Original Article

Use of the McGRATH™ MAC videolaryngoscope to evaluate the ability of anesthetists to give effective cricoid pressure: An interventional study

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Abstract

Background and Aims: The application of cricoid pressure (CP) for rapid sequence induction is questioned on two grounds: its effectiveness in clinical settings and its impact on the laryngeal view. The main reason cited for its ineffectiveness is the lack of knowledge and training in its correct application. This study assessed, the performance of anesthetists in applying effective CP in a clinical setting.

Material and Methods: Eighty-five ASA I/II adult patients posted for elective surgery requiring oral endotracheal intubation with nasogastric tube (NGT) placement participated in the study. Eighty-five anesthetists divided into five groups based on their level of experience were randomly chosen to apply CP after induction of anesthesia. An experienced anesthetist performed videolaryngoscopy and attempted NGT insertion. The primary outcome was effectiveness of CP defined as the inability to pass the NGT into the esophageal opening. We also noted that the glottic view with and without CP and the effectiveness of CP across different levels of experience of anesthetists.

Results: Of the 85 anesthetists, 61 (71.8%) applied effective CP. The effectiveness improved with experience (first-year residents-11/17 [64.7%], second-year residents-11/17 [64.7%], third-year residents-10/17 [58.8%], senior residents-13/17 [76.5%], and consultants-16/17 [94.1%]) ($P = 0.157$). Post hoc analysis showed higher effectiveness among anesthetists with >3 years of experience (85.3%) compared with <3 years of experience (62.7%) ($P = 0.024$). CP did not always impede the laryngeal view, rather it has no effect or actually improves the glottic view in many instances (81%).

Conclusion: CP is effective in occluding the esophageal lumen without hampering glottic view in the majority of the cases, and its effectiveness improves with experience.

Keywords: Airway management, cricoid pressure, pulmonary aspiration, rapid sequence intubation, training

Introduction

Cricoid pressure (CP) has been an integral component of rapid sequence induction to prevent aspiration of gastric content during induction of anesthesia. In 1961, Brian Sellick introduced CP, which consisted of temporary occlusion of the upper end of the esophagus by backward pressure on the cricoid cartilage against the cervical vertebrae.[1] Also, referred to as "Sellick's maneuver," CP has been adopted worldwide as a standard of practice in at-risk patients. Over the last few decades, studies have debated whether CP is effective in

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clinical settings and questioned its impact on laryngeal view and ease of intubation.

Studies using magnetic resonance imaging (MRI) images of awake volunteers have revealed conflicting results. Smith *et al*.[2] found that in over 50% of subjects, the esophagus was lateral to the cricoid and CP displaced it further, thereby rendering the maneuver ineffective. This study was challenged by Rice *et al*.,[3] who suggested that it is the postcricoid hypopharynx that is occluded by CP, making the position of the esophagus irrelevant to the efficacy of CP. Zeidan *et al*.[4] studied CP using the glidescope videolaryngoscope in anesthetized and paralyzed patients and demonstrated the effectiveness of CP in occluding the esophageal entrance, which was independent of the position of the esophagus. One of the major reasons cited for the ineffectiveness of CP is the lack of cognitive knowledge and technique in its proper application. Numerous studies have found that many of those who regularly perform CP, do not know the correct techniques, duration, or amount of force to apply.[5-8] There is also contradictory evidence about the effects of CP on laryngoscopy and glottic view.[9-16] Studies using videolaryngoscopes to examine the effect of CP on laryngoscopic view have shown mixed results.[14,15,17,18] Most studies on CP have controlled the force used by training the operator on a simulator or by the usage of a cricoid yoke. However, this is not representative of what happens in a clinical setting. There has been no study that has assessed the effectiveness of CP using a videolaryngoscope and its impact on the laryngeal view in the clinical setting, where the method of giving CP has not been standardized. Keeping this in mind, this interventional study was designed to assess the performance of anesthesia residents and consultants in applying effective CP using a McGRATH™ MAC videolaryngoscope and the impact it has on the laryngoscopic view. In addition, we assessed if the level of experience made a difference in the quality of the CP applied.

Material and Methods

Ethical approval for this study (IEC/0716/1655/001) was provided by the hospital Institutional Review Board on May 9th, 2016, and was prospectively registered with the Clinical Trials Registry of India (CTRI/2016/07/007106).

