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Research Article

Evaluation of Effectiveness of Cricoid Pressure with Ultrasound in Anesthetized Patients: An Observational Study

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ABSTRACT

Background: Sellick's maneuver is a well-known technique of cricoid pressure application that is practiced during rapid sequence induction to prevent regurgitation of gastric contents. The effectiveness of the cricoid pressure application has been often questioned with respect to the success of cricoid pressure application in preventing regurgitation and aspiration. The study aims to measure the outer anteroposterior(A-P) diameter of the esophagus visualized on ultrasound during the application of cricoid pressure in real time to assess its effectiveness.
Methods: 50 inpatients were enrolled as per inclusion and exclusion criteria. After obtaining informed consent, patients were examined with palpation and USG for identification of the cricoid and marked. As per institutional protocol, general anesthesia was induced. After administration of the induction agent, USG was placed over the cricoid in a slight oblique plane, and an uncompressed image of the esophagus was recorded as T1. An anesthesiologist trained in cricoid pressure application applied 30 N cricoid pressure with thumb and index finger. The anesthesiologist was not shown the image of the USG. The image after the application was recorded as T2. The compression was released after the recordings, and the case proceeded as per protocol. The images were analyzed for the anteroposterior diameter of the oesophagus visualized on cross-section, and values were taken.
Results: Appropriate statistical tests were used to obtain mean values of A-P diameter before and after compression. A-P value of 0.05 was considered significant. The oesophagus was visualized in 45/50 (95%) of individuals. In 45 patients, the oesophagus was visualized on the left side of the trachea in the groove behind the thyroid gland and trachea. In 27/45 (60%), there was occlusion of the oesophagus with cricoid pressure application. There was a significant change in the A-P diameter of the oesophageal lumen. In 18/45 (40%), occlusion was not observed.
Conclusion: In our study, the oesophagus as located on the lateral side of the trachea towards left. The cricoid pressure was effective in 60% of cases.

Introduction

Cricoid pressure, also known as Sellick's maneuver, is a well-known technique used to reduce the risk of regurgitation during endotracheal intubation. The assumption being, occlusion of the oesophagus by compression of the cricoid between its posterior part and the anterior part of the cervical vertebral body, can prevent regurgitation and aspiration. Despite the application of cricoid pressure, there are reports of regurgitation, aspiration, and interference with airway management [1-2]. It is

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postulated that during cricoid pressure, the post-cricoid hypopharynx is compressed and not the esophagus [1]. CT and MRI studies have shown that the esophagus lies lateral to the cricoid and vertebral bodies in more than 50% of individuals [2]. Evidence shows conflicting results for its effectiveness, especially with respect to the degree of pressure application, site of administration, and utility in patients with gastric tubes [1-3]. Few pieces of evidence propose para-laryngeal pressure application to be more effective than the commonly practiced midline cricoid pressure application [4-5]. Even though the credibility of the Sellick maneuver is still a question for debate, the maneuver is recommended in the guidelines for difficult and failed endotracheal intubation and is an integral part of rapid sequence induction [1-2]. In our study, we aimed to evaluate the effectiveness of cricoid pressure by measuring the outer anteroposterior diameter of the esophagus visualized during the maneuver using ultrasound.

Methods

This observational study was conducted at Bangalore Medical College and Research Institute over a period of 6 months. Institutional ethical clearance was obtained (BMCR/PS/107/2022-23). Written informed consent was obtained from all participants. A sample size of 50 patients was derived based on the anteroposterior diameter changes observed in previous studies on ultrasound images during Sellick's maneuver. All inpatients in ASA PS 1 and 2, aged 18-60 years, posted for elective surgeries requiring general anesthesia with endotracheal intubation were enrolled for the study.

Patients with a history of facial, cervical, pharyngeal, and epiglottic surgery or trauma; anterior neck swelling like thyroid swellings; arthritis; patients undergoing emergency surgeries; patients with allergies to drugs used during anesthesia; patients with diseases of the cervical spine; patients with cricoid fractures; and patients with anticipated difficult airways were excluded from the study.

Based on the study conducted by Anuszkiewicz et al. [4], using the change in the outer antero-posterior diameter of the esophagus as a parameter, -0.79 (0.13) cm, with an alpha error at 5% and a power of the study at 80%, the calculated sample size required was 40. We included 50, considering the possibility of dropouts. Before the study, to standardize the cricoid pressure of 30N, an anesthesiologist not involved in data collection was trained and had practiced 2-finger pressure application on a weighing scale. The study was conducted after the assurance of successful application of 30 N of force (+/-2 N) for 20 times consecutively by the provider.

The ultrasound measurements were done by a person who was blinded to the aims and the pressures applied over the cricoid during the study. In the preop area, an 18G intravenous cannula was secured in the upper limb, and IV fluids were connected. The cricoid was identified using a landmark and confirmed with USG imaging and marked with a skin marker. Standard vital monitors, such as pulse oximetry, noninvasive blood pressure, ECG, and basal parameters, were noted. Anesthesia induction was done with midazolam 0.02 mg/kg, propofol 2.5 mg/kg, fentanyl 2 micrograms/kg, and vecuronium 0.1 mg/kg.

