WORKSHEET for Evidence-Based Review of Science for Emergency Cardiac Care

Worksheet author(s)

Ian Maconochie

Date Submitted for review: 27/1/10

Clinical question.

In infants and children with respiratory failure who require endotracheal intubation, does the use of cricoid pressure or laryngeal manipulation, when compared with standard practice, improve outcome (e.g. success of intubation, aspiration, side effects, etc.)

Is this question addressing an intervention/therapy, prognosis or diagnosis? Intervention/therapy

State if this is a proposed new topic or revision of existing worksheet: New topic

Conflict of interest specific to this question

No

Search strategy (including electronic databases searched).

Cochrane, AHA Master, Medlars, Embase, Scisearch, Psychoinfo, psycinfo, cinahl and hand searches of relevant papers from search

For systematic/metaanalysis and RCT studies

1. (respirat$ adj5 (fail$ or insuffic$ or depres$ or deficien$ or disturb$ or dysfun$)).tw.
2. (ventilat$ adj5 (fail$ or insuffic$ or depres$ or deficien$ or disturb$ or dysfun$)).tw.
3. limit 2 to "all child (0 to 18 years)"
4. limit 3 to "all child (0 to 18 years)"
5. exp cricoid cartilage/
6. cricoid$.tw.
7. exp larynx/
8. exp manipulation, osteopathic/
9. exp Neck/
10. (neck$ adj5 (manipulat$ or handl$ or treat$ or press$)).tw.
11. (laryn$ adj5 (manipulat$ or handl$ or treat$ or press$)).tw.
12. (osteopath$ adj5 (manipulat$ or handl$ or treat$ or press$)).tw.
13. exp Respiratory Failure/
14. 8 or 6 or 11 or 7 or 10 or 9 or 12 or 5
15. limit 14 to "all child (0 to 18 years)"
16. 1 or 13 or 2
17. limit 16 to "all child (0 to 18 years)"
18. (review or review, tutorial or review, academic).pt.
19. (medline or medlars or embase or pubmed).tw,sh.
20. (scisearch or psychoinfo or psycinfo).tw,sh.
21. (psychlit or psyclit).tw,sh.
22. cinahl.tw,sh.
23. ((hand adj2 search$) or (manuals$ adj2 search$)).tw,sh.
24. (electronic database$ or bibliographic database$ or computeri?ed database$ or online database$).tw,sh.
25. (pooling or pooled or mantel haenszel).tw,sh.
26. (peto or dersimonian or fixed effect).tw,sh.
27. (retraction of publication or retracted publication).pt.
28. 27 or 25 or 26 or 20 or 22 or 19 or 18
29. 28 and 18
30. meta-analysis.pt.
31. meta-analysis.sh.
32. (meta-analysis$ or meta analy$ or metaanalyS$).tw,sh.
33. (systematic$ adj5 review$).tw,sh.
34. (systematic$ adj5 overview$).tw,sh.
35. (quantitative$ adj5 review$).tw,sh.
36. (quantitative$ adj5 overview$).tw,sh.
37. (quantitative$ adj5 synthesis$).tw,sh.
38. (methodologic$ adj5 review$).tw,sh.
39. (methodologic$ adj5 overview$).tw,sh.
40. (integrative research review$ or research integration).tw.
41. 35 or 33 or 32 or 39 or 40 or 36 or 38 or 34 or 30 or 37 or 31
42. 41 or 29
43. exp Randomized Controlled Trials/
44. "randomized controlled trial".pt.
45. "controlled clinical trial".pt.
46. (random$ or placebo$).ti,ab,sh.
47. ((singl$ or double$ or triple$ or treble$) and (blind$ or mask$)).tw,sh.
For Observational, case-control and case studies
1. exp Respiratory Failure/
2. (respirat$ adj5 (fail$ or insuffic$ or depres$ or deficien$ or disturb$ or dysfun$)).tw.
3. (ventilat$ adj5 (fail$ or insuffic$ or depres$ or deficien$ or disturb$ or dysfun$)).tw.
4. 3 or 1 or 2
5. limit 4 to ("all infant (birth to 23 months)" or "all child (0 to 18 years)" or "newborn infant (birth to 1 month)" or "infant (1 to 23 months)" or "preschool child (2 to 5 years)" or "child (6 to 12 years)" or "adolescent (13 to 18 years)")
6. exp Cricoid Cartilage/
7. cricoid$.tw.
8. exp Larynx/
9. exp Manipulation, Osteopathic/
10. exp Neck/
11. (laryn$ adj5 (manipulat$ or handl$ or treat$ or press$)).tw.
12. (neck$ adj5 (manipulat$ or handl$ or treat$ or press$)).tw.
13. (osteopath$ adj5 (manipulat$ or handl$ or treat$ or press$)).tw.
14. 6 or 11 or 7 or 9 or 12 or 8 or 10 or 13
15. exp cohort studies/
16. cohort$.tw.
17. controlled clinical trial.pt.
18. epidemiologic methods/
19. exp case-control studies/
20. (case$ and control$).tw.
22. case reports.pt.
25. 21 or 17 or 20 or 15 or 22 or 18 or 24 or 16 or 19 or 23
26. 25 and 14 and 5

