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ORIGINAL ARTICLE

# Life-saving or ineffective? An observational study of the use of cricoid pressure and maternal outcome in an African setting<sup>☆</sup>

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## ABSTRACT

**Background:** Cricoid pressure is a routine part of rapid-sequence induction of general anaesthesia in obstetrics, but its efficacy in saving life is difficult to ascertain.

**Methods:** As part of a prospective observational study of caesarean sections performed between January 1998 and June 2000 in 27 hospitals in Malawi, the anaesthetist recorded whether cricoid pressure was applied, the method of anaesthesia, the use of endotracheal intubation, the occurrence and timing of regurgitation and any other pre- or intra-operative complications. Logistic regression was used to assess the effect of cricoid pressure, type of anaesthetic and pre-operative complications on vomiting/regurgitation and death.

**Results:** Data were collected for 4891 general anaesthetics that involved intubation. Cricoid pressure was applied in 61%; 139 women vomited or regurgitated, but only 30 on induction of anaesthesia, in 24 of whom cricoid pressure was applied. There were 77 deaths, 11 of which were associated with regurgitation, in 10 of which regurgitation contributed to the death. Nine of the 11 mothers had cricoid pressure applied. Only one died on the table, the rest postoperatively. All those who died had preoperative complications.

**Conclusion:** This study does not provide any evidence for a protective effect of cricoid pressure as used in this context, in preventing regurgitation or death. Preoperative gastric emptying may be a more effective measure to prevent aspiration of gastric contents.

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**Keywords:** Caesarean section; Cricoid pressure; Maternal mortality; Regurgitation; Acid aspiration syndrome

## Introduction

The application of digital pressure to the cricoid ring in order to prevent passive regurgitation and therefore aspiration of stomach contents during unconsciousness was first described in 1961 by Sellick.<sup>1</sup> The ability of the manoeuvre to prevent regurgitation has been demonstrated in cadavers,<sup>2</sup> but its efficacy in saving life is difficult to establish. The reduced number of deaths from pulmonary aspiration in obstetric patients in recent years may be attributable not only to the use of cricoid pressure, but also to starvation policies, reduced use of systemic opioids and administration of H<sub>2</sub> antagonists and non-particulate antacids in

labour, the advent of failed intubation drills and not least to the increased use of regional anaesthesia for caesarean section.<sup>3</sup>

Notwithstanding, in many centres the application of cricoid pressure during induction of anaesthesia is routinely taught and regarded as indispensable where there is considered to be a risk of regurgitation, such as for caesarean section under general anaesthesia. It would be difficult to demonstrate a life-saving or even an aspiration-preventing effect of cricoid pressure by randomised controlled trial, since these events are now so rare. In many developing countries, however, general anaesthesia is still widely used for caesarean section and the mortality rate remains rather high. A prospective audit of over 8000 caesarean sections in Malawi, therefore, presented a unique opportunity to examine the possible effect that cricoid pressure, which was not used universally, might have on regurgitation and death. The general data are presented elsewhere;<sup>4</sup> this paper examines whether the application of cricoid pressure had any effect on outcome among those women who were given general anaesthesia.

Accepted July 2008

<sup>☆</sup> The Obstetric Anaesthetists Association contributed to the expenses of the study, but played no part in its design or conduct.

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## Methods

The course and outcome of caesarean sections performed between January 1998 and June 2000 in 27 hospitals in Malawi (2 central and 25 district) were recorded prospectively by those providing anaesthesia. These anaesthetists were clinical officers (not medically qualified) and had received either formal or on-the-job training in anaesthesia. Each anaesthetist was asked to complete forms reporting on at least 20 consecutive caesarean sections that came under his/her management. The method of data collection has been described previously.<sup>4</sup>

During the management of the case, the anaesthetist recorded whether cricoid pressure was applied and who applied it, the method of anaesthesia including use of tracheal intubation, the occurrence and timing of regurgitation and any other pre- or intra-operative complications. Postoperative complications were monitored up to 72 h post partum.