The ultrasound machine, SONOSITE M turbo, with a linear probe (6-12 MHz), was placed obliquely at the groove between cricoid and sternocleidomastoid muscle to visualize the structures as mentioned in (Figure 1) Ultrasound imaging of the neck was done in the sniffing air position with neck extended. Bilateral para laryngeal ultrasound imaging was done at the level of the cricoid cartilage using minimal pressure on the skin to image the oesophagus. In cases where the oesophagus was not visualized, those patients were eliminated from the study. When visualized, the image of the oesophagus recorded before cricoid pressure application was saved as T1; with the oesophagus on the imaging screen, cricoid pressure of 30N was applied. After applying cricoid pressure, the image was saved as T2. The image of the oesophagus was captured and stored in the system's memory. To reduce the bias, the screen was not shown to the person providing the cricoid pressure. All stored images are evaluated by an independent researcher. The outer antero-posterior (AP) diameter of the oesophagus was measured before and after application of cricoid pressure. At the end, the effect of cricoid pressure was assessed by evaluating the changes in outer AP diameter because of the cricoid pressure application.

The cricoid pressure was considered effective if there was complete occlusion of the oesophageal lumen in the T2 image. This was substantiated with a significant decrease in the AP diameter of the oesophagus ($p<0.05$) with the inner mucosal lining touching each other; then the cricoid pressure was deemed to be effective with respect to complete occlusion of the lumen by pressure. Ineffective cricoid pressure was defined as either incomplete occlusion of the esophagus or displacement from position in T1 without any occlusion or insignificant decrease in AP diameter in the T2 image ($p>0.05$), with the lumen diameter partially reduced but the inner mucosal lining not touching each other. After the recordings were taken, cricoid pressure was released, and mask ventilation and intubation proceeded as per institutional protocol. The incidence of regurgitation and aspiration was also noted.

Statistical analysis

Data was entered in Microsoft Excel and analyzed with SPSS version 21.0. Categorical data was presented as numbers and percentages. Continuous data was tested for normal distribution and presented as mean (SD) or

median (IQR). The chi-square test was used for categorical data. The paired t-test was used for intra-group comparison and the Student's t-test for inter-group comparison. A P value < 0.05 was considered statistically significant.

Results

One hundred and ninety-eight patients were enrolled in the study. 50 patients met the inclusion criteria. The demographic parameters are presented in (Table 1).

Table 1- Demographic parameters

Parameter	Value (mean)
Male: female	27:23 (50)
Age (y)	35.93 (9.2)
BMI (kg/m²)	24.54 (2.49)

Of 50 patients assessed, the esophagus was visualized in 45 patients (90%); among them, the esophagus was lying partially to the left of the trachea in 38 patients (84.44%) and completely to the left of the trachea in 7 patients (15.5%). In 5 patients (10%), the esophagus was not visualized, and they were eliminated from the study.

In patients where the esophagus was visualized, occlusion was obtained with or without displacement of the esophagus in 27 (60%) patients. In eighteen patients (40%), there was no occlusion of the esophagus with application of cricoid pressure (Table 2, Figure 1).

Table 2- Changes in the esophagus with cricoid pressure

Effect of cricoid pressure	Number (%)
Esophageal occlusion	27 (60%)
Without displacement	6
With displacement	21
Esophageal non-occlusion	18 (40%)

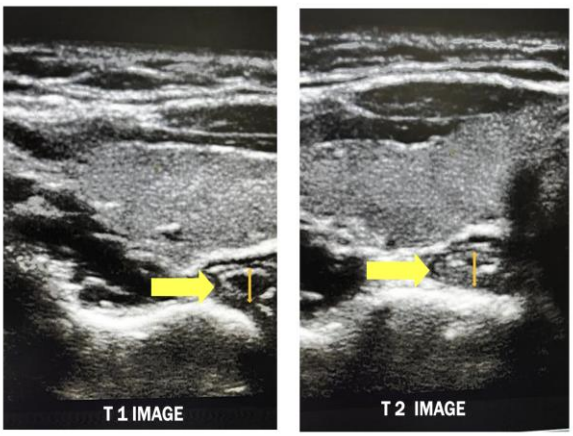

Figure 1- Ultrasound images of the esophagus at the cricoid area, before (T1) and during (T2) application of cricoid pressure (wide horizontal yellow arrow pointing at the esophagus and vertical arrow showing the diameter in T1 and T2 images)

The outer anteroposterior diameter was measured with a built-in caliper on the USG machine. There was a significant difference between the T1 image and the T2 image (Table 3). There was no incidence of regurgitation in any patient.

Table 3- Changes in outer anteroposterior diameter of esophagus

Parameter	AP diameter in mm	P value
T1	7.5 (0.4)	<0.001
T2	6.5(0.6)	

T1- before application of cricoid pressure; T2- during application of cricoid pressure; mm- millimeters

Discussion

We found that the cricoid pressure was effective in completely occluding the esophagus in 27 out of 45 (60%) patients, with displacement to the left side of the trachea in 21/27 (77%) of patients.

