Trends in Anaesthesia and Critical Care 2 (2012) 123–127

Contents lists available at SciVerse ScienceDirect

Trends in Anaesthesia and Critical Care

journal homepage: www.elsevier.com/locate/tacc

OPINION

Use of cricoid pressure during rapid sequence induction: Facts and fiction

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Keywords:
Cricoid pressure
Rapid sequence induction
Airway management

SUMMARY

Cricoid pressure (CP) was introduced into anaesthetic practice based on a single case series that lacked information on the force applied and on the method of application. Up to now, there are no controlled, prospective randomised trials which document that CP pressure reduces the incidence of regurgitation of gastric content and pulmonary aspiration. On the other hand, numerous studies have shown that CP has multiple adverse effects, the most important one being interference with airway management. In addition, numerous surveys have shown that most anaesthetists lack adequate knowledge about all aspects of CP. Despite lack of evidence for its beneficial effect, CP is still considered by many anaesthetists an integral part of any rapid sequence induction of anaesthesia.

1. Introduction

The issue of cricoid pressure (CP) is probably the most controversial one in the management of rapid sequence induction (RSI).[1–6] The plethora of publications on various aspects of CP reflects not only continued interest but also considerable controversy on its efficacy. Many anaesthetists continue advocating CP as integral part of any RSI because they believe in its effectiveness.[1] Until as recently as 2009, the opinion was expressed that a technique not employing CP cannot be considered a RSI.[7] Other anaesthetists advocate abandoning it because it increases overall patients' risks without any proven benefit.[2–4,8] Still other anaesthetists argue that although the effectiveness of CP has not scientifically been proven, it is a technique with little or clinically irrelevant side-effects and may actually be effective in some patients.[9] The following overview will address various controversial issues of CP and try to separate facts and fictions surrounding the technique of CP.

2. Sellick had demonstrated effectiveness of cricoid pressure: fact or fiction?

CP was introduced by Sellick in 1961 "to control regurgitation until intubation with a cuffed endotracheal tube was completed".[10] What did Sellick actually do and find? He applied CP during induction of anaesthesia in 26 patients considered to be at high risk of pulmonary aspiration. In three of the 26 patients, regurgitation into the pharynx occurred immediately after release of CP following successful tracheal intubation. The manoeuvre of CP consisted of "occlusion of the upper oesophagus by backward pressure on the cricoid ring against the bodies of cervical vertebrae to prevent gastric contents from reaching the pharynx". Evidence for occlusion of the upper oesophagus at the level of the 5th cervical vertebra during neck extension and application of CP was derived from a lateral X-ray of the neck showing lack of contrast media at the site of application of CP in a previously placed soft latex tube which had been distended with contrast media to a pressure of 100 cm H_2O.

The study had several considerable limitations. Patients were not randomised to receive or not receive CP. No quantitative information on the force applied during CP at the various stages of induction of anaesthesia was provided. During induction of anaesthesia, laryngoscopy and intubation, patients' heads were hyperextended as for tonsillectomy. Anaesthesia was induced intravenously or by volatile anaesthetics with and without intermittent positive-pressure ventilation, with no information on what method was used in which patient. For all of these reasons, the publication was rightly published under the category of 'Preliminary Communications'. Despite the major limitations, the practice of CP was adopted rapidly and rather uncritically by the anaesthesia community worldwide. It soon became a standard of care during RSI of anaesthesia.

In summary, the assumption that Sellick had demonstrated effectiveness of cricoid pressure is more fiction than fact.

3. Cricoid pressure occludes the oesophagus: fact or fiction?

Crucial to the postulated effectiveness of CP is conclusive demonstration that backward pressure of the cricoid cartilage against the cervical vertebrae reliably occludes the oesophagus.

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doi:10.1016/j.tacc.2012.01.006

Sellick postulated that "extension of the neck and application of pressure on the cricoid cartilage obliterates the oesophageal lumen at the level of the body of the 5th cervical vertebra".[10] This was based on just two lateral neck X-rays taken in a single anaesthetised patient in whom a latex tube had been inserted into the oesophagus. In Sellick's original communication, head and neck were extremely extended during induction of anaesthesia and application of CP. This will tether the oesophagus against the cervical vertebrae. Occlusion of the oesophagus must be expected to be less pronounced or even absent in the sniffing position which is mostly used in today's practice.

