Accepted Manuscript

Cricoid pressure: the argument against

J. Turnbull, Locum Consultant Anaesthetist, A. Patel, Consultant Anaesthetist

PII: S2210-8440(14)20057-8

DOI: 10.1016/j.tacc.2015.02.002

Reference: TACC 228

To appear in: *Trends in Anaesthesia and Critical Care*

Received Date: 5 November 2014

Revised Date: 20 February 2015

Accepted Date: 24 February 2015

Please cite this article as: Turnbull J, Patel A, Cricoid pressure: the argument against, *Trends in Anaesthesia and Critical Care* (2015), doi: 10.1016/j.tacc.2015.02.002.

Cricoid pressure: the argument against

J.Turnbull[1], A.Patel[2]

1 Locum Consultant Anaesthetist, jamesturnbull@nhs.net, University College Hospital, 235 Euston Road, NW1 2BU

2 Consultant Anaesthetist, anil.patel@uclh.nhs.uk, Royal National Throat, Nose and Ear Hospital, 330 Grays Inn Road, WC1X 8DA (corresponding author)

Summary

Cricoid pressure was introduced in the 1960's to protect patients undergoing general anaesthesia against pulmonary aspiration. Evidence supporting its use was largely based on small cadaver studies, expert opinion and case studies. However, its uptake across the anaesthetic community was universal, perhaps due to the fear of aspiration, but also because it was thought to have little in the way of adverse effects. Recently, the role of CP has been reassessed, with many suggesting its use is no longer warranted, particularly in fully fasted patients. Evidence has shown that not only is CP ineffective in occluding the oesophageal lumen, but it may also interfere with crucial aspects of airway management. Moreover, the ability of medical and nursing staff to perform effective, consistent CP is questionable. However, at present, there is no valid alternative, and the use of CP is therefore likely to continue in selected patients.

Keywords

Cricoid pressure, CP, aspiration, anaesthesia

Introduction

The effectiveness of cricoid pressure (CP), or Sellick's manoeuvre, to prevent pulmonary aspiration, continues to crystallise opinion within the anaesthetic community [1-3]. Advocates highlight studies showing a reduction in gastric insufflation and regurgitation with CP applied [3]. Others highlight a reduction in the incidence of pulmonary aspiration since it was introduced, particularly in the obstetric population [4]. However, the fact remains that there is insubstantial evidence to support the use of CP in preventing pulmonary aspiration [5,6]. On the other hand, there is good evidence that CP interferes with crucial aspects of airway management [7]. This article will attempt to untangle some of the misconceptions surrounding CP and demonstrate why the argument *against* continues to strengthen.

To do this we will look at three main areas. Firstly, we will look at whether CP reliably occludes the oesophageal lumen. Secondly, we will look at whether it prevents gastric regurgitation and pulmonary aspiration. Finally, we will assess how competently CP is performed in practice and whether it is detrimental to overall airway management. Before this we will look at the historical inception of CP, which is crucial to understand the ongoing debate.

Historical background

In 1961, in response to a growing awareness of the dangers of pulmonary aspiration [8], London anaesthetist Dr Brian Sellick advocated the use of a 'simple manouevre' to control regurgitation of gastric contents 'until intubation with a cuffed endotracheal tube is completed' [9]. Sellick suggested that backward pressure on the complete ring-like cricoid cartilage against the 5th cervical vertebra could result in occlusion of the oesophageal lumen, thus preventing regurgitation. He first tested this theory in a cadaver, instilling water into the stomach up to a pressure of 100 cmH_2O, applying a 'firm' pressure to the cricoid cartilage, followed by a steep Trendelenburg position. Sellick found that 'cricoid pressure' prevented water from regurgitating into the pharynx, the flow of which could be controlled by the degree of force used.