Those who had received formal training in anaesthesia (with regular refresher course updates) had been given the then standard teaching to apply 40 Newtons of force to the cricoid ring. Apart from this, anaesthetists were not given any further instruction in the application of cricoid pressure for individual cases reported in this study. It was accepted that cricoid pressure 'ought' to be applied but anaesthetists were encouraged to be frank about reporting when it was not. Further monitoring of the technique that was actually used was not feasible.

Data were collected and recorded in Epi Info 6 by one of the authors (PF) over the period of the study. The relationships between cricoid pressure and regurgitation and death were explored using the  $\chi^2$  test. Logistic regression was used to assess the influence of the use of cricoid pressure, intubation, type of anaesthesia and the presence of pre-operative complications on the frequency of regurgitation and death.

## Results

Of the total of 8070 caesarean sections recorded in the main study, 4934 mothers had general anaesthesia and

of these, information about whether cricoid pressure was applied was available in 4891, all of whom had tracheal intubation following suxamethonium. Ninety-six percent were emergencies in labour, had been in labour or had uterine rupture (318 mothers). Cricoid pressure was applied in 2985 (61%) (Table 1). The reasons for applying or omitting cricoid pressure were not known but in the study context, the manoeuvre was probably not afforded high priority. In all, 139 women were reported to have regurgitated or vomited, but in only 30 did this occur at induction of anaesthesia. Twenty-four mothers (0.8%) regurgitated at induction of anaesthesia when cricoid pressure was applied compared to six (0.3%) when it was not applied. This difference is in the unexpected direction and not significant ( $\chi^2 = 1.58$ ). In all mothers the incidence of regurgitation at extubation or during recovery from anaesthesia (103) was more than three times greater than at induction of anaesthesia.

It was not reliably recorded who applied cricoid pressure. In the two central hospitals it was usually a student anaesthetist and in the district hospitals a theatre servant under instruction from an anaesthetic clinical officer. Eight anaesthetists (out of 45 who took part in the study), reporting 598 cases, had received no formal training in application of cricoid pressure, the remainder had received such training during a 15–18 month training course.

Difficult intubation was reported in 100 cases, associated with four instances of regurgitation, one at induction of anaesthesia. Cricoid pressure had been applied in this one case but general anaesthesia was later abandoned and the caesarean section performed with local infiltration.

The types of anaesthesia, the use of cricoid pressure and the occurrence of regurgitation or vomiting are shown in Table 2. Except when ketamine anaesthesia was used, the trachea was intubated after thiopentone and suxamethonium and anaesthesia was maintained with ether or halothane using spontaneous respiration.

The choice of ether or halothane did not influence the occurrence of regurgitation during or after anaesthesia. There was a higher incidence of regurgitation in mothers intubated after ketamine, despite cricoid pressure. The small number of women who received ketamine,

**Table 1 Application of cricoid pressure and incidence of regurgitation and death among patients receiving endotracheal general anaesthesia**

	Cricoid pressure applied	Cricoid pressure not applied	Total
All patients having general anaesthesia	2985 (61%)	1906 (39%)	4891
Regurgitation at induction n (% of above)	24 (0.8%)	6 (0.3%)	30
Intra-operative regurgitation	2	4	6
Regurgitation or vomiting at extubation or in recovery	52	51	103
Total regurgitating	78	61	139
Maternal death associated with regurgitation	9	2	11
Maternal death from all causes	57	20	77

Data are n (%).

**Table 2 Methods of general anaesthesia, use of cricoid pressure and occurrence of regurgitation**

Method of anaesthesia	Mothers (% of all general anaesthetics)	Cricoid applied (% of all type of anaesthesia)	Regurgitating during induction, cricoid applied	Regurgitating during induction, no cricoid applied	Regurgitation or vomiting at any other time, all mothers	Total regurgitating
Halothane with tracheal intubation	3124 (64%)	1832 (59%)	9 (0.5%)	4 (0.3%)	68 (2.2%)	81 (2.6%)
Ether with tracheal intubation	1629 (33%)	1057 (65%)	9 (0.85%)	1 (0.2%)	39 (2.4%)	49 (3%)
Ketamine with tracheal intubation	138 (2.8%)	96 (70%)	6 (6.2%)	1 (2%)	2 (1.5%)	9 (6.5%)
Total	4891	2985	24	6	109	139

Data are n (%).

however, were more likely to have had severe pre-operative complications such as prolonged labour, shock, sepsis and a history of taking local herbal remedies compared to the main groups. Starvation status was unknown and antacids unavailable.