We obtained written informed consent from 85 patients aged 18 years or above with the American Society of Anesthesiologists (ASA) physical status I or II, who were posted for a nonhead and neck elective surgery under general anesthesia requiring oral endotracheal intubation and nasogastric tube (NGT) placement. The exclusion criteria were: patients undergoing emergency surgery or with indications for rapid sequence induction of anesthesia (full stomach, bowel obstruction, pregnancy, gastroesophageal reflux disease [GERD], and diabetic gastroparesis), body mass index (BMI) ≥ 35 kg m^{-2}, a history of difficult airway, pathologies associated with difficult laryngoscopy or intubation, anticipated difficult airway on clinical examination (thyromental distance <6.5 cm plus modified Mallampati test III and IV), or those with contraindication for CP (suspected cricotracheal injury, active vomiting, and unstable cervical spine injuries).

Two anesthesia providers (operator I and operator II) participated per case in the study. Operator I performed the CP. Operator II performed the laryngoscopy using the McGRATH™ MAC videolaryngoscope (Medtronic, Minneapolis, MN, USA) and inserted an NGT. Operator II also observed the change in glottic view with and without CP.

Operator I was selected from one of the five groups divided as per the level of experience: group A–first-year anesthesia residents, group B–second-year anesthesia residents, group C–third-year anesthesia residents, group D–senior residents (completed 3 years of anesthesia postgraduate training), and group E–consultants; each group comprising 17 anesthetists. The group of the operator was selected by randomization using computer-generated chits placed in sealed opaque envelopes, and the operator in the respective group was selected as per the serial number assigned to the operator in their group. The selected operator performed CP only once.

The operator performing videolaryngoscopy (operator II) was an anesthetist experienced with the McGRATH MAC videolaryngoscope with a minimum of 2 years of experience in using videolaryngoscope. Previous 20 successful intubations were considered as the criteria to label the anesthetist experienced with McGRATH MAC videolaryngoscope.[19] In our study, two anesthetists who fulfilled this criteria participated as operator II.

In the operating room, after attaching the standard ASA monitors, surgical safety checklist and patient positioning, the patient was preoxygenated with 100% oxygen via a facemask using a circle system. Once end-tidal oxygen was more than 90%, general anesthesia was administered as per the discretion of the operating room anesthetist. Adequate muscle relaxation was assessed by the disappearance of three twitches on train-of-four mode using a peripheral nerve stimulator for ulnar nerve stimulation. Once adequately relaxed, operator I applied CP. Operator II then performed laryngoscopy using McGRATH MAC videolaryngoscope with the patient's head in the neutral position and observed the view of the glottis and the esophageal entrance. Following this, operator II passed

a well-lubricated 14-Fr NGT and attempted cannulation of the esophagus manually. If unsuccessful, a Magill forceps was used to do the same. The distance from the anterior nasal spine to the esophageal inlet is about 21 cm. Hence, successful insertion of the NGT, indicative of a patent esophagus, was defined as the insertion of the NGT beyond the esophageal inlet up to 40 cm from the anterior nasal spine.

Inability to pass the NGT during application of CP was considered evidence of effective CP. When NGT insertion occurred in the presence of CP, it was considered evidence of ineffective CP. If the NGT could not be passed when CP was applied, operator I removed the CP and then operator II passed the NGT. Patients in whom the NGT could not be passed despite removing the CP were excluded from the study. Operator II observed the change in the glottic view after removal of the CP and scored the glottic views with and without CP as per Cormack–Lehane (CL) grading. The operator ll then intubated the trachea with an appropriate size tracheal tube.

The primary outcome was the percentage of patients in whom effective CP was applied. Secondary outcomes were the change in the glottic view with and without CP and the effectiveness of CP across the groups of anesthetists based on their levels of experience.

Statistical analysis

Since prior data on the effectiveness of CP was lacking, we assumed that CP would be effective in 75% of patients; to detect this with 10% precision at 95% confidence, 73 patients would be needed. We, therefore, planned to study 85 patients to account for protocol deviations. Demographic and clinical related variables were presented as frequency and mean (with standard deviation) as appropriate. The groups were compared using one-way ANOVA for continuous data and χ^2 test for categorical data. The percentage of patients in which effective CP was applied was calculated. The effectiveness of CP across groups of anesthetists with varying levels of experience was expressed as the percentage of cases of effective CP in that group. Groups were compared using the χ^2 test or Fisher's exact test. Wilcoxon signed-rank test was used to compare CL grading with and without CP. The degree of change in CL view (improvement or worsening) was measured as the percentage of patients showing a change in grade. A P value of <0.05 was considered to indicate statistical significance, and no adjustment was made for multiple comparisons. The data were analyzed using IBM® SPSS V. 24.

