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Measurement of cricoid pressure force during simulated Sellick's manoeuvre

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Abstract

Background: Cricoid pressure is a standard anaesthetic procedure used to reduce the risk of aspiration of gastric contents during the induction of general anaesthesia. However, for several years its validity has been questioned. There still remains the question of whether we perform it correctly. The aim of the study was an evaluation of the theoretical knowledge of Sellick's manoeuvre, as well an assessment of practical skill related with it when simulated on a model of the upper airway.

Methods: The study was performed on a cohort of anaesthetists and anaesthetic nurses working in various hospitals in the Warsaw area. Measurements were taken on an upper airway model placed on an electronic kitchen scale. Participants were asked to perform Sellick's manoeuvre in the way they do it in their clinical practice. The test was done twice. Both the position and pressures applied on the model were documented. Knowledge concerning current recommendations of cricoid force was noted.

Results: 206 subjects participated in the study. Only 49% (n = 101) properly identified cricoid cartilage during their application of Sellick's manoeuvre. Application of the correct pressure on the model of the airway was noted in 16.5% (n = 34) during the first attempt and in 20.4% (n = 42) during the second attempt. The median force applied during simulated Sellick's manoeuvre was 36 N (IQR: 26–55) in the first attempt, and 38 (IQR 25–55) in the second attempt.

Conclusions: Sellick's manoeuvre was performed incorrectly in many cases. Half of the participants of our study applied the pressure in the wrong place while the majority of them used an inappropriate amount of force. Thus, the application of cricoid pressure in patients should be preceded with simulation training.

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Key words: anaesthesia, endotracheal intubation, Sellick's manoeuvre, cricoid pressure, aspiration

Regurgitation of gastric contents during the induction of general anaesthesia is an extremely dangerous complication which has an impact on morbidity and mortality related with anaesthesia. Fifty years ago, Brian Sellick in his cadaver study showed that application of firm cricoid pressure (CP) occluded the oesophagus, thus preventing aspiration of stomach contents [1, 2].

The manoeuvre postulated by Sellick was enthusiastically accepted by anaesthetists and became a mainstay of a rapid sequence induction and intubation procedure (RSII). However, since its introduction both the efficacy and safety of cricoid pressure application have been questioned. Indeed, in numerous articles incidents of aspiration, despite CP application, have been reported [3, 4].

Nevertheless, CP remains the standard of care recommended by acknowledged medical bodies [5, 6]. According to a recent study, it is used by more than 92% of British anaesthetists [7]. Failing to apply CP in patients with a high risk of regurgitation was considered to be responsible for severe complications in the NAP 4 study and was deemed malpractice by a British judge [5, 8]. Since the efficacy of Sellick's manoeuvre is debatable, the question remains whether its performance is fully justified.

The aim of study was the evaluation of the theoretical knowledge and practical skills concerning Sellick's manoeuvre in a cohort of anaesthetists and anaesthetic nurses. The area of a particular interest was an assessment of the force used during a simulated Sellick's manoeuvre.

METHODS

The prospective observational study was conducted after approval by Warsaw Medical University Ethics Committee.

The study was performed on anaesthetists and anaesthetic nurses working in Warsaw-area hospitals who volunteered for the study. General information, without details of its purpose was given to all subjects prior to the study. An airway demonstration model (Laerdal; Norway) (Fig. 1) with clearly visible relevant upper airway anatomical structures (cricoid, thyroid cartilages and oesophagus) was used for all measurements and demonstrations. The model was placed on an electronic kitchen scale (Salter 1037, China) equipped with a screen enabling instant measurement of the weight–force of compression in the 0–5.5 kg range. A weight of over 5.5 kg was presented as an "Err" — error on an the information screen of the scale and was registered as > 5.5 kg (> 55 N) in the study questionnaire. The participants were asked to perform Sellick's manoeuvre in the way they do in their daily practice, when the patient is already unconscious. Each participant performed two attempts. The readings of the applied force were not visible to them. The independent researcher noted both the place and weight-force of the applied pressure. For the purpose of the statistical analysis of the study, we assumed values between 25 and 35 N as a correct range of pressure. Each participant was also asked to specify the pressure force (N) which is actually recommended during RSII in unconscious patients.