**State inclusion and exclusion criteria**

Four hundred and four articles were found from the observation, case-control and case studies, and ten from the former search. Limitation by age, and animal models excluded. Articles were checked by hand for additional papers leading from the search. This led to 4 papers being considered, as the determinants were based on clinical features and results. Discussion from webinar meeting led to 2 more included.

**Number of articles/sources meeting criteria for further review:**

6 in total
Level of evidence L2 = 1 paper, L4 = 1 paper, L5 = 4 papers
## Summary of evidence

### Evidence Supporting Clinical Question

<table>
<thead>
<tr>
<th>Level of Evidence</th>
<th>Good</th>
<th>Fair</th>
<th>Poor</th>
<th>Other Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(gast) Moynihan 1993</td>
<td></td>
<td>(gast) Salem 1974</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(refl) Salem 1972 &amp; 1985 Ellis 2007</td>
</tr>
</tbody>
</table>

**Level of evidence:**

A = Return of spontaneous circulation  
B = Survival of event  
C = Survival to hospital discharge  
D = Intact neurological survival  
E = Other endpoint  

*Italics = Animal studies*
## Evidence Neutral to Clinical question

<table>
<thead>
<tr>
<th>Good</th>
<th>Fair</th>
<th>Poor</th>
<th>Kluger 1999</th>
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</thead>
<tbody>
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</tbody>
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### Level of evidence

A = Return of spontaneous circulation  
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E = Other endpoint  

*Italicics = Animal studies*

## Evidence Opposing Clinical Question

<table>
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<tr>
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<th>Fair</th>
<th>Poor</th>
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### Level of evidence

A = Return of spontaneous circulation  
B = Survival of event  
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D = Intact neurological survival  
E = Other endpoint  

*Italicics = Animal studies*
**REVIEWER’S FINAL COMMENTS AND ASSESSMENT OF BENEFIT / RISK:**

There is insufficient evidence to state a preference for or against the practice of cricoid pressure in RSI as regards prevention of aspiration of stomach contents into the trachea and beyond into the respiratory tree.

The reader is referred to Worksheets A 007 A & B for adults

The question was not whether cricoid pressure could occlude the alimentary tract in children or if could be taught and be correctly applied in children. This eliminated the vast bulk of papers that addressed the anatomy by various means or were observations of fluids of various types getting to the glottis under varying conditions. No study examined the incidence of aspiration in children in the acute setting with or without cricoid pressure. There were, in fact, very few studies that involved children or surrogate models for children.

Fortunately, the risk of aspiration during RSI is likely to be less than 1 per 2000 children and the case mortality is probably less than 5% (Kluger 1999). However, that means that there has not been and will not be a study or combination of studies that will have sufficient numbers to prove that the use of cricoid pressure changes the risk of aspiration during intubation.

Cricoid pressure increases the pressure required to reflux fluid from the stomach to the esophagus (Salem 72 & 85). The importance of this finding in cadavers may mean that gastric contents are less likely to reach the laryngeal inlet in intact children during RSI, however that theory and its association with aspiration, are not proven.