Results

We obtained written informed consent from 85 patients who were enrolled between July 2016 and November 2016. The process of subject selection and randomization is shown in Figure 1.

Figure 1 CONSORT diagram of patient recruitment. Group A–first-year residents; group B–second-year residents; group C–third-year residents; group D–senior residents; group E–consultants.

The patients in the five groups were comparable for baseline characteristics [Table 1].

Effective CP was given by 61 out of the 85 (71.8%) anesthetists. Of the 24 who gave ineffective CP, in 21 patients, NGT was passed with a Magill's forceps after a failed attempt at manual insertion as prestated in the methodology. However, in three of the 24 patients, the NGT could be passed manually in the first attempt. Therefore, there was no patient in whom NGT placement was unsuccessful and needed to be excluded from the study.

There was an improvement in the effectiveness of CP with an increased level of experience [Figure 2]. However, this was not found to be statistically significant ($P = 0.157$).

Figure 2 Effectiveness of CP across groups of anesthetists based on their level of experience.

Of the 85 anesthetists, 51 were residents (first, second, and third-year residents) having <3 years of experience and 34 were senior residents and consultants having more than 3 years of experience. Post hoc analysis showed higher effectiveness among senior residents and consultants (29/34 i.e., 85.3%) as compared with residents (32/51 i.e., 62.7%). The difference between the two groups was statistically significant ($P = 0.024$).

Application of CP improved the glottic view in 31/85 (36.5%) of the patients, made no difference in 38/85 (44.7%), and worsened the glottic view in 16/85 (18.8%) patients. Degree of change in Cormack–Lehane view with CP was as shown in Figure 3.

Wilcoxon signed-rank test found no statistically significant association between application of CP and glottic view ($Z = -0.985$, $P = 0.325$). The median Cormack–Lehane view was CL-I with CP and CL-IIa without CP. No serious complications occurred during the conduct of the study and no patient had a drop in SpO_2 of <92%.

Discussion

The most important findings of our study are that effective CP was applied by 61 out of 85 (71.8%) anesthetists despite

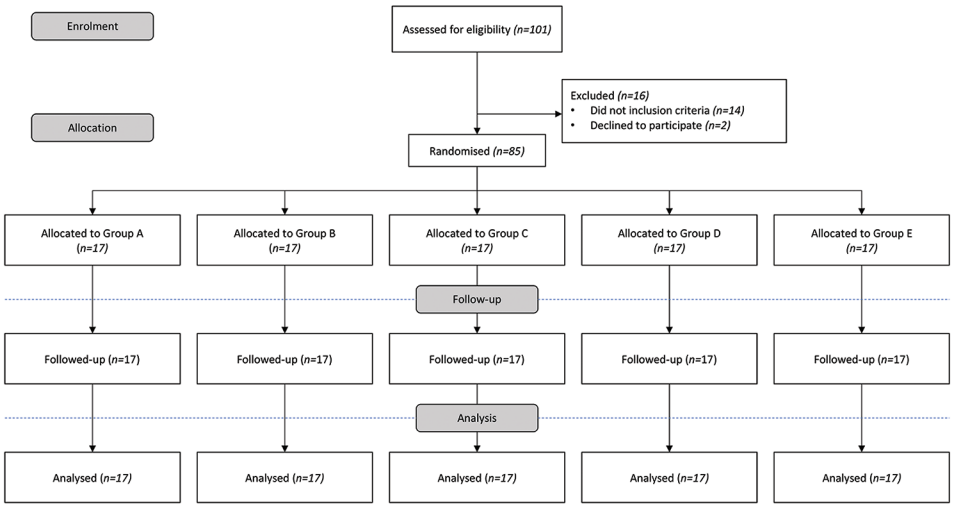

Figure 1: CONSORT diagram of patient recruitment

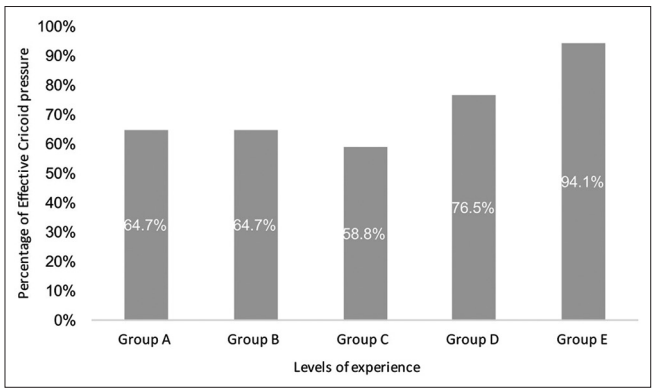

Figure 2: Effectiveness of cricoid pressure across groups of anesthetists based on their level of experience