In the second phase of his study, he inserted a soft latex tube filled with contrast into the oesophagus of an anaesthetised and paralysed patient. Following the application of CP, lateral neck x-rays were taken which showed loss of contrast at the level of the applied pressure,

further confirming his theory. Finally, he went on to study a cohort of 26 high risk patients, all of whom had CP applied at induction of anaesthesia. In three of these patients, he witnessed gastric regurgitation on release of the CP [9]. Sellick conducted another study in 1962 based on a single patient undergoing oesophagectomy under general anaesthesia [10]. Using an endotracheal tube placed in the oesophagus, he demonstrated that CP prevented regurgitation of saline instilled into the oesophagus up to a pressure of 100 cmH_2O.

Significant limitations of the initial studies existed, with Sellick himself acknowledging that these were 'preliminary' findings [9]. The studies were small, non-randomised and unblinded, with no accurate quantification of the cricoid force used or anaesthetic drugs used. Moreover, those applying the CP were midwifes or nurses with 'a few seconds' training. The patients were positioned supine with the head and neck extended in the tonsillectomy position, and a 'slight head down' tilt on the table. In this position, traction on the oesophageal lumen makes it easier to fix against the cervical vertebra, unlike the modern 'sniffing' position. Thus, both the methodology of the study, and the conduct of anaesthesia, varied enormously from current academic and clinical standards.

With minimal scrutiny, widespread uptake of CP occurred across the anaesthetic community. It was adopted as an integral part of a rapid sequence induction/intubation (RSII) [11], and quickly became a standard of care for the prevention of pulmonary aspiration. To this day, despite a lack of cohesive evidence, guidelines and experts continue to endorse its use [12,13]. But will there ever be conclusive evidence? For this we need to take a closer look at the current incidence of pulmonary aspiration and its ramifications.

The risk of pulmonary aspiration

In Mendelson's original paper from 1946, the incidence of aspiration in parturients was approximately 1 in 667, with a mortality rate of 1 in 22,000 [8]. This was before the advent of tracheal intubation, when patients underwent facemask anaesthesia with ether and nitrous oxide, and anaesthesia was administered by inexperienced residents. Furthermore, the two patients who died were already said to be critically unwell prior to the aspiration. Studies from Europe and the USA subsequently suggested an incidence of pulmonary aspiration during general anaesthesia that ranged between 1 in 2000 [14] and 1 in 3000 [15], with significantly higher estimates in emergency surgery (1:900) [15].

Mortality rates in these studies were extremely low, ranging between 1:45,000 [14] to 1:70,000 [15], with deaths largely confined to ASA III-IV patients and often a result of failed intubation [15]. More recent estimates from elective surgery suggest the incidence of pulmonary aspiration is even lower (1 in 7000), and mortality as little as 1 in 100,000 [16]. Thus, pulmonary aspiration is rare, and mortality from aspiration even rarer. In the elective ASA I-II surgical patient the risk appears to be negligible [4]. This has led to some suggestions that the use of CP is based on 'exaggerated fear', and by trying to solve 'hypothetical' problems we are simply creating others [17]. What is beyond doubt, is that randomised controlled evidence that either proves or disproves the effectiveness of CP will never be achieved.

Does CP occlude the oesophagus?

A number of studies have sought to build on Sellick's original paper to determine whether oesophageal occlusion does occur with cricoid pressure. Of particular debate was the assumption that the oesophagus lies posteriorly to the cricoid ring in the axial plane. A retrospective review of CT scans in healthy individuals showed that in fact the oesophagus sits postero-lateral to the cricoid ring in almost 50% of subjects [18]. These findings were supported in a prospective analysis of 22 awake patients who underwent cervical magnetic resonance imaging (MRI) with and without CP applied [19]. The authors found that CP increased the incidence of lateral displacement of the oesophagus from 53 to 91%. These studies suggest the degree of oesophageal occlusion with CP is likely to be highly variable.