A prospective analysis of 22 cervical magnetic resonance imaging (MRI) scans showed that application of CP increased the incidence of preexisting lateral displacement of the oesophagus from 53% to 91%.[11] The oesophagus was not completely opposed between the cricoid cartilage and the vertebral body in 48% of subjects without and in 71% of subjects with CP. The airway was displaced relative to the middle of the vertebral body in 33% of subjects without and in 67% of subjects with CP. By increasing the frequency of the oesophagus being unopposed between the airway and the vertebral body, CP may facilitate regurgitation of gastric content. These findings neither support the assumption that cricoid cartilage, oesophagus and vertebral body are normally aligned, nor that backward pressure of the cricoid cartilage against the cervical vertebrae occludes the oesophagus. For anatomical as well as physical reasons alone, it is unreasonable to expect that in the individual patient a defined externally applied force will make the cricoid cartilage (a rigid tubular structure) completely compress the oesophagus (a semi-mobile, non-rigid tubular structure of varying thickness) against the vertebral body (a rigid structure with a curved surface) in the presence of potentially large variations in intraluminal oesophageal pressures (induced by regurgitation and vomiting).

It has recently been argued that the position of the oesophagus is irrelevant in the context of this discussion. MRI showed that cricoid cartilage and hypopharynx act as an anatomical unit.[12] When force was applied to the cricoid cartilage, all tissues behind it (including the oesophagus) were compressed. Even when CP displaced the oesophagus laterally to the cervical spine, the lumen of the oesophagus was occluded. The authors interpreted the findings as showing that location and movement of the oesophagus are irrelevant to the efficiency of CP in preventing regurgitation into the pharynx because CP effectively occludes the postcricoid hypopharynx.

The findings by Rice et al. have been interpreted as strongly supporting the efficacy of CP in occluding the alimentary tract posterior to the cricoid cartilage.[1] However, the physiological relevance of these anatomical findings is uncertain.[2] The laterally displaced oesophagus was compressed between the cricoid cartilage and the left longus colli muscle. As the surface of a muscle is certainly more elastic than that of a cervical vertebra, it is questionable whether oesophageal occlusion will effectively be maintained when regurgitation significantly increases oesophageal distending pressures.

In summary, the assumption that CP reliably occludes the oesophagus, is more fiction than fact.

4. Cricoid pressure prevents reflux of gastric content from entering the pharynx: fact or fiction?

It has correctly been pointed out that the primary purpose of CP is not to prevent gastrooesophageal reflux, but to prevent gastric contents from reaching the pharynx.[1] Thus, demonstration that CP prevents reflux of gastric content from entering the pharynx is essential for the claimed effectiveness of CP. Sellick postulated that CP "… can be used to occlude the oesophagus … to control regurgitation of stomach or oesophageal contents during induction of anaesthesia …".[10] This was based on the finding in the three patients who regurgitated after release of CP, and on findings in a cadaver showing that "… when the stomach was filled with water and firm pressure was applied to the cricoid, … a steep Trendelenburg tilt did not cause regurgitation of fluid into the pharynx. Moreover, the flow of water from the pharynx could be controlled by varying the pressure on the cricoid cartilage". Sellick concluded that CP "… can be used … to prevent gastric distension from positive-pressure ventilation applied by facepiece or mouth-to-mouth respiration".

Evidence to support this assumption comes mostly from cadaver studies.[13–16] All four experimental studies employed comparable methodology. Saline or water was administered into the oesophagus via stomach while the pharynx was directly visualized for detection of fluid leak from the oesophagus into the pharynx. All four investigations found that CP consistently prevented leak of fluid into the pharynx at oesophageal pressures of up to 100 cm H_2O. However, all of these studies have considerable limitations. The most relevant one is the use of cadavers, varying in age and not all them being human. The number of experiments was small. With one exception[16] cricoid force was not quantified. Otherwise, support for the effectiveness of CP in preventing regurgitation of gastric content into the pharynx is either limited because of a highly artificial methodology[17] or purely anecdotal.[18]

