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ULTRASOUND EVALUATION OF OESOPHAGEAL COMPRESSION BY CLASSICAL CRICOID PRESSURE APPLICATION VERSES ULTRASOUND GUIDED COMPRESSION DURING RAPID SEQUENCE INDUCTION

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ABSTRACT

AIMS AND OBJECTIVE The aim of our study was to investigate the functional impact of cricoid and paralaryngeal pressure respectively, on the outer anteroposterior (AP) diameter of the upper oesophagus at the cricoid cartilage level.

METHOD The study was conducted by dividing subjects into two groups.In both groups , the image of the oesophagus was captured and stored in the system's memory.

Group 1 [n=30]Cricoid pressure was applied by one of the two anaesthetists .One anaesthetist localised the cricoid cartilage between the thumb and middle finger and applied gradual backwards pressure with the index finger until 30 N was achieved

Group 2[n=30] Ultrasound imaging was performed on subjects placed in the supine position with the head extended and images were taken with pressure applied by the ultrasound probe and images taken . .

RESULT : It was seen that localization of oesophagus was mostly on the left side. Successful compression was seen in 75% of cases in manual classical CP whereas it was 100% in ultrasonography method. Classical CP method was also associated with more complications like tissue edema, aspiration due to inadequate compression etc.

CONCLUSION : It was found that CP does not effectively reduce the AP diameter of the oesophagus. Successful compression was seen in 75% of cases in classical CP whereas it was 100% in ultrasonography method. Classical CP method was also associated with more complications .Therefore it was concluded that use of ultrasound for oesophageal compression is a superior method.

KEYWORDS : Cricoid pressure , ultrasonography, oesophagus, anteroposterior

INTRODUCTION

Cricoid pressure (CP) is applied during rapid sequence induction of general anaesthesia to prevent regurgitation of gastric contents , first described by Sellick, which he believed resulted in the occlusion of the oesophagus between the cricoid cartilage and the body of the fifth cervical vertebrae aligned in the axial plane . Numerous cases of regurgitation despite CP being applied have led to increased questioning of the reliability and validity of this technique . Cricoid pressure may also interfere with important aspects of airway management. [1,2]

Few studies have evaluated the mechanism and efficacy of CP with advanced imaging technologies. Computed tomography (CT) and magnetic resonance imaging (MRI) studies show that the oesophagus commonly lies laterally in its relation to the cricoid .It was postulated that the postcricoid hypopharynx, not the oesophagus, was the part of alimentary tract squeezed by CP . They also noticed that anteroposterior diameter of the hypopharynx was reduced by 35% with 2–4 N of CP even when cricoid ring lay lateral to the vertebral body . In a clinical study of anaesthetised patients .[2]

Zeidan et al visually and mechanically confirmed the occlusion of the oesophageal entrance by CP, their study provided additional visual and mechanical evidence supporting a success rate of at least 95% by using a cricoid force of 30 N to occlude the esophageal entrance in anesthetized and paralyzed normal adult patients. The efficacy of the maneuver was independent of the position of the esophageal entrance relative to the glottis, whether midline or lateral In other words, pressure generally applied is itself efficacious, regardless of exact oesophageal position or its susceptibility anatomically to be compressed. Although the effectiveness of cricoid pressure remains a matter of debate , Sellick's manoeuvre is still recommended in the recently published guidelines for the management of difficult and failed tracheal intubation .[3]

Bedside ultrasound can be used to assess the anatomy related to the application of CP. In preliminary observations, we noticed various degrees of collapse of the upper oesophagus when firm pressure was applied by the transducer sited paralaryngeally at the level of cricoid. We hypothesised that this different manoeuvre may have potential to occlude the oesophagus.[4]

Thus, the aim of our study was to investigate the functional impact of manual cricoid pressure respectively, on the outer anteroposterior (AP) diameter of the upper oesophagus at the cricoid cartilage level and to compare it with ultrasound guided pressure.

Methodology:

Study design: Prospective, randomised, double blind study.The study was done in pregnant females who presented in our hospital for emergency caesarean section with suspected full stomach .Cricoid pressure was applied by one of the two experienced consultant anaesthetists. To standardise the 30 N compression force, during the pre-study preparation phase, each provider performed over 50 compressions of a weighing scale. Competence in the application of CP was assured by 20 consecutive successful applications of a 30 N force (within a range of ± 2 N).