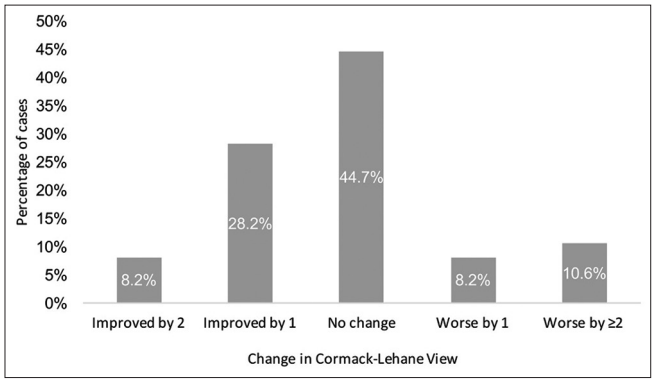

Figure 3: Degree of change in Cormack–Lehane grade with cricoid pressure

the CP not being standardized, and its effectiveness improved with the operator's level of experience. In addition, the study successfully concluded that CP does not always impede the laryngeal view rather it has no effect or improves the glottic view in many instances. Aspiration remains the most common cause of airway-related death in anesthesia practice accounting for 50% of anesthesia-related deaths as reported to National Audit Projects 4 (NAP4).[20] In recent years, the use of CP as a part of rapid sequence induction for aspiration prevention has been questioned based on its effectiveness and its impact on the laryngeal view.

This study, in which anesthetists performed CP without the use of force measurement devices, feedback trainers, or cricoid yokes, is representative of what occurs in routine practice. The study demonstrates CP effectiveness in a real clinical setting using real-time mechanical and visual means. The use of the compact, fully self-contained, and portable McGRATH MAC videolaryngoscope produced excellent laryngoscopic views allowing real-time visualization of both the glottis and the esophageal entrance and an assessment of the glottic view during CP application.

One of the primary reasons cited for the ineffectiveness of CP is the lack of knowledge and adequate training among those who routinely apply it. Studies by Meek *et al*.[7] and Schmidt *et al*.[8] reported that anesthetists lack knowledge regarding CP. Incorrect timing, inconsistent CP technique, application of inadequate/excessive pressure, and application of CP over the thyroid cartilage instead of the cricoid have been suggested as explanations for the failure of CP and the subsequent worsening of the laryngeal view. In conformity with the above explanations, in this study, it was observed that when the CP was not centralized, the larynx was pushed to one side exposing the hypopharynx on the contralateral side, which quite often allowed the passage of the NGT through it making the CP ineffective. Also, when applied over the thyroid cartilage, CP was ineffective in addition to a significant worsening of the laryngeal view. Another reason for the application of ineffective CP was apprehension in the application of a force of 30 N, especially among the junior anesthetists. For CP to be effective at preventing regurgitation without impeding the laryngeal view

Table 1: Patient characteristics and preoperative data. Values are expressed as mean (SD) or number (proportion)

Characteristics	Group A (*n*=17)	Group B (*n*=17)	Group C (*n*=17)	Group D (*n*=17)	Group E (*n*=17)
Age; years	51.88 (10.72)	49.08 (12.38)	43.00 (13.48)	48.47 (13.49)	47.76 (12.61)
Sex					
Male	10 (59%)	7 (41%)	9 (53%)	12 (71%)	8 (47%)
Female	7 (41%)	10 (59%)	8 (47%)	5 (29%)	9 (53%)
Height; cm	158.47 (10.18)	160.41 (8.07)	162.47 (11.55)	163.53 (5.76)	160.94 (8.59)
Weight; kg	63.12 (14.49)	56.88 (10.97)	57.06 (13.86)	58.18 (14.07)	58.82 (9.40)
BMI; kg m^{-2}	25.01 (4.74)	22.25 (4.83)	21.56 (4.41)	21.67 (4.70)	22.85 (4.00)
ASA Physical Status					
I	6 (35%)	11 (65%)	12 (71%)	10 (59%)	11 (65%)
II	11 (65%)	6 (35%)	5 (29%)	7 (41%)	6 (35%)
Mallampati score					
I	10 (59%)	12 (71%)	9 (53%)	9 (53%)	13 (76%)
II	6 (35%)	4 (23%)	8 (47%)	8 (47%)	4 (24%)
III	1 (6%)	1 (6%)	0 (0%)	0 (0%)	0 (0%)
Thyromental distance					
≥6.5 cm	10 (59%)	14 (82%)	14 (82%)	14 (82%)	11 (65%)
<6.5 cm	7 (41%)	3 (18%)	3 (18%)	3 (18%)	6 (35%)