It has been claimed[1] that studies demonstrating the efficacy of CP in preventing gastric inflation in anaesthetized children and adults[19–21] are convincing evidence for its effectiveness. The same authors went on to conclude[1] that it is inconceivable that a manoeuvre (i.e., CP) which effectively prevents gastric inflation during manual ventilation should not be effective in preventing gastric contents from reaching the pharynx. However, effectiveness and efficacy of CP are not determined on the basis of surrogate outcome variables like the extent of gastric insufflation during mask ventilation, but on the basis of whether it prevents regurgitation of gastric content into the pharynx and, subsequently, pulmonary aspiration. Overall, there is no convincing evidence that CP reliably prevents reflux of gastric content from entering the pharynx.

In summary, the belief that CP prevents reflux of gastric content from entering the pharynx, is more fiction than fact.

5. Cricoid pressure reduces the incidence of pulmonary aspiration: fact or fiction?

The ultimate clinical test for the effectiveness of CP would be its effect on the incidence of pulmonary aspiration. The incidence of pulmonary aspiration during anaesthesia for emergency surgery has been reported to be as low as 0.02%[22] and 0.11%.[23] At such low incidence, tens of thousands of patients would have to be studied to detect a clinically meaningful, statistically robust decrease in the incidence of pulmonary aspiration. While there is lack of convincing evidence for CP to reduce the incidence of pulmonary aspiration, numerous surveys, case reports, confidential enquiries, medico-legal reviews and epidemiological studies have reported aspirations despite the use of cricoid pressure.[24–28]

In summary, the belief that CP pressure reduces the incidence of pulmonary aspiration, is more fiction than fact.

6. Cricoid pressure is effective in obstetric anaesthesia: fact or fiction?

Especially in obstetric anaesthetic practice, the importance of CP continues to be emphasized. A rather recent United Kingdom

survey showed that CP was still considered by basically all responding anaesthetists an integral part of the routinely used RSI of anaesthesia for elective caesarean delivery in healthy parturients.[7] However, even in this patient population the effectiveness of CP in preventing pulmonary aspiration is increasingly being questioned.[6,29]

No case of pulmonary aspiration occurred in 1067 healthy parturients managed with a laryngeal mask airway for elective caesarean section.[30] In 2114 parturients in whom general anaesthesia for caesarean section was induced without CP and whose lungs were gently mask-ventilated until full succinylcholine-induced muscle relaxation had developed, all were successfully endotracheally intubated, and neither regurgitation nor signs or symptoms of pulmonary aspiration were observed.[31] The increased risk of failure to intubate, and of regurgitation and pulmonary aspiration of gastric content in this patient population may not only be caused by the pregnancy-induced changes in upper airway morphology, intra-abdominal pressure and gastrointestinal function, but to a clinically relevant degree to limited experience of the anaesthetist and to application of CP.[31,32] Superimposition of CP-induced intubating difficulties on the underlying pregnancy-induced upper airway anomalies must almost be expected to further increase the risk of intubation failure in the parturient.

In summary, the belief that CP is effective in obstetric anaesthesia, is more fiction than fact.

7. Cricoid pressure may not be of proven benefit, but neither is it of any proven harm: fact or fiction?

If there is no convincing evidence for a benefit of CP, assessment of the risk-benefit ratio of this intervention requires analysis of the evidence for any risk associated with it.

7.1. Cricoid pressure and airway management

CP interferes with basically all aspects of airway management. First, CP can worsen laryngoscopic view.[33] When assessing laryngoscopy by photographing the view through a rigid, zero-degree endoscope positioned along, and matching the larnyngoscopist's line of sight, the effect of CP was highly variable and complex. In some subjects, the laryngoscopic view improved with CP, while in others it worsened. However, at the recommended cricoid forces between 10 and 40 N, the laryngoscopic view more often worsened than improved. In addition, application of greater axial force to the laryngoscope was required to counteract the adverse effect of cricoid pressure on laryngoscopy, and to completely or partially restore the laryngoscopic view. This requirement for a greater force is in itself expected to render intubation more difficult.