STATISTICAL ANALYSIS

Statistica v 12.0 and StatDirect 3.1.4 used for all analyses. Parametric data are presented as a mean and standard deviation, nonparametric data are presented as median and interquartile ranges and nominal data are presented as frequencies and percentages. The parametric nature of the data was confirmed by the Shapiro-Wilk test. For the two-group comparison, Student's t-test and the Mann-Whitney U test were conducted for data with parametric and nonparametric characteristics, respectively. $P < 0.05$ was adopted as significant.

RESULTS

A total of 206 anaesthetists and anaesthetic nurses employed in seven Warsaw-area hospitals participated in the study. A general outline of the participants is shown in Table 1.

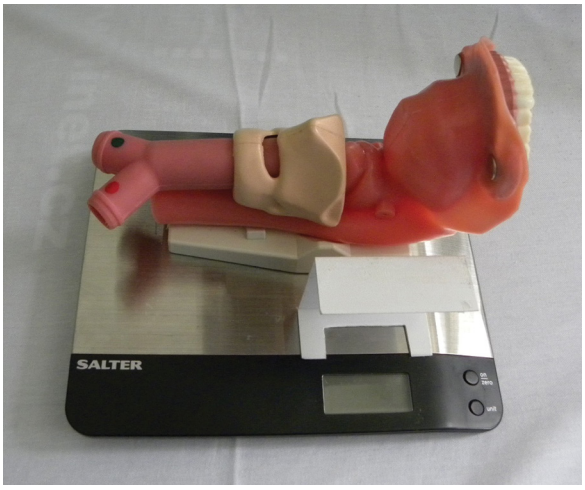

Figure 1. Upper airway model used in the study

Table 1. Data from the questionnaire

Profession n (%)	
Anaesthetist	126 (61.2)
Anaesthetic nurse	80 (38.8)
Place of work	
Teaching hospital	161 (78)
General district hospital (Warsaw)	31 (15)
General district hospital (Mazovia district)	14 (7)
Work experience in anaesthesiology	
< 1 year	14 (7)
> 1 and < 5 years	31 (15)
> 5 years	131 (78)
Previous experience in cricoid pressure force application	
Yes	18 (8,7)
Knowledge of recommended force	
Yes	37 (18)
Correct localisation of cricoid force	
Yes	101 (49)

Only 49% of the participants (n = 101) correctly identified the cricoid cartilage as the place of application of pressure during Sellick's manoeuvre (anaesthetists more often; $P < 0.0001$); 85% (n = 89) of the remaining group applied pressure on the thyroid cartilage. We observed that during the simulated Sellick's manoeuvre, a correct pressure force of between 25 and 35 N was applied only by 16.5% (n = 34) of the participants in the first attempt and 20.4% (n = 42) in the second attempt (Fig. 2). No statistically significant difference was found in cricoid force between the two attempts ($P = 0.062$) (Fig. 3).

The median value and interquartile range were 38 N (IQR: 26–55) for the first attempt and 36 N (IQR: 25–55) for the second attempt, respectively (Fig. 4). Moreover, 26% (n = 55)

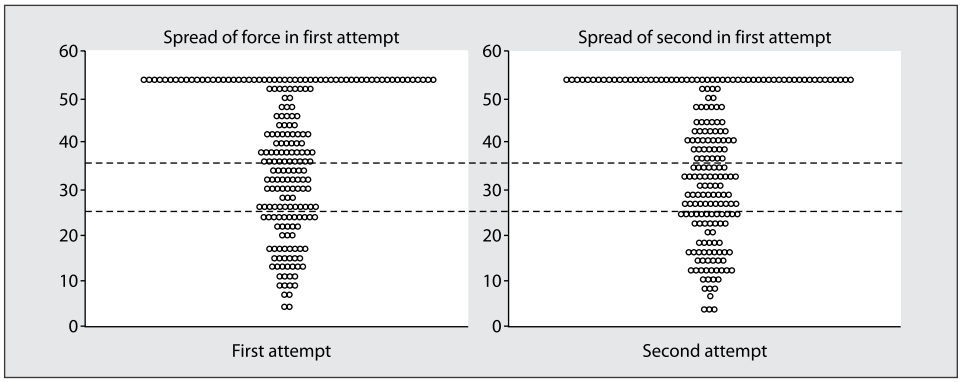

Figure 2. Spread of the force (N) during the first and second attempt of the force application on the neck (The figure presents application of 100 randomly selected attempts. Each dot represents one attempt)