Inclusion criteria

1. Age group: 18 - 40 years
2. BMI <35 kg/ m^2
3. American Society of Anesthesiologist (ASA) physical status I and II
4. Patients scheduled for emergency LSCS

Exclusion criteria

1. Patients' refusal or inability to give informed consent.
2. American Society of Anesthesiologist (ASA) ≥3 physical status of either sex
3. Upper respiratory tract infection
4. History of allergy to any drug

In the first stage of the examination, ultrasound imaging was performed on all subjects placed in the supine position with the head extended ('sniffing' position). The sonographer carried out bilateral paralaryngeal ultrasound examination of the neck at the

level of the cricoid cartilage, attempting to image the oesophagus.

In the second stage of the examination, ie in group 1 pressure is applied by the ultrasound probe compressing the anteroposterior diameter of oesophagus and intubation done with real time on screen visualization on the moniter. At that time, the image of the oesophagus was captured and stored in the system's memory. The physician performing airway imaging during paralaryngeal pressure with the ultrasound transducer and data storage had expertise in point-of-care and airway ultrasound and did not himself perform any measurements during the examination

In the next stage, ie in group 2 with the oesophagus visualised on the ultrasound screen, the anaesthetist (not involved in scanning) localised the cricoid cartilage between the thumb and middle finger and applied gradual backwards pressure with the index finger until 30 N was achieved or if the participant asked them to stop . During CP application, the screen of the ultrasound machine was not visible to the anaesthetist administering CP to minimise the risk of bias.To standardise the 30 N compression force, he performed over 50 compressions of a weighing scale during the pre-study preparation phase. Competence in the application of the desired paralaryngeal pressure was assured by 20 consecutive successful applications of a 30 N force.

TABLE 1: PATIENT CHARACTERISTICS.

	Ultrasound (*n*=30)	Cricoid Pressure (*n*=30)
Age (yr)	30 (9) (27–61)	30 (12) (23–62)
Weight (kg)	51 (21) (85–180)	49 (17) (96–160)
Height (m)	1.65 (0.09) (1.52–1.79)	1.64 (0.09) (1.50–1.83)
BMI (kg m^{-2})	34 (5) (36–56)	34 (5) (38–55)
Ideal weight (kg)	47 (8) (45.1–73)	47 (9) (43–78)

TABLE 2: GROUP VARIABLES, CHARACTERISTICS.

	Ultrasound (*n*=30)	Cricoid Pressure (*n*=30)
Lateralization	27	28
Compression	100%	75%

TABLE 3 ANTEROPOSTERIOR DIAMETER

ANTEROPOSTERIOR DIAMETER				
	CRICOID PRESSURE		ULTRASOUND	
S.No.	BEFORE COMPRESSION (in mm.)	AFTER COMPRESSION(in mm.)	BEFORE COMPRESSION(in mm.)	AFTER COMPRESSION(in mm.)
1.	.83	.66	.80	.56
2.	.82	.58	.82	.58
3.	.83	.80	.81	.60
4.	.80	.55	.80	.55
5.	.79	.54	.79	.54
6.	.78	.56	.80	.56
7.	.84	.60	.84	.60
8.	.83	.79	.83	.59
9.	.84	.54	.82	.54
10.	.81	.58	.81	.58
11.	.80	.58	.80	.58
12.	.81	.54	.81	.54
13.	.82	.78	.83	.58
14.	.83	.56	.81	.56
15.	.78	.54	.79	.54
16.	.80	.55	.81	.55
17.	.82	.74	.80	.54
18.	.81	.56	.81	.56
19.	.80	.58	.84	.58
20.	.83	.54	.83	.54
21.	.80	.55	.80	.55
22.	.79	.73	.78	.53
23.	.78	.56	.78	.56
24.	.84	.57	.82	.57
25.	.82	.56	.82	.56
26.	.82	.55	.83	.55
27.	.81	.54	.81	.54
28.	.80	.75	.79	.55
29.	.78	.56	.78	.56
30.	.82	.77	.80	.57

RESULT

Sixty five healthy volunteers were included in the study . The study was done in pregnant females who presented in our hospital for emergency caesarean section with suspected full stomach The mean (SD) age was 24.5 (8.1) years; body mass index (BMI) 26.4 (4.6) $kg.m^{-2}$. Among the 65 volunteers, in five of them , the oesophagus was not visualised during US examination and they were not studied further. In the remaining 60 participants, the oesophagus was visualised.