Second, CP impedes mask ventilation resulting in decreased tidal volumes and increased inspiratory pressures,[34,35] causes subglottic narrowing[35,36] and airway compression and obstruction,[11,35,37–39] and hinders placement and functioning of supraglottic airway devices.[40,41] Contrary to what is often stated,[1] CP interferes with all aspects of airway management not only when applied at greater than recommended forces, but also at recommended forces.[11,35,36] Thus, increased incidence of anatomic airway distortions and difficult airway management during CP is unlikely the result of incorrect application of CP, but is due to the manoeuvre itself. As the cricoid cartilage is located 2–3 cm caudad to the larynx, for purely anatomical reasons CP must be expected to prevent optimal external laryngeal pressure.[42]

A minority of investigators found that CP does not increase the rate of failed intubation.[43,44] In the blinded study by Turgeon et al.,[43] 700 patients were randomized to receive either CP or sham CP during laryngoscopy and intubation. There was no difference between groups in the number of patients who could not be intubated within 30 s, in the quality of the laryngoscopic view and in the difficulty to intubate. These findings seemingly contradict the several reports of airway distortion and of difficult laryngoscopy and intubation during CP, and they seemingly contradict the common clinical impression that CP frequently worsens the laryngoscopic view and renders intubation more difficult.

Several factors could explain the lack of adverse outcome of CP on the ease of intubation in this study. Baseline upper airway anatomy was generally favourable. Non-elective surgery, and pregnant and morbidly obese patients were excluded, thereby excluding patients at increased risk for difficult laryngoscopy and intubation. Optimal baseline conditions for a smooth intubation are reflected by a mean intubation time of just over 11 s in the control group. Finally, CP was applied by anaesthesia assistants who had been trained daily in the identification of the cricoid cartilage and in the application of a force of 30 N. The findings can thus be interpreted as showing that application of CP by highly trained and supervised anaesthesia personnel in healthy patients with normal upper airway anatomy at low risk for difficult laryngoscopy and intubation is unlikely to hinder endotracheal intubation. In clinical reality, however, CP is mostly applied by less trained anaesthesia and emergency personnel with very limited knowledge of all aspects of CP, and to patients presenting with risk factors for difficult intubation. In general, anaesthesia and emergency personnel has limited knowledge of all aspects of CP[45–48] (see below).

Overall evidence suggests that application of CP may cause significant distortion of upper airway anatomy which, in turn, may seriously interfere with optimal airway management. Obstruction of the upper airways during application of CP resulting in difficult ventilation and increased inspiratory pressures is of concern, considering the recommendation that CP be maintained during ventilation following failed intubation,[49,50] and considering that CP most of times does not occlude the oesophagus[11] leaving the possibility that the increased inspiratory pressure causes gastric insufflation. By compressing the upper airway with subsequent impairment of ventilation, and by worsening laryngoscopic view, CP may contribute to a "cannot intubate cannot ventilate" scenario.[51]

7.2. Cricoid pressure and lower esophageal sphincter tone

The oesophageal barrier pressure (the difference between lower oesophageal sphincter and intragastric pressure) is an important determinant of gastric regurgitation. CP consistently decreases oesophageal barrier pressure by lowering oesophageal sphincter tone[52–55] which is not attenuated by prior administration of metoclopramide.[55] The decrease in lower oesophageal sphincter tone will facilitate gastric regurgitation and may explain observations of pulmonary aspiration during application of cricoid pressure. CP may predispose to gastric regurgitation by lowering lower oesophageal sphincter tone.

In summary, the belief that CP may not be of proven benefit, but neither is it of any proven harm, is fiction.

8. Medical personnel is knowledgeable about cricoid pressure: fact or fiction?

In general, anaesthesia and emergency personnel lack knowledge about theoretical as well as practical aspects of CP.[3,45–48] Technical limitations include incorrect location (compression of thyroid instead of cricoid cartilage), use of too low as well as excessive force, irreproducibility of effective cricoid forces, and uncertainty as to when to begin applying CP (in the awake vs. the asleep patient).[5,9,56] Advocates of CP claim that these technical limitations are the main reason for the reported complications.

In summary, the belief that medical personnel is knowledgeable about cricoid pressure, is fiction.