and avoiding airway obstruction, it must be applied correctly.[11] At first, it must not be applied to the thyroid cartilage; otherwise, the resultant anatomical distortion during laryngoscopy makes CP ineffective and causes airway obstruction. Secondly, the larynx must not be pushed too far from the midline. Thirdly, the correct force must be used, amounting to 30 N to prevent the regurgitation. A force of over 40 N can obstruct the airway[21] and cause difficulty with intubation.

This study provides an insight into the effectiveness of CP given by anesthetists with different levels of experience to assess the role of training. NAP4 noted that 43% of reported cases of aspiration involved trainee anesthetists in contrast with 15% involving consultants.[20] We found that the effectiveness of CP improved with the operator's level of experience. In an emergency, a senior experienced anesthetist may not always be available. In such situations, junior anesthetists are usually called upon to apply CP, and it is in these situations that the application of effective CP becomes most crucial. Since we found that CP becomes more effective as the level of experience increased, our study suggests that there is a scope for improvement with proper training programs.

Our study also showed in many cases, CP improves the glottic view. These results are consistent with the findings of other studies, which demonstrated that CP does not hinder the laryngoscopic view.[11,12,14] While Turgeon *et al*.[12] demonstrated that CP does not increase the rate of failed intubation when applied by trained personnel, another study using a Truview Evo2TM laryngoscope found that application of CP improves the glottic view and it is not associated with increased difficulty in intubation.[14]

The use of the videolaryngoscope in this study has been invaluable. Training in the use of videolaryngoscope can further enhance the effectiveness and safety of CP applied by getting real-time feedback on how its application is affecting the laryngeal view. There is an increasing argument for the use of videolaryngoscopes for all rapid sequence inductions.[22]

The merit of this study was that since the CP was not standardized and anesthetists with different levels of experience took part in the study, we could find out the effectiveness of CP in a clinical setting and the impact of training in the anesthetists' performance. We could even study how, routinely applied CP affected the glottic view, the results of which debunked the popular belief that CP impedes the laryngeal view.

The limitation of this study was that it was performed on nonpregnant adult healthy volunteers. Hence, we cannot extrapolate the results of the study to the pediatric, pregnant, and obese population. Future studies including these populations may give further insight. Another potential shortcoming of this study was the failure to blind the anesthetist performing laryngoscopy. Our decision to not blind was based on our experience that the anesthetist could easily determine whether CP was applied or not, based on "feel" and the change in view.

CP is an important safety measure, with much room for improvement in training and the standard of performance. We suggest that all anesthetists should have a thorough theoretical understanding of CP and should be subjected to practical training on a model before practicing on patients. Simple methods of training can easily teach CP. Anesthetists can be trained to apply the correct force by practicing on weighing

scales.[6] By doing this, the range of forces can come within a range of 5 N of the target force with good retention.[6] Once trained, anesthetists can rehearse the required force by depressing a capped air-filled syringe before induction.[22] Thus, all anesthetists can use simple, effective interventions to aid in the acquisition, and maintenance of this vital skill, thereby improving the reliability and safety of the technique.

Although there have been no significant morbidities reported due to the application of CP,[20] the complications related to pulmonary aspiration still loom large. CP remains a contentious issue with opponents trying to abandon it on different grounds. However, there is no conclusive evidence justifying its abandonment. Besides, there is no viable alternative. On the other hand, CP seems like a benign procedure with no complications reported to NAP4. In such a setting, we need to balance the risks and benefits.[23] While dealing with such a life-threatening hazard, it is only logical to do all that we can to avoid it, and thus, CP is still a component of rapid sequence induction.[24] The goal now should be to make CP a safer technique by improving knowledge and training. Also, experience in the use of videolaryngoscopes can further enhance its efficacy by getting real-time feedback.

In conclusion, this study demonstrates that, although CP is effective in occluding the esophageal entrance in most cases, it does not hamper the glottic view; rather it improves the view in a significant number of cases. Thereby, this study successfully demonstrated the efficacy of CP in a real clinical setting, the efficacy of which improves with more training. Correctly applied CP provides the potential for benefit without increasing the risk.

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Conflicts of interest

There are no conflicts of interest.

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