against the force of cricoid pressure

applied before the patient lost consciousness (12). Although this is an extremely rare complication, it led the authors to caution against applying full cricoid pressure until the patient has fully lost consciousness.

A year after this report, Vanner and colleagues published the results of their study in cadavers. Rupture of the saline-filled oesophagus occurred in one cadaver when pressure on the cricoid reached 30 N and in two other cadavers when pressure reached 40 N. These results led the authors to recommend that no more than 20 N of cricoid force should be applied to the awake patient, increasing to 30 N after loss of consciousness (6).

Shorten and colleagues described applying cricoid pressure to a patient with undiagnosed laryngeal trauma; the patient required emergency tracheostomy (23). Georgescu and others reported on a patient who could not be intubated or ventilated with cricoid pressure because of ball-valve obstruction because of a lingual thyroid. This patient was easily ventilated without cricoid pressure (24). Finally, Heath and colleagues described fracture of the cricoid ring in an adult patient with a previous laryngeal injury who had been treated with long-term steroids and underwent emergency intubation for status asthmaticus. The fracture, which was discovered when the patient developed stridor and hypoxia on extubation, was considered unavoidable (25).

Conclusions

Properly applied, cricoid pressure facilitates intubation with rapid sequence induction and mask ventilation. However, safe and effective use of this procedure requires knowledge of neck anatomy and appropriate technique (especially pressure to be applied) and experience.

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