The significance of these findings have been challenged by Rice et al [20] who studied the MRI scans of 24 individuals with and without CP. They showed that even in the presence of lateral oesophageal displacement, an average 35% (or 3.2 mm) reduction in the AP diameter of the post-cricoid hypopharynx occurred with CP. Although impossible to prove, they argue that this is likely to represent complete occlusion of the hypopharynx lumen. Their findings suggest that it is not the upper oesophageal lumen that is compressed with CP but the post-cricoid hypopharynx. This is significant as the hypopharynx is less mobile than the oesophagus, acting as a continuous anatomical unit with the cricoid ring and cervical vertebra. However, this study was conducted in healthy awake volunteers, the physiology of whom cannot be compared to that of unwell anaesthetised patients. Moreover, as suggested by Lerman, fixing the cricoid ring against a muscular structure, as is the case in the lateral position, is less of a barrier to regurgitation than fixing it against a cervical vertebra [1].

A recent study by Zeidan et al [21] attempted to overcome these issues by assessing the ability to pass gastric tubes through the post-cricoid hypopharynx in healthy anaesthetised patients. They found that in all 79 patients, the application of CP at 30N made it impossible to insert a 4mm gastric tube, with oesophageal occlusion confirmed by video laryngoscopy. They concluded that this provided further visual and mechanical evidence to support the use of cricoid pressure. However, what this study actually achieved was to confirm that when applied by the same fully trained assistant, CP can prevent the regurgitation of particles 4mm or greater.

Does CP prevent gastric regurgitation and aspiration?

Following Sellick's initial work, four studies were conducted, all with similar findings [22-25]. As with Sellick's study, these studies were small, non-randomised experiments on cadavers, the tissue response of which is incomparable to that of an anaesthetised patient. Prevention of gastric insufflation during facemask ventilation has been used as a surrogate outcome measure to highlight the benefits of CP. Studies in both children and adults have shown that CP prevents gastric insufflation up to inflation pressures of 60cmH_2O [26-29]. However, these studies assume a causal link between gastric insufflation and regurgitation, a theory which has never been proven. Moreover, the relevance of these studies to modern anaesthetics is debatable as they were conducted when high tidal volumes and inflation pressures were standard practice. This is no longer the case, and research has shown that facemask ventilation using inflation pressures of less than 15cmH_2O provides adequate ventilation without significant gastric insufflation, in the majority of non-obese individuals [30].

Two systematic reviews have since been conducted on CP, both of which showed no evidence for or against its use [5,6]. Moreover, a number of case reports [31], surveys [32], confidential enquiries [33] and national audits [13] have all shown that aspiration still occurs when CP is performed, with at least 11-14% of anaesthetists having witnessed aspiration during its application [32]. In a study of 297 patients undergoing emergency tracheal intubation, 12 patients had a new infiltrate on CXR, nine of which had CP applied [34]. In addition, evidence shows aspiration does not only occur at intubation, but frequently during maintenance and extubation [13].

What is the evidence for CP in obstetric anaesthesia?

The debate surrounding the use of CP is often heightened when considering its role in obstetric anaesthesia. As things stand, RSI with cricoid pressure remains the default technique for elective caesarean delivery in healthy, normal BMI parturients who require general anaesthesia [35]. However, this default position has come under increasing scrutiny [36]. A study on 2114 parturients undergoing general anaesthesia without CP, and with gentle facemask ventilation prior to intubation, showed no episodes of regurgitation or aspiration, and no failed intubations [37]. Studies have also showed that in carefully selected parturients, an LMA can be used for elective caesarean delivery, with little or no risk of aspiration [38,39]. These studies further question the blanket use of CP in a population with a high incidence of failed intubation.

As our co-authors point out, the triennial reports into maternal deaths from the UK showed 52 deaths from pulmonary aspiration from 1964 to 1969 [40], compared with only three aspirations from 1994 to 2005 [33,41,42]. However, also of note is the report between 1979 and 1981 which showed 8 episodes of aspiration, of which 6 *had* CP applied [43]. In a review of almost 5000 general anaesthetics for obstetric procedures in Malawi, 11 deaths were directly related to regurgitation, 9 of which had CP applied [44]. Thus, attributing the overall reduction in aspiration to the introduction of CP is incorrect, and ignores major advances in obstetric anaesthesia during this period, such as adequate fasting times and regional anaesthesia.

Does CP contribute to adverse events?