It was seen that localization of oesophagus was mostly on the left side. Successful compression was seen in 75% of cases in manual classical CP whereas it was 100% in ultrasonography method. Classical CP method was also associated with more complications like tissue edema, aspiration due to inadequate compression etc .The mean (SD) diameter of the outer AP oesophagus was 0.77 (0.11) cm in the neutral position, 0.79 (0.13) cm with CP application and 0.68 (0.12) cm with paralaryngeal pressure application ($p = 0.004$). Post-hoc analysis yielded no statistically significant difference in outer AP diameter in the neutral position versus CP application ($p = 0.504$), but a statistically significant difference in outer AP diameter in the neutral position versus paralaryngeal pressure application ($p < 0.001$).

The time required to complete full ultrasound examination on each participant was < 1 min. We did not observe any incident of bradycardia or nausea during CP or ultrasound application.

STASTISTICAL ANALYSIS

Data was analyzed using SPSS 20 statistical package. A descriptive analysis was done on all variables to obtain a frequency distribution. The mean + SD and ranges were calculated for quantitative variables. Continuous variables were compared by the Student t test. Proportions were analyzed with the chi-square test. A P value of 0.05 or less was considered statistically significant

DISCUSSION

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.[4]

Our main result is that using real-time ultrasound imaging of healthy conscious volunteers, we found that CP was not effective at compressing the upper oesophagus. In the absence of cricoid pressure, the oesophagus lay lateral to the larynx on the left side .Whereas while using the ultrasound probe we can effectively and almost under vision compress the AP diameter of the oesophagus . These results challenge the conventional argument in favour of CP, as described by Sellick, as occluding the oesophageal lumen by backwards pressure of the cricoid ring against the bodies of the cervical vertebrae .

Zeidan AM, Salem MR et al did a study on the cricoid force necessary to occlude the esophageal entrance and postulated that

there is a gender difference . The current study provides evidence that the median force necessary to occlude the esophageal entrance to prevent regurgitation is less in women compared with men. Applying the appropriate cricoid force in women should also decrease airway-related problems that tend to occur with the use of excessive forces. The findings of the current study may only be applicable to patients with normal body habitus .[5]

Hashimoto Y, Asai T et al did a a randomised study on effect of cricoid pressure on placement of the I-gel Andruszkiewicz P, Wojtczak J et al did a similar study about ultrasound evaluation of the impact of cricoid pressure versus novel 'paralaryngeal pressure'on anteroposterior oesophageal diameter .Similar conclusions to ours have been presented in these studies . The authors noticed that the postcricoid hypopharynx, not the oesophagus, lies behind the cricoid ring and is compressed by CP. Because the cricoid ring and postcricoid hypopharynx have a fixed anatomical relationship, connected by ligaments and muscles, both structures act as a functional unit when they are compressed together posteriorly against vertebral body or deep neck muscles. Unfortunately, using ultrasound, we were not able to verify these observations, as it was impossible to visualise the hypopharynx due to the air barrier for sound wave transmission in the upper airway.[6,7]

On the other hand, explicit data supporting the effectiveness of CP in occluding the oesophagus were reported in a recent study on 79 anesthetised and paralysed patients . The authors provided evidence that the insertion of gastric tubes was unsuccessful after CP application, which was confirmed by visualising the occlusion of the oesophageal entrance using videolaryngoscopy. The insertion of a gastric tube was possible in all patients without CP. However, the efficacy of the CP was independent of the position of the oesophageal entrance relative to the glottis, and the high degree of tissue compliance resulting from anaesthesia and muscle relaxation may have had an impact on the excellent efficacy of CP presented in this study.[6]

Similar to our results, the non-central position of the oesophagus and its relationship with the larynx, trachea and vertebral column were confirmed by CT , MRI and videolaryngoscopy studies . It was found that without CP application, the oesophagus lay lateral to the midline of the vertebral body in 53% of awake subjects examined in the neutral position and in 68% of anaesthetised patients examined in the sniffing position . A predominant left shift was observed in all cited studies. The higher incidence of oesophageal deviation observed in our study may be explained by the difference in the imaging plane. Ultrasound imaging of the oesophagus in the midline and the transverse view was impossible because the air filling the larynx and trachea blocked sound wave transmission. To eliminate this obstacle, we modified the position of the transducer using the paralaryngeal transverse view.