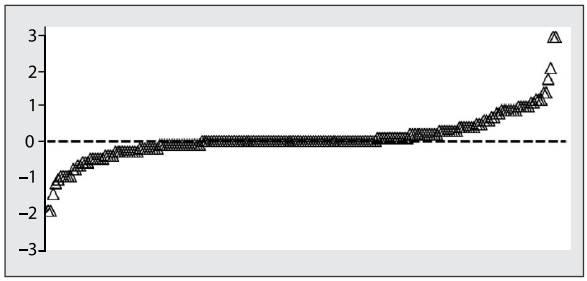

Figure 3. Variability of force (kg) between first and second attempts of cricoid pressure.
Each triangle (Δ) represents a difference in force (in kg) between the first and second attempt of cricoid pressure for each subject (for example, a triangle at level –2 represents a difference of –2 kg (20 N) between two attempts which means that the force of the second attempt was 2 kg stronger than in the first

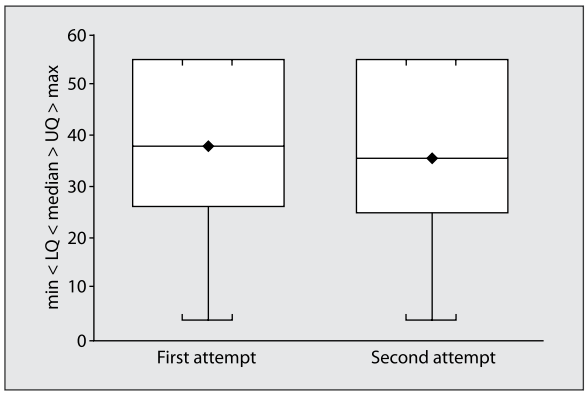

Figure 4. Box plot of the force (N) during the first and second attempts of cricoid pressure on the model of the upper airway. (median, interquartile range, maximum and minimum)

of the subjects applied a force exceeding 55 N. Neither the profession nor work experience had an impact on the force used during the neck compression. Only 8.7% (n = 18) of the participants admitted to having had proper training in Sellick's manoeuvre which included cricoid force measurement during their professional career (anaesthetists more often; $P < 0.0001$). In addition, 18% (n = 37) of the subjects knew the correct force of pressure which should be applied during Sellick's manoeuvre (more often anaesthetists; $P < 0.0001$).

DISCUSSION

In recent years, Sellick's manoeuvre has come under considerable scrutiny due to growing evidence of numerous cases of its inefficacy [4, 5]. One of the possible explanations of this failure rate may be an "original sin", which is rather inaccurate description of the procedure by its inventor. In his original paper published in 1961, Sellick rather enigmatically proposed applying "firm pressure" on the cricoid cartilage without giving any particular value of this force [1]. The force necessary to occlude oesophagus without inducing simultaneous airway obstruction was postulated in the following years [9–11]. Since 2004, both the Difficult Airway Society (DAS) and the Section of Difficult Airway Management (SPUDO) of the Polish Society of Anaesthesiology and Intensive Care have recommended force of 10 N of cricoid pressure when the patient is awake, increasing to 30 N once anaesthesia is established [5, 6].

One newton (N) is a unit of force defined as the force needed to accelerate 1 kg of mass at the rate of 1 m sec^{-2} [12]. We do not use newtons in our everyday life. To facilitate our perception of the amount of force related with particular number of newtons, we can convert newtons to kilograms (kg). Thus, compression with the force of 10 N is an equivalent of 1 kg. Although, our life experience helps us to imagine the amount of force we must use to lift 10 kg bag of sugar, it is far more challenging to imagine the amount of force during neck compression with 10 N.

The problems described above may explain the poor results presented in our study, with only 20% of the subjects performing neck compression with the proper force within the normal range (25–35 N). However, a review of international articles concerning this issue showed similar results.