Protagonists of CP sometimes argue that despite a lack of supporting evidence, there is little evidence to show it can cause harm either [2,3]. However, this position has been challenged [1,7], with increasing evidence that CP interacts with all facets of airway management.

During facemask ventilation CP increases inspiratory pressures, reduces tidal volumes, and may cause complete airway obstruction [45-47]. On direct laryngoscopy, CP frequently causes distortion of laryngeal structures [48] and is associated with an increase in failed intubation [13]. Following failed intubation, maintaining CP has been shown to increase the likelihood of difficult or even impossible facemask ventilation [49]. An endoscopic study in adults using a cricoid yolk showed CP applied at 30N caused difficulty with ventilation and vocal cord closure in over 50% of subjects [45]. When applied at 40N, as previously

recommended, complete airway obstruction occurred in almost 50% of subjects. Similar findings have been confirmed in other studies in adults and children [50,51].

In terms of airway placement, CP has been shown to impede placement and subsequent ventilation through a laryngeal mask airway (LMA) [52,53]. In his meta-analysis of LMA studies, Brimacombe [54] found that CP reduced the chance of successful LMA placement from 94% to 67%. The debate surrounding ease of endotracheal intubation is less certain. The only randomised study to date showed no difference in tracheal intubation time, laryngeal view or intubation success [55]. However, this study was performed in non-obstetric, ASA one and two patients, highlighted by the fast intubation times in the control group. Several case reports have highlighted an inability to pass an endotracheal tube with CP applied, becoming straightforward on removal [56,57].

There is little doubt that CP is uncomfortable in the awake patient and may stimulate nausea and vomiting. However, there are also concerns that CP may promote vomiting by causing relaxation of the lower oesophageal sphincter [58,59], an effect which cannot be attenuated by the prior administration of metoclopramide [60]. Initially confirmed in awake volunteers, recent work on anaesthetised patients has suggested the effect is pronounced, with an overall 29% decrease in lower oesophageal sphincter pressure and a 44% reduction in barrier pressure [61]. Cadaver studies and case reports have shown that rupture of the oesophagus may occur secondary to CP [62,63].

Do we perform CP correctly?

As we have seen, the benefits of correctly applied CP are keenly debated. However, when applied incorrectly, the benefits of CP become a secondary issue. Current guidelines recommend gentle cricoid pressure (10N) with the patient awake, increasing to 30N once the patient is unconscious [12]. However, both knowledge and application of this technique is highly variable. Audit data has suggested that CP is performed incorrectly in up to 70% of cases, with over 50% producing a force < 30N and greater than 20% producing a force > 65N [64]. This is unsurprising given that studies suggest only 5-10% of anaesthetists are even aware of the correct amount of force to apply [65].

Some have suggested mechanically applied CP may provide better results compared with manual techniques. Manually applied CP is difficult to reproduce and deteriorates with time

[65] and although performance and consistency is improved with direct training [66], retention of these skills cannot be demonstrated after 3 months [67]. Mechanical CP using yokes are more accurate and consistent, but are uncomfortable, and more prone to cause airway obstruction, due to uneven and excessive force on the anterior cricoid [45].

What are the alternatives to CP?

Advocates of CP argue that in the absence of viable alternatives, it is at least 'something' that can be done and easily removed in the event of airway difficulties. Indeed, in our experience, relaxation or removal of CP is extremely common during RSI, perhaps reflecting the importance afforded to it by clinicians. But instead of accepting the status quo, should we not be exploring valid alternatives?

The benefits of the head-up position in preventing gastric regurgitation are often overlooked, despite being described as early as the 1950s [68,69]. The head-up tilt provides a barrier to regurgitation in cmH_2O equal to the height of the cricoid cartilage above the stomach in centimetres. In the Snow and Nunn study [68], a 40^o head-up tilt was applied to 606 high risk cases without any CP. The degree of tilt was based on earlier observations that stomach pressures seldom rise above 18 cmH_2O, even with a full stomach, and a 40^o tilt approximates to a height of 19 cm between the stomach and cricoid ring. In this case series, there was only one case of regurgitation, which was attributed to under-dosing of muscle relaxant. Of course, this degree of head-up tilt has its own dangers, particularly in those at risk of cardiovascular collapse.