A novel finding in this study is that paralaryngeal pressure (even when applied unilaterally) significantly decreased the AP oesophageal diameter. We used the ultrasound probe itself, but in clinical practice, paralaryngeal pressure can be applied with the fingertips. Although we applied the same 30 N pressure as with cricoid pressure, our study does not determine if this is indeed the optimum for paralaryngeal pressure. Furthermore, we cannot conclude that this finding has any clinical utility in the prevention of regurgitation. We also do not know if paralaryngeal pressure, like CP, would result in airway obstruction with implications for tracheal intubation and mask ventilation .[7]

Palmer JH, Ball DR etal did similar study like us .They studied the effect of cricoid pressure on the cricoid cartilage and vocal cords .It was an endoscopic study in anaesthetised patients. They concluded from their observational study that application of cricoid pressure with a yoke produces force-dependant deformation of the cricoid cartilage with complete occlusion and airway obstruction at 44 N in up to 50% of patients, females being at greater risk. In addition, apposition of the vocal cords may occur under the same circumstances compounding the problem. Failure of ventilation was lower at 20 N than at 44 N in the group studied. We believe that this adds further evidence for a reconsideration of the benefits and risks of the use of cricoid pressure, and reinforces the practise of reducing the applied force if failed ventilation follows failed intubation .[8]

Salem MR, Khorasani A et al . reported number of complications associated with the use of CP , most being the consequences of airway obstruction. Minor complications include discomfort, retching, and nausea in the awake patient. Other very rare but serious complications have been described, including esophageal rupture, esophageal injuries due to the presence of sharp objects, fracture of the cricoid cartilage, and potential worsening of cervical spine injuries. Consequently, contraindications for the use of CP have emerged, some based on reported complications and others on merely theoretical grounds. For example, it has been suggested that CP should be avoided in patients with retropharyngeal abscess because of the possibility of rupture of the abscess. However, such a complication has not been reported.[9]

CP is not a "simple maneuver that can be taught to an assistant in a few seconds,"[1] as once thought. Although CP was introduced into anesthesia practice more than half a century ago, it is currently not the standard of care. Questions regarding its use remain unanswered. Many clinicians use a 30-N cricoid force, but should this force be used in all situations and how should it be measured? Is there a difference between the sexes? Should a different force be used in the morbidly obese or in children? What is the desirable force when CP is combined with other maneuvers, such as head-up position or preanesthetic NGT placement? A wider acceptance of CP has been hampered by the lack of reliable randomized studies demonstrating its reliability in preventing aspiration. The performance of such studies requires that many factors be standardized, including the CP technique and the force applied. A simple comparison of two groups of patients, one with and the other without CP, while ignoring these factors, will yield misleading information and results that are difficult to interpret.[9]

There are some limitations to our study. As we did not further study the patients in whom the oesophagus was not visualised due to its midline position, our results may be biased by excluding the very participants in whom CP might have been effective. However, as these formed a minority of the group, we do not think this is a generalisable subset that affects our main conclusion. Due to the imperfect quality of the image resolution, we were not able to precisely evaluate the cross-sectional area of the oesophageal lumen and therefore only measured the AP diameter. We assumed that because of flaccidity of the oesophageal wall, the change in outer AP diameter would reflect the efficacy of compression on its lumen, and achieved a resolution of 1 mm change in diameter.

Although our participants were healthy, conscious volunteers, it is possible that patients under anaesthesia will behave differently. Factors like age, pregnancy or obesity may also yield different results. Although we performed pre-training, we did not measure pressures in real time and so cannot exclude the possibility that there was variability in the application of CP during the study. We used the ultrasound probe to provide paralaryngeal pressure and cannot confirm that the same result would apply if one's fingertips were used. Finally, the study design required paralaryngeal pressure to be administered after CP and we did not randomise the techniques, which could be a source of bias.

Lastly, like other airway management techniques, the use of CP requires preparatory instruction and periodic training. Future investigations are warranted to determine the characteristics of the CP technique that maximize its effectiveness while avoiding the risk of airway-related complications in the various patient populations. In view of our findings, there are possible interpretations: either the Sellick manoeuvre is an effective manoeuvre, but the mechanism of

its action is not related to the occlusion of the oesophagus; or the Sellick manoeuvre does not work at all. As compared to conventional CP , pressure applied by ultrasound provides a better compression and minimizes the complications and side effects.

CONCLUSION

In summary, we found that CP does not reduce the AP diameter of the oesophagus effectively and thus in our view, this cannot explain the efficacy of the Sellick manoeuvre. Paralaryngeal pressure decreases this diameter and has the potential to occlude the oesophagus. Successful compression was seen in 75% of cases in classical CP whereas it was 100% in ultrasonography method. Classical CP method was also associated with more complications .Therefore it was concluded that use of ultrasound for oesophageal compression is a superior method.

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