In 751 mothers (15.4%) one or more of the following pre-operative complications were recorded: moderate or severe hypovolaemic shock, anaemia, sepsis, toxicity from traditional medicines, pneumonia, advanced HIV infection (Table 3). The frequency of regurgitation of stomach contents during anaesthesia or in recovery among these mothers was 39 (5.2%) compared to 100 of 4140 mothers (2.4%) without pre-operative complications. The presence of these pre-operative complications significantly increased the risk of regurgitation ( $\chi^2 = 48$ ;  $P < 0.001$ ). Of these 751 mothers, 62 died, and among the 39 who suffered

regurgitation or vomiting at any time, 11 died, one on the table and ten in the postoperative period. Of these 11 deaths, detailed case review (PF) suggested that aspiration of stomach contents was the direct cause in eight (all regurgitated on induction), may have contributed in two more and did not contribute in one case (the latter three regurgitated during extubation or recovery). There were no deaths among mothers who regurgitated but did not have pre-operative complications.

The application of cricoid pressure was associated with an increased frequency of both regurgitation and death (Table 4). More important, however, was lack of training and, above all, the presence of pre-operative complications.

The presence of preeclampsia or eclampsia was not associated with any increased regurgitation risk or

**Table 3 Episodes of regurgitation and deaths with and without cricoid pressure among 751 mothers with pre-operative medical complications (mainly advanced HIV, pneumonia and anaemia) and moderate or severe haemorrhagic shock receiving general anaesthesia**

Time	Cricoid pressure applied		Cricoid pressure not applied		Total	
	Regurgitation	Death	Regurgitation	Death	Regurgitation	Death
On induction	15 (3.2%)	8 (1.7%)	2 (0.7%)	0	17 (2.3%)	8 (1.1%)
At other times	10 (2%)	1 (0.2%)	12 (4.2%)	2 (0.7%)	22 (2.9%)	3 (0.4%)
Total regurgitating	25 (5.4%)	9 (1.9%)	14 (4.9%)	2 (0.7%)	39 (5.2%)	11 (1.5%)
Death not associated with regurgitation		39 (8.4%)		12 (4.2%)		51 (6.8%)
Total	463	48 (10.4%)	288	14 (4.9%)	751	62 (8.3%)

Data are numbers regurgitating (% of all patients in treatment group).

**Table 4 Significant risk factors for regurgitation and maternal death among those receiving endotracheal anaesthesia**

	Odds ratio (95% CI)		
	Regurgitation on induction	Regurgitation at any time	Maternal death (any cause)
Cricoid pressure applied	2.60 (1.05 to 6.47)	0.80 (0.57 to 1.13)	1.88 (1.10 to 3.20)
Untrained anaesthetist	4.35 (1.98 to 9.54)	1.90 (1.24 to 2.91)	2.36 (1.29 to 4.34)
Preoperative complications	5.63 (2.48 to 12.7)	2.11 (1.40 to 3.17)	20.9 (11.5 to 37.9)
Regurgitation at any time			3.80 (1.81 to 7.98)

mortality from aspiration of stomach contents (5/191, no deaths).

## Discussion

While acknowledging that this was not a randomised controlled trial, our data provide no evidence that cricoid pressure, as it was applied in these patients, can prevent regurgitation or save life, if anything the reverse. The apparent ineffectiveness of cricoid pressure shown in this study may have been because anaesthetists applied cricoid pressure in mothers who were considered at high risk of regurgitation (and it proved ineffective) or that the application of cricoid pressure impeded easy, rapid intubation.

Another possibility is that some anaesthetists may have claimed to have used cricoid pressure only when regurgitation had actually occurred, but would not use it normally. This study does not claim to judge the efficacy of correctly applied cricoid pressure, but there may be a certain value in reporting the situation as it exists rather than that pertaining to an ideal environment.