Some experts have argued that there are no valid alternatives to CP [70], and perhaps a modification of the current technique is required. In his editorial, Vanner highlights the benefits of combining the 20^o head up position with a reduced cricoid force of 20N [70]. This is based on cadaver studies which have shown that 20N is effective in preventing regurgitation with gastric pressures up to 25 mmHg [62]. The result is a longer apnoeic time, better functional residual capacity, an improved view at laryngoscopy and a lower risk of airway problems caused by excessive cricoid force. CP, he argues, could be removed with greater confidence should airway problems arise. Whilst we would agree that these modifications would represent an improvement in current practice, many of the problems with CP would remain, and cardiovascular compromise, although less, may be significant in certain patients.

Conclusions

The ongoing use of cricoid pressure to prevent pulmonary aspiration is controversial, and polarises opinion across the anaesthetic community. However, certain aspects of the debate are indisputable. There is, and never was, good evidence to support the use of CP. Its introduction was based on a small number of cadaver studies and expert opinion over 40 years ago. Anaesthetic techniques have changed dramatically during this time, and the perceived risks no longer apply. There is also good evidence that nearly all aspects of airway management can be affected by CP. To put this into current context, if CP was treated as a new airway device, the level of evidence supporting its use would fall well short of the 'ADEPT' criteria suggested by the *Difficult Airway Society* to receive further evaluation [71]. So why does CP receive such special dispensation? This remains unclear, but is perhaps a combination of factors including fear of aspiration, a lack of a viable alternative and a realisation that it can be easily removed should airway difficulties arise. We would strongly argue that current guidelines should be changed to reflect these uncertainties, and the current evidence base.

Competing interests

None declared

References

1. Lerman J. On cricoid pressure: 'May the force be with you'. *Anesth Analg* 2009;109: 1363-1366.
2. Vanner RG. Cricoid pressure. *Int J Obstet Anesth* 2009;18: 103-105.
3. Ovessapian A, Salem MR. "Sellick'sManeuver: To Do or Not Do". *Anesth Analg* 2009;109(5):1360–1362.
4. Engelhardt T, Webster NR. Pulmonary aspiration of gastric contents in anaesthesia. *Br J Anaesth* 1999;83:453-460.
5. Neilipovitz DT, Crosby ET. No evidence for decreased incidence of aspiration after rapid sequence induction. *Can J Anesth* 2007;54:748–764.
6. Brimacombe JR, Berry AM. Cricoid pressure. *Can J Anaesth* 1997;44:414-425.
7. Priebe HJ. Use of cricoid pressure during rapid sequence induction: Facts and fiction. *Trends Anaes Crit Care* 2012; 2(3):123-127.
8. Mendelson CL. The aspiration of stomach contents into the lungs during obstetric anaesthesia. *Am J Obs Gyne* 1946;52:191-205.
9. Sellick BA. Cricoid pressure to control regurgitation of stomach contents during induction of anaesthesia. *Lancet* 1961;2:404–6.
10. Sellick BA. The prevention of regurgitation during induction of anaesthesia. *First European Congress Anaesthesiology* 1962;89:1-4.
11. Stept WJ, Safar P. Rapid induction-intubation for prevention of gastric-content aspiration. *Anesth Analg* 1970;49:633-636.
12. Difficult Airway Society. Failed intubation and failed ventilation. Available at http://www.das.uk.com/guidelines/cvci.html. Accessed September 2014.
13. Fourth National Audit Project. Major complications of airway management in the UK. Report and findings of the Fourth National Audit Project of the Royal College of Anaesthetists and the Difficult Airway Society. March 2011.
14. Olsson GL, Hallen B, Hambraeus-Jonzon K. Aspiration during anaesthesia. A computer-aided study of 185 358 anaesthetics. *Acta Anaesth Scand* 1986;30:84–92.
15. Warner MA, Warner ME, Weber JG. Clinical significance of pulmonary aspiration during the perioperative period. *Anesthesiology* 1993;78:56–62.