Cricoid pressure may decrease the extent of gastric insufflation during bag-valve-mask ventilation (Moynihan 93, Salem 74). The importance of this is not established for children. It is postulated that gastric distension may impair ventilation or increase the risk of aspiration, but these theories are not proven.

There are contradictory papers regarding the safety and efficacy of cricoid pressure in the setting of actual or suspected cervical spine injury in adults and no studies in children. Therefore, no recommendation for or against its use is suggested.

As it has become the standard of care by common use and there does not appear to be significant risk to its use, no change in its use in the beginning of a RSI can be recommended.

On the other hand, it is clear that any laryngeal manipulation can adversely affect the ability to ventilate with bag-valve-mask and to successfully visualize or intubate the trachea in adults and thus should be used if desired but altered or removed immediately if it impairs ventilation or the speed or ease of intubation (Ellis 2007).

The reviews by Ellis and Kluger were suggested for inclusion by the webinar meeting of the paediatric taskforce at Osaka 2009.

**Acknowledgements:**
Alex McNeil, Information Specialist, BMJ clinical evidence
Citation List


1. Level of Evidence 5
2. Quality limited – review article
3. Direction of support

Cricoid pressure is considered an integral part of patient safety in rapid sequence tracheal intubation and emergency airway management. Cricoid pressure is applied to prevent the regurgitation of gastric contents into the pharynx and subsequent aspiration into the pulmonary tree.


Kluger MT, Short TG. Aspiration during anaesthesia: a review of 133 cases from the Australian Anaesthetic Incident Monitoring Study. Anaesthesia 1989; 54:19-26

1. Level of Evidence 5
2. Quality limited – review of 5000 reported incidents from routine monitoring data
3. Direction of support Neutral

Passive regurgitation occurred three times more common than actively so. Aspiration more common in elective cases (by factor of 2). Majority of cases had a risk factor. Cricoid pressure said only to be of benefit if airway was planned to be intubated.

Considerations
No denominator for the number of intubations during reporting time. Twenty percent of cases occurred in children aged under 14 years of age.


1. Level of Evidence 2
2. Quality limited case-control series with patients their own controls and assessed by single non blinded investigator
3. Direction of support For cricoids pressure to prevent insufflation of the stomach and hence decrease the risk of aspiration of gastric contents

4. Brief Summary

Methods 59 infants and children, 2 weeks to 8 years of age enrolled. No overt airway abnormality, respiratory or gastrointestinal pathology known. 34 were for cardiac surgery. Anaesthesia induced by halothane 1-3% with 70% nitrous oxide and 30% oxygen. After 5 minute spontaneous breathing via mask via an anaesthetic system with 1-2% halothane and 7% nitrous oxide, an oral airway was placed.

The two had two arms to it
1. Nonparalysed (i.e. no muscle paralysing agents used)
2. Paralysed

Investigator listened over the upper abdomen and Doppler probe to detect when air entered the stomach ‘pop off point’.

The same investigator checked for the pop off point as provided the cricoid compression, hence it was not blind.

Before each study sequence, the stomach was evacuated of gas by oral gastric suction catheter.

The study sequence: Close the anaesthetic machine valve so that there was an increase in the proximal airway pressure to the mask. The end point was to determine the pop off point, or if the airway pressure reached 40 cm H2O or epigastric distension was seen.
Patients were divided into two groups, with either starting off with cricoids pressure on and then removed, and this sequence repeated one more time, whilst in the other group the order of cricoid pressure application was reversed.

Study 2
Muscle relaxants were administered with either pancuronium or vecuronium. The procedure as above was repeated, with the on/off (and vice versa for the other half of patients) being performed 4 times.

Age, weight, sex, existence of congenital heart disease, pre-op midazolam were considered in the analysis.

Results
Cricoid pressure was effective in preventing gastric insufflations in all 59 children with and without paralysis, up to 40 cm H2O PIP. Paralysis gave a lowered pop off point. Seven patients did not have a pop off point. This paper notes that ‘firm cricoid pressure’ is not defined – this is important as especially in young children, complete airway obstruction may arise if the trachea is compressed. It also notes that the integrity of the oesophageal sphincters, the upper and lower oesophageal sphincters have a role in decreasing the likelihood of reflux of gastric contents and aspiration into the lung.