A study of American anaesthetic nurses showed that only 17.8% of them used the recommended force during cricoid pressure [13]. In a study on anaesthetists, physicians representing various specialities and medical students, Cavalache *et al.* [14] reported that the majority of participants used cricoid pressure with inadequate force.

Inappropriate cricoid force during Sellick's manoeuvre may have severe practical consequences. Too weak compression may lead to gastric contents regurgitation and pulmonary aspiration, whereas to strong compression may result in upper airway obstruction and mechanical damage of the larynx and oesophagus [9, 10]. This information is extremely alarming in the context of our results which showed that 26% of participants used over 55 N during simulated neck compression. Ashurst *et al.* [15] reported that 63% of the subjects compressed the airway model with inappropriate force. Unfortunately, one out of four of the subjects we were not able to evaluate the maximum force of compression precisely.

The maximum limit of the kitchen scale we used was 5.5 kg (55 N). Hence, it is possible that in some cases the force could have been much higher. Hartsilver showed that a cricoid force of 30 N did not induce ventilatory problems, whereas compression of 40 N resulted in impairment of airway patency in 35% of cases [11].

In spite of evident discrepancies in the force of neck compression among the participants, we did not observe significant differences in force of pressure generated by each individual in two consecutive attempts. Thus, it seems that compression performed by each individual is not random, but reproducible. On the other hand, however, it is possible that our conclusion is incorrect, as each attempt which exceeded the maximum limit of the scale was reported as a 5.5 kg (55 N) reading. Hence, in a hypothetical situation, one subject could have applied considerably different forces of 60 N and 80 N in two consecutive attempts, which were then reported as an equal result of 55 N (Fig. 2). This hypothesis seems to be supported by the results showing significant discrepancies in cricoid force measured between consecutive attempts [14, 15]. Similar to our results, no correlation between one's work experience, profession and skill in applying the correct cricoid pressure was found [14].

The poor proportion of participants who performed Sellick's manoeuvre correctly can be explained by the fact that only 18% of the subjects knew the current recommendations for cricoid pressure application. Similar results were presented in a study on Australian emergency physicians and nurses, as well as British anaesthetists [16, 17]. Even worse results were reported by Guirro [18] on Brazilian anaesthetists, only 3.8% of whom knew the current recommendations regarding cricoid force in a rapid sequence induction intubation scenario [18]. Likewise, the majority of emergency physicians and nurses from one university hospital in the USA were not familiar with such recommendations [19]. In the context of these data, it is noteworthy to mention that the current recommendations were introduced several years ago [5, 6].

We noticed that almost half of the participants did not localize the correct place for pressure application on the neck model correctly. Although all the cartilages were clearly visible in the model we used in the study, in the majority of wrongly performed cases the force was placed on the thyroid cartilage. Shimabukuro *et al.* [20] stated that CP application was confused by some study subjects with the Backwards Upwards Rightwards Pressure (BURP), a manoeuvre used for difficult intubation to facilitate laryngoscopy.

It is believed that inadequate knowledge and a lack of technology-based training may be explanatory causes of the incorrect performance of Sellick's manoeuvre [17, 19]. In his pioneering article, Sellick stated that "cricoid pressure is a simple skill which can be acquired within a few minutes" [1]. We know from our own anaesthetic training that the great majority of trainees have learnt Sellick's manoeuvre on living patients without any objective verification of the force applied. Indeed, only 8.7% of study participants stated that they had completed simulation-based training, including feedback, in order to enhance correct CP application. Similar results were found in a survey of emergency department personnel in a major academic teaching institution in Michigan [19]. The key role of simulation in learning both the technique and correct force of cricoid pressure application has been emphasized in many articles. With proper training, the cricoid force can be reproducible within 2 N, but retention of this skill remains 2 weeks to 3 months only [2, 15, 17]. Thus, periodic training for anaesthetic personnel is essential.

CONCLUSIONS

In many cases, Sellick's manoeuvre may be performed incorrectly as half of our study participants applied pressure in the incorrect place and the great majority of them used incorrect force. Thus, cricoid pressure application on real patients should be proceeded by simulation-based training.

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