16. Sakai T, Planinsic RM, Quinlana JJ, Handley LJ, Kim T-Y, Hilmi IA. The incidence and outcome of perioreative pulmonary aspiration in a university hospital: a 4-year retrospective analysis. *Anesth Analg* 2006;103:941-947.
17. Maltby JR, Beriault MT. "Science, pseudoscience and Sellick". *Can J Anaesth* 2002; 49 (5):443–7.
18. Smith K, Ladak S, Choi L, Dobranowski J. The cricoid cartilage and the oesophagus are not aligned in close to half of adult patients. *Can J Anaesth* 2002;49(5):503-507.
19. Smith KJ, Dobranowski J, Yip G, Dauphin A, Choi PTL. Cricoid pressure displaces the esophagus: an observational study using magnetic resonance imaging. *Anesthesiology* 2003;99 (1):60–4.
20. Rice MJ, Mancuso AA, Gibbs C, Morey TE, Gravenstein N, Deitte LA. Cricoid pressure results in compression of the postcricoidhypopharynx: the esophageal position is irrelevant. *Anesth Analg* 2009;109:1546–52.
21. Zeidan AM, Salem MR, Mazoit JX, Abdullah MA, Ghattas T, Crystal GJ. The effectiveness of cricoid pressure for occluding the esophageal entrance in anesthetized and paralyzed patients: an experimental and observational glidescope study. *Anesth Analg* 2014;118(3):580-6
22. Fanning G.L. The efficacy of cricoid pressure in preventing regurgitation of gastric contents. *Anesthesiology* 1970;32:553-555.
23. Salem MR, Joseph NJ, Heyman HJ, et al. Cricoid compression is effective in obliterating the esophageal lumen in the presence of a nasogastric tube. *Anesthesiology* 1985;63:443-446.
24. Salem MR, Wong AY, Fizzotti GF. Efficacy of cricoid pressure in preventing aspiration of gastric contents in paediatric patients. *Br J Anaesth* 1972;44:401-404.
25. Vanner RG, Pryle BJ. Regurgitation and oesophageal rupture with cricoid pressure: a cadaver study. *Anaesthesia* 1992;47:732-735.
26. Lawes EG, Campbell I, Mercer D, et al. Inflation pressure, gastric insufflation and rapid sequence induction. *Br J Anaesth* 1987;59:315-318.
27. Moynihan RJ, Brock-Utne JG, Archer JH, et al. The effect of cricoid pressure on preventing gastric insufflation in infants and children. *Anesthesiology* 1993;78:652-656.
28. Petito SP, Russell WJ. The prevention of gastric inflation—a neglected benefit of cricoid pressure. *Anaesth Intens Care* 1988;16:139-143.