The position of the esophagus may be central or paramedian. Its position may change in anesthetized patients depending on the tone of paralaryngeal structures [6-7]. Several studies have noted a sliding towards the left side of the trachea during compression by hand [1-3]. In our study, we noted deviation to the left side of the trachea in all cases. Kim H et al. [7] noted that the esophagus slid towards the left of the trachea in anesthetized patients, and both cricoid pressure and paralaryngeal pressure effectively reduced the outer diameter of the esophagus, but cricoid pressure was more effective than paralaryngeal pressure. In our study, 60% of patients had significant occlusion despite the esophagus being placed on the left side of the trachea in an anesthetized state, like the finding in the study by Kim et al. [7].

The pressure applied by hands may vary between the anesthetists. As the pressure applied cannot be recorded, the effectiveness of occlusion may vary. Real-time recording of occlusion with imaging modalities such as ultrasound, MRI, or CT may provide objective endpoints [8-9]. Bhatia et al. [10] observed that effective compression of the esophagus was achieved more by pressure with an ultrasound probe (100%) than by the hand technique (75%). We obtained esophageal occlusion in 60% of patients with a significant reduction in anteroposterior diameter. In our study, the USG probe was not used for applying cricoid pressure, which might have influenced the success of occlusion.

The cricoid pressure application is known to interfere with visualization during laryngoscopy. Studies have shown that the Cormack-Lehane grading might be altered due to compression of the cricoid [11-14]. It can also cause discomfort in awake patients. (references).

Ramyashree et al. [13] evaluated the mid-cricoid-to-mid-esophagus distance and A-P diameter of the esophagus using ultrasound during application of compression in awake patients. It was observed that though cricoid pressure effectively reduced the diameter of the esophagus, it did not displace the esophagus to a significant amount. However, difficulty in swallowing was noted during cricoid pressure. Our study was conducted on anesthetized patients before laryngoscopy; hence, the difficulty in swallowing or laryngoscopy was not recorded in our study.

There are contradictory studies on the success of the application of cricoid pressure. It is reasoned to merely displace without effective occlusion of the lumen [1-2,5-8,14]. Studies suggest that the cricoid only compresses the posterior hypopharynx and not the esophagus as such [5]. Kei et al. [11] used ultrasound to examine how cricoid pressure affects the anatomical relationship between the cricoid and esophagus in awake patients. Kei et al. [11] found that the esophagus slides laterally with cricoid pressure, and participants were able to swallow during the pressure, thus concluding that cricoid pressure was ineffective in achieving esophageal occlusion. We differ with the findings of Kei et al. [11], which were conducted on awake patients. However, in our study, we noted displacement as well as effective compression, in contrast to the findings of Ramyashree et al., Kei et al. [11], which could be due to a difference in tone of paralaryngeal muscles under anaesthesia.

The ability to identify the cricoid as a landmark may vary and lead to ineffective application of cricoid pressure [2,7-8]. Fearnley et al. [9] found that only 44% of nurse anesthetists and anaesthesia providers could accurately identify and apply cricoid pressure to an accuracy of less than 5 mm difference in marking of cricoid over landmarks [9]. The doubt of effective occlusion remains if performed in inexperienced hands. In our study, cricoid was identified based on the landmark technique as well as with ultrasound, and cricoid pressure was applied by a trained person not involved in the analysis of reports.

There is evidence proposing paralaryngeal pressure application as an alternative to midline cricoid pressure application to achieve esophageal occlusion. Andruszkiewicz et al. [4], observed that the esophagus was found to lie beside the trachea in 90% of patients, and para-lymph node pressure was more effective in reducing the anteroposterior diameter of the lumen as visualized in a transverse section of the esophagus. Hence, it was concluded that Sellick's maneuver was not effective. We differ with observations of Andruszkiewicz et al. [4], as we could visualize the esophagus on the left side /lateral aspect of the trachea in 90%, and the measured outer A-P diameter of the esophagus changed with cricoid pressure application in 60% of healthy volunteers, with displacement to the left side. However, para-lymph node pressure was not studied, and it is not valid to comment on the utility of para-lymph node pressure. In our study, the sagittal view was not examined to assess the compression of the esophagus. Our study discusses the effect of cricoid pressure only when the esophagus was visualized using ultrasound. Patients with the esophagus directly behind the trachea were not included in the study. Hence, it is beyond the scope of this article to comment on the occlusion of the esophagus positioned behind the trachea in the midline. Also, we did not assess the difficulty of intubation with a cricoid pressure application. The observer bias could not be eliminated.

The use of ultrasound for the identification of the cricoid and for real-time visualization and occlusion of the esophagus may pave the way for a higher success rate in Sellick's maneuver. Endoscopy may be included to assess the occlusion of the esophagus in anesthetized patients. Future studies may emphasize the application of the need for paralaryngeal pressure for esophageal compression.

Conclusion

Cricoid pressure is effective at compressing the upper esophagus, even with lateral displacement with cricoid pressure.

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