9. Present recommendations

The 2007 Guideline on Rapid Sequence Induction by the *Difficult Airway Society (DAS)* recommends light pressure (no more than 10 N force) on the cricoid cartilage prior to loss of consciousness, and 30 N cricoid force (equivalent to registering 3 kg on a weighing machine) after loss of consciousness.[50] If intubation fails, the DAS algorithm recommends,

- continue cricoid force at 30 N and attempt facemask ventilation;
- if facemask inflation is not possible, maintain 30 N cricoid force and insert laryngeal mask
- release cricoid force during insertion of laryngeal mask airway and reapply when inserted;
- attempt to ventilate with 100% oxygen via laryngeal mask airway with cricoid force
- if attempt to ventilate fails,release cricoid force and try ventilation again through the laryngeal mask airway.

In the presence of lack of scientific evidence that CP reduces regurgitation, and evidence that it interferes with airway management, the 2010 Clinical Practice Guidelines on General Anaesthesia for Emergency Situations by the *Scandinavian Society of Anaesthesiology and Intensive Care Medicine* do not consider use of CP mandatory and leave its use up to individual judgement.[57] They make the following specific recommendations based on grading existing evidence[58]:

(i) The use of CP cannot be recommended on the basis of scientific evidence (recommendation E = supported by non-randomized, historic controls, case series, uncontrolled studies and expert opinion)
(ii) The use of CP is therefore not considered mandatory but can be used on individual judgement (recommendation E).
(iii) If facemask ventilation becomes necessary, CP can be recommended because it may reduce the risk of causing inflation of the stomach (recommendation D = supported by non-randomized, contemporaneous controls)
(iv) CP should be released and backwards, upwards and rightwards pressure (BURP) should be applied instead, if CP limits the glottic view during laryngoscopy (recommendation D)
(v) CP should be released before inserting a laryngeal mask airway should initial attempts at tracheal intubation prove unsuccessful (recommendation C = supported by small, randomized trials with uncertain results, and with moderate-to-high risk of false-positive [α] and/or a false-negative [β] error)
(vi) Those choosing to use CP in the at-risk patient must take care to apply it correctly and release it should ventilation or laryngoscopy and intubation prove difficult (recommendation D).

The uniformly low classes of recommendation reflect the lack of adequate scientific evidence for each of those recommendations, necessarily resulting in recommendations mostly based on expert opinion.

10. Summary

The use of cricoid pressure remains highly controversial.[1–4,6,8,29,59] Its safety and effectiveness, and its continued use have increasingly been questioned and criticized.[60–62] Surprisingly, many anaesthetists seem to accept the numerous and potentially life-threatening clinical side-effects of CP although not a single randomized controlled trial has yet demonstrated efficacy of CP in reducing the incidence of pulmonary aspiration. Although it cannot conclusively be ruled out that failure of CP in preventing regurgitation and aspiration might have been caused by its incorrect application, it equally cannot be ruled out that the technique itself might contribute to pulmonary aspiration by, inducing retching and vomiting when applied early during induction of anaesthesia,[16] delaying intubation because of worsening laryngeal visualization, and facilitating oesophageal regurgitation secondary to decreasing lower oesophageal sphincter tone.[52,55] Many, if not most anaesthesiologists have had the experience of struggling to view the glottis during application of CP, only to have an unrestricted view as soon as CP was released. Application of CP in the not yet fully anaesthetized patient may lead to retching and vomiting. At this time, the protective airway reflexes are already lost. However, several guidelines recommend starting to apply CP in the still awake patient.

The crucial question is whether CP is effective in reducing the risk of pulmonary aspiration or whether it presents an unnecessary, potentially hazardous technique.[5,59] The three major factors considered to be important in reducing the incidence of pulmonary aspiration are experience, assistance by experienced anaesthesiologists and close supervision of inexperienced anaesthesiologists.[63] Furthermore, optimal pharmacologic preparation, optimal patient positioning, and rapid induction of adequate depth of anaesthesia and muscle relaxation in the patient at-risk for regurgitation of gastric content are likely more effective in reducing the risk of regurgitation than sole reliance on CP. Whereas the postulated benefit of CP (prevention of gastric content from entering the pharynx) are mostly potential and theoretical, its side-effects and complications are real and clinically relevant. “We need to prove that properly applied cricoid pressure is effective at preventing regurgitation or discard it. It is time to take stock of what we do and do it better. We owe it to our patients”.[2]

Conflict of interest statement

None.

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