29. Salem MR, Wong AY, Mani M, et al. Efficacy of cricoid pressure in preventing gastric inflation during bag-mask ventilation in pediatric patients. *Anaesthesiology* 1974;40:96-98.
30. Bouvet L, Albert ML, Augris C, Boselli E, Ecochard R, Rabilloud M, Chassard D, Allaouchiche B. Real-time detection of gastric insufflation related to facemask pressure-controlled ventilation using ultrasonography of the antrum and epigastric auscultation in nonparalyzed patients: a prospective, randomized, double-blind study. *Anesthesiology* 2014;120(2):326-34.
31. Whittington RM, Robinson JS, Thompson JM, et al. Fatal aspiration (Mendelson's) syndrome despite antacids and cricoid pressure. *Lancet* 1979;2:228-230.
32. Howells TH, Chamney AR, Wraight WJ, et al. The application of cricoid pressure: An assessment and a survey of its practice. *Anaesthesia* 1983; 38: 457-460.
33. Confidential Enquiry into Maternal and Child Health. Why Mothers Die 2000–2002. The sixth report of the Confidential Enquiries into Maternal Deaths in the United Kingdom. London: RCOG: 128.
34. Schwartz DE, Matthay MA, Cohen NH. Death and other complications of emergency airway management in critically ill adults. *Anaesthesiology* 1995;82:367-376.
35. Koerber JP, Roberts GE, Whitaker R, Thorpe CM. Variation in rapid sequence induction techniques: current practice in Wales. *Anaesthesia* 2009;64:54–9.
36. De Souza DG, Doar LH, Metha SH. Aspiration prophylaxis and rapid sequence induction for elective caesarean delivery: time to reassess old dogma? *Anesth Analg* 2010; 110:1503-5.
37. Ajmal M. General anaesthesia for caesarean sections: are anaesthetists dealing with exaggerated fear? *Eur J Anaesth* 2011;28:815-6.
38. Han TH, Brimacombe J, Lee EJ, Yang HS. The laryngeal mask is effective (and probably safe) in selected healthy parturients for elective caesarean section: a prospective study of 1067 cases. *Can J Anaesth* 2001;48:1117-21.
39. Halaseh BK, Sukkar ZF, Haj Hassan L, Sia ATH, Bushnaq WA, Adarbeh H. The use of ProSeal laryngeal mask airway in caesarean section – experience in 3000 cases. *Anaesth Intens Care* 2010;38:1023-1028.
40. Report on confidential enquiries into maternal deaths in England and Wales 1964–1966. Department of Health 1969. London: HMSO.

41. Confidential Enquiry into Maternal and Child Health. Why Mothers Die 1997–1999. The fifth report of the Confidential Enquiries into Maternal Deaths in the United Kingdom. London: RCOG: 137–138.
42. Lewis, G (ed) 2007. The Confidential Enquiry into Maternal and Child Health (CEMACH). Saving Mothers' Lives: reviewing maternal deaths to make motherhood safer: 2003–2005. The Seventh Report on Confidential Enquiries into Maternal Deaths in the United Kingdom. London: CEMACH.
43. Turnbull AC, Tindall VR, Robson G, Dawson IMP, Cloake EP, Ashley JSA. Report on confidential enquiry into maternal deaths in England and Wales, 1979-1981, London, England; HMSO; 1986. No. 29.
44. Fenton PM, Reynolds F. Life-saving or ineffective? An observational study of the use of cricoid pressure and maternal outcome in an African setting. *Int J Obstet Anaesth* 2009; 18: 106-110.
45. MacG, Palmer JH, Ball DR. The effect of cricoids pressure on the cricoids cartilage and vocal cords: an endoscopic study in anaesthetised patients. *Anaesthesia* 2000;55:263–8.
46. Hartsilver EL, Vanner RG. Airway obstruction with cricoids pressure. *Anaesthesia* 2000;55:208-211.
47. Georgescu A, Miller JN, Lecklitner ML. The sellickmaneuver causing complete airway obstruction. *Anesth Analg* 1992;74:457-459.
48. Levitan RM, Kinkle WC, Levin WJ, Everett WW. Laryngeal view during laryngoscopy: a randomized trial comparing cricoid pressure, backward-upward rightward pressure, and bimanual laryngoscopy. *Ann Emerg Med* 2006; 47: 548-555.
49. Hawthorne L, Wilson R, Lyons G, Dresner M, Failed intubation revisited: 17-yr experience in a teaching maternity unit. *Br J Anaesth* 1996;76:680-4.
50. Haslam N, Parker L, Duggan JE. Effect of cricoid pressure on the view at laryngoscopy. *Anaesthesia* 2005; 60: 41-47
51. Noguchi T, Koga K, Shiga Y, et al. The gum elastic bougie eases tracheal intubation while applying cricoid pressure compared to a stylet. *Can J Anaesth* 2003; 50:712-717.
52. Aoyama K, Takenaka I, Sata T, Shigematsu A. Cricoid pressure impedes positioning and ventilation through the laryngeal mask airway. *Can J Anaesth* 1996;43:1035–40.