This is a non-blinded study of children, undergoing a procedure requiring anaesthesia, who are used as their own controls in having cricoid pressure and measuring the entry of gas into the stomach. There is no randomisation in the study and the assessor was not blinded as he caused the intervention being studied and determined its effects.


1.  Level of Evidence 5
2.  Quality limited case series of 6 adult cadaver models. The quality is poor in the demographic descriptions are sparse and the information on technical details scant.
3.  Direction of support Cricoid pressure decreases the risk of aspiration of gastric contents
4.  Brief Summary

Methods
6 fresh adult cadavers, who had their stomach exposed by abdominothoracic incision, with either a mushroom gastrotomy or Foley cather then inserted into the distal oesophagus and tape firmly wrapped around the oesophagus to secure the catheter and prevent leakage. This catheter was connected to 3 way tap to allow coloured saline to run freely into the oesophagus. The coloured saline bag kept at a height of 100cm from the body. An 18 French Salem Sump nasogastric tube was introduced via the nose in 5 cadavers and via the mouth in 1 cadaver. Each tube had a clamp applied proximally, i.e. to every nasogastric tube before it entered the body.

Sellick technique, that is, cricoid compression was applied to produce temporary occlusion of the upper oesophagus by backwards pressure of the cricoid ring against the bodies of the cervical vertebrae. The oesophagus was filled with coloured saline from the 100 mL reservoir, the intraoesophageal pressure being assumed to be 100 cm H20. The pharynx was visualised throughout whilst the nasogastric tube was clamped and released. Thereafter, the clamp was reapplied and the oesophagus was refilled to 100cm H2O with cricoid pressure maintained. The pharynx was visualised after releasing the cricoid pressure and 20-30s after removal of clamp. In 3 cadavers, the experiment was repeated with use of contrast material, with lateral x-rays of head, neck and upper chest.

Results
With a clamped nasogastric tube, the coloured saline did not reach the pharynx with cricoid compression in place. Releasing the clamp led to saline passing freely through the nasogastric tube but there was no fluid in the pharynx.

Removal of cricoid pressure lead to coloured saline appearing in the pharynx, oropharynx, nasopharynx and mouth. If the clamp on the nasogastric tube was released, then coloured saline also came out of the nasogastric tube.

Assumptions and considerations in this paper
That the oesophageal pressure was 100 cm H2O – there may have been distension of the oesophagus, as it is not a static entity but can distend. How much distension of the oesophagus occurs in the cadavers is not discussed, but if it did occur would suggest that the pressure being kept at bay by cricoid pressure was lower than 100 cm H2O. It is a cadaveric model and using adults, not children. Its applicability to everyday practice is questionable.


1.  Level of Evidence 4
2.  Quality limited case series of 10 anaesthetised patients. The quality is poor in the demographic descriptions are sparse and the information on technical details scant.
3.  Direction of support For cricoid pressure to prevent insufflation of the stomach and hence decrease the risk of aspiration of gastric contents
4. Brief Summary

Methods
Ten patients between 3 months to 5 years undergoing elective surgical procedures, who did not have gastrointestinal or respiratory disease, were studied. They all had an oropharyngeal airway inserted and were pharmacologically paralysed.

Each patient had two periods on intermittent positive pressure ventilation (IPPV), each period being for 2 minutes.

Sellick technique used, namely Cricoid compression applied to produce temporary occlusion of the upper oesophagus by backwards pressure of the cricoid ring against the bodies of the cervical vertebrae. For one period of IPPV, there was no cricoid pressure whilst during the other, gentle cricoid pressure was exerted.
An orogastric tube was inserted prior to each test to ensure gastric emptying and immediately after each period, the orogastric tube was inserted and the volume of gas that could be aspirated measured.

IPPV was conducted by tight fitting face mask via Air Shields Ventimeter Ventilator with paediatric attachment; minute volume was 1.5 times that calculated from standard normogram. Ventilation settings were maintained throughout. The volume of exhaled gas during each period was measured via Wright’s respirometer and the peak airway pressures were monitored by a pressure gauge.