Cricoid pressure is not easy to perform,<sup>5</sup> and many of those who provided it in Malawi may have received little or no instruction. Anaesthetists were almost always single-handed and working under difficult conditions. The scrub nurse and surgeon would not be involved during induction of anaesthesia or later in helping to turn patients for extubation, being otherwise occupied. It is recognised that cricoid pressure, particularly if inexpertly applied, may obscure the view and make intubation more difficult.<sup>6</sup> Since the upper oesophageal sphincter relaxes *before* complete loss of consciousness, to be fully effective cricoid pressure must be applied before the onset of full unconsciousness, at a tolerable pressure of 20 N,<sup>7</sup> then increased with full unconsciousness.<sup>8</sup> It is perhaps unrealistic to suppose that such strict conditions can be achieved universally.

Among the 77 women who had general anaesthesia and died from all causes,<sup>4</sup> 11 had regurgitated or vomited at some time, eight on induction of anaesthesia. In ten cases aspiration of stomach contents probably contributed to the death, even when it did not occur on the operating table. So in this particular group, it could be that cricoid pressure correctly applied might have prevented aspiration of stomach contents and possibly saved eight lives. Many mothers in this survey, however, presented *in extremis*, after days of labour and, as it was among these high-risk women that all the deaths occurred, aspiration of gastric contents may have been merely the last straw. The one positive correlation we did find, between the preoperative complications and regurgitation/aspiration during induction of anaesthesia, supports this.

The use of cricoid pressure is not without controversy.<sup>9</sup> Although in English-speaking countries it may

be regarded as the linchpin of a rapid-sequence induction where there is danger of refluxed gastric contents, it is used, though increasingly, less consistently elsewhere,<sup>10,11</sup> many centres relying more on preoperative stomach emptying. This study provides more reason to support this approach than to criticise it.

It should be acknowledged moreover that, as has been reported in the UK and elsewhere,<sup>9</sup> most episodes of vomiting or regurgitation occurred postoperatively, when cricoid pressure is not applicable. Mothers were generally extubated in the supine position, there being no assistance available for turning patients. The lack of recovery facilities in most hospitals and the prolonged period of post-extubation unconsciousness among patients in this study would be expected to be hazardous, especially after ether anaesthesia, although no death from aspiration occurred after ether. Regurgitation in recovery may have contributed to death in two more cases, one after ketamine and one after halothane. One mother regurgitated in the recovery room after ether anaesthesia, but cause of death was considered to be anaemia, not aspiration. Regurgitation during induction of anaesthesia (30 instances, eight associated deaths) appeared more hazardous than regurgitation at or after extubation (103 instances, three associated deaths;  $\chi^2$  with Yates' correction: 14.2,  $P < 0.001$ ).

The mechanism allowing aspiration of gastric contents is a four-stage process:<sup>12</sup>

1. A full stomach, either from eating or from delayed gastric emptying, due to stress or systemic opioid administration.
2. Reflux, a known problem in late pregnancy.
3. Regurgitation of oesophageal contents into the pharynx, once the upper oesophageal sphincter relaxes during induction of anaesthesia.
4. Aspiration, which can occur with loss of laryngeal reflexes and before the airway is secured by a cuffed tracheal tube.

Little can be done about (2), correctly applied cricoid pressure can only prevent (3) and swift and skilled intubation is designed to cope with (4). It may be that the situation in the developing world could be more easily improved by attacking the initial cause (1), and emptying the stomach preoperatively. This would, moreover, have the added advantage of addressing the problem of postoperative vomiting.

This study provides no evidence that, in situations such as those encountered in Sub-Saharan Africa, cricoid pressure prevents regurgitation or saves lives. Passing an oro- or naso-gastric tube preoperatively to empty the stomach or induce vomiting before anaesthesia could be more effective than cricoid pressure as a means of preventing aspiration of stomach contents.

## Acknowledgements

We would like to thank Dr. Robert B. Gerzoff, Statistical Analyst, U.S. Centers for Disease Control, who performed the analysis and checked the accuracy of data entries, the patients who participated in this study and the staff of the participating centres. We would also like to thank staff of the Nick Simons Institute, Kathmandu, Nepal, for their assistance in bringing the data to publication. There are no conflicts of interest.

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