53. Asai T, Barclay K, McBeth C, Vaughan RS. Cricoid pressure applied after placement of the laryngeal mask prevents gastric insufflation but inhibits ventilation. *Br J Anaesth* 1996;76:772-6.
54. Brimacombe J, White A, Berry A. Effect of cricoid pressure on ease of insertion of the laryngeal mask airway. *Br J Anaesth* 1993; 71: 800-802.
55. Turgeon AF, Nicole PC, Trepanier CA, et al. Cricoid pressure does not increase the rate of failed intubation by direct laryngoscopy in adults. *Anaesthesiology* 2005;102:315-319.
56. Williamson R. Cricoid pressure. *Can J Anaesth* 1989; 36: 601.
57. Lyons G. Failed intubation. Six years' experience in a teaching maternity unit. *Anaesthesia* 1985; 40:759-762.
58. Tournadre JP, Chassard D, Berrada KR, Boulétreau P. Cricoid cartilage pressure decreases lower esophageal sphincter tone. *Anesthesiology* 1997;86:7–9
59. Thorn K, Thorn SE, Wattwil M. The effects of cricoid pressure, remifentanil, and propofol on esophageal motility and the lower oesophageal sphincter. *Anesth Analg* 2005; 100:1200-3.
60. Salem MR, Bruninga KW, Dodlapatii J, Joseph NJ. Metoclopramide does not attenuate cricoid pressure-induced relaxation of the lower esophageal sphincter in awake volunteers. *Anesthesiology* 2008;109:806–10
61. Garrard A, Campbell AE, Turley A, Hall JE. The effect of mechanically-induced cricoid force on lower oesophageal sphincter pressure in anaesthetized patients. *Anaesthesia* 2004;59:435-9.
62. Vanner RG, Pryle BJ. Regurgitation and oesophageal rupture with cricoid pressure: a cadaver study. *Anaesthesia* 1992;47:732-5.
63. Ralph SJ, Wareham CA. Rupture of the oesophagus during cricoid pressure. *Anaesthesia* 1991;46:40-41.
64. Walton S, Pearce A. Auditing the application of cricoid pressure. *Anaesthesia* 2000;55:1028-1029
65. Meek T, Gittins N, Duggan JE. Cricoid pressure: knowledge and performance amongst anaesthetic assistants. *Anaesthesia* 1999;54:59-62.
66. Owen H, Follows V, Reynolds KJ, Burgess G, Plummer J. Learning to apply effective cricoid pressure using a part task trainer. *Anaesthesia* 2002;57(11):1098-1101
67. Ellis DY, Harris T, Zideman D. Cricoid pressure in the emergency department rapid sequence tracheal intubations: A risk-benefit analysis. *Ann Em Med* 2007;50:653-665.

68. Snow RG, Nunn JF. Induction of anaesthesia in the foot-down position for patients with a full stomach. *Br J Anaesth* 1959; 31:493-7.
69. Hodges RJH, Bennett JR, Tunstall ME, Knight RF. General anaesthesia for operative obstetrics. *Br J Anaesth* 1959;31:152-63.
70. Vanner RG. Cricoid pressure. *Int J Obstet Anesth* 2009; 18:103-105.
71. Pandit JJ, Popat MT, Cook TM, Wilkes AR, Groom P, Cooke H, Kapila A, O'Sullivan E. The Difficult Airway Society 'ADEPT' guidance on selecting airway devices: the basis of a strategy for equipment evaluation. *Anaesthesia* 2011;66:726-737.

Key Points

- Cricoids pressure was introduced in the 1960s to protect against pulmonary aspiration
- The evidence supporting its use comes from cadaver studies and case series
- Imaging studies have shown that CP does not reliably occlude the oesophageal lumen
- CP interferes with all aspects of airway management
- Use of CP should be limited to those at high risk of aspiration

Outstanding questions

- What is the optimal patient position to prevent pulmonary aspiration whilst minimising cardiovascular effects?
- What is the optimal cricoid force needed to prevent regurgitation in the head-up position?
- Does a reduced cricoid force cause less interference with airway management?
- Should guidelines be changed to reflect the uncertainty surrounding the use of CP?
- Should all rapid sequence inductions be *modified* rapid sequence inductions?