Results
IPPV for 2 minutes resulted in appreciable accumulation of air in the stomach, according to the table that is quoted. The figures are:

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Differences in stomach gas volumes (i.e. Control-cricoid) (mL)</th>
<th>Differences in exhaled gas volumes (i.e. Control-cricoid) (mL)</th>
<th>Peak pressure (cm H2O)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.25</td>
<td>127</td>
<td>120</td>
<td>24</td>
</tr>
<tr>
<td>1.5</td>
<td>315</td>
<td>300</td>
<td>25</td>
</tr>
<tr>
<td>2</td>
<td>118</td>
<td>100</td>
<td>22</td>
</tr>
<tr>
<td>2</td>
<td>109</td>
<td>110</td>
<td>22</td>
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<tr>
<td>2</td>
<td>18</td>
<td>20</td>
<td>21</td>
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<tr>
<td>3</td>
<td>160</td>
<td>150</td>
<td>20</td>
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<tr>
<td>4</td>
<td>47</td>
<td>50</td>
<td>21</td>
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<tr>
<td>4</td>
<td>0</td>
<td>0</td>
<td>19</td>
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<tr>
<td>5</td>
<td>600</td>
<td>520</td>
<td>22</td>
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<tr>
<td>5</td>
<td>10</td>
<td>10</td>
<td>20</td>
</tr>
</tbody>
</table>

Assumptions and considerations
This study looked at pharmacologically muscle relaxed children undergoing routine surgical procedure. The air aspirated from the stomach is assumed to have been derived from the IPPV.
There is no consideration of the change in size of the airway, the change in the length of the oesophagus and the other anthropometric changes associated with change in age. No comments are made about airway abnormality or the presence of congenital heart disease.
This is a case series.


1. Level of Evidence 5
2. Quality limited case series of 8 cadaver models and 6 anaesthetised patients. The quality is poor in the demographic descriptions are sparse and the information on technical details scant.
3. Direction of support Cricoid pressure decreases the risk of aspiration of gastric contents

4. Brief Summary
This paper comprises 2 different studies, one of cadavers and the other on anaesthetised children.

Study 1
Method
8 infant cadavers had an abdominal incision and a plastic catheter inserted into the distal oesophagus via the stomach. The catheter was connected by a 3 way tap to a reservoir of coloured saline, maintained at a height of 100 cm above the body.
Cricoid pressure was maintained whilst the oesophagus was filled at 100 cm H2O. The pharynx was visualised for 5 minute after complete filling of the oesophagus.
The experiment was repeated after a nasogastric tube was inserted to the mid-oesophageal region and a clamp placed proximally to it, i.e. outside the body. Cricoid pressure was then applied and the oesophagus was filled with the coloured saline, as before.
The pharynx was visualised with the clamp on, off and after removal of the cricoid pressure. 4 cadavers had the experiment repeated, with contrast material and x-rays were taken of the head, neck and upper abdomen.

Result
Firm pressure prevented reflux in all cadavers during (presumed) intraoesophageal pressure of 100 cm H2O. This was the case in the presence of a nasogastric tube, located in the mid-oesophageal region. (The amount of pressure involved in performing Sellick’s procedure is not specified).
Releasing the clamp, saline came out via the nasogastric tube but was not seen in the pharynx. Taking off cricoid pressure led to fluid being present in the pharynx.

**Study 2**

**Method**
Three different size of nasogastric tube were used in this manner in 6 anaesthetised children, aged between 1 to 12 years of age. Tubes filled with contrast media, tied off at both ends, placed by nasal or oral route with the lower end being at the mid-oesophageal level. Lateral neck X-rays were taken before and after cricoids compression. The patients’ necks were in an extended position throughout.

**Result**
In all anaesthetised patients, cricoids compression failed to occlude any of the oesophageal tubes.

**Assumptions and considerations about this paper**
This is a combined study using two different populations, living and the dead. The cadaveric study has the inherent difficulty in that the physiological homeostatic mechanisms are absent and hence the applicability of this study in every day practice can be called into question. There is a limited amount of technical and demographic information in this article.