Anaesthesia 2020, 75, 313–322 doi:10.1111/anae.14867

Original Article

An international survey about rapid sequence intubation of 10,003 anaesthetists and 16 airway experts*

M. Zdravkovic,[1,2] **J. Berger-Estilita,**[3] **M. Sorbello,**[4] and **C. A. Hagberg**[5]

1 Resident, Department of Anaesthesiology, Intensive Care and Pain Management, University Medical Centre Maribor, Maribor, Slovenia
2 PhD Student, Faculty of Medicine, University of Maribor, Maribor, Slovenia
3 Consultant, Department of Anaesthesiology and Pain Medicine, Inselspital, Bern University Hospital, Bern, Switzerland
4 Consultant, Department of Anesthesia and Intensive Care, AOU Policlinico Vittorio Emanuele, Catania, Italy
5 Professor, Department of Anesthesiology, Critical Care and Pain Medicine, University of Texas MD Anderson Cancer Center, Houston, TX, USA

Summary

Pulmonary aspiration of gastric content is a significant cause of anaesthesia-related morbidity and mortality. High-quality prospective randomised evidence to support prevention strategies, such as rapid sequence intubation, is difficult to generate due to well-described practical, ethical and methodological barriers. We aimed to generate an understanding of worldwide practice through surveying clinically practicing anaesthetists and airway experts. Our survey was designed to assess the influence of: departmental standards; patient factors; socio-economic factors; training; and supervision. We surveyed 10,003 anaesthetists who responded to an invitation to participate on LinkedIn. We then surveyed 16 international airway experts on the same content. When asked about a hypothetical patient with intestinal obstruction, respondents expressed preferences for [OR (95%CI)]: the head-up or -down position 4.26 (3.98–4.55), $p < 0.001$; nasogastric tube insertion 29.5 (26.9–32.3), $p < 0.001$; and the use of cricoid force 2.80 (2.62–3.00), $p < 0.001$, as compared with a hypothetical patient without intestinal obstruction also requiring rapid sequence intubation. Respondents from lower income countries were more likely to prefer [OR (95%CI]: the supine position 2.33 (2.00–2.63), $p < 0.001$; nasogastric tube insertion 1.29 (1.09–1.51), $p = 0.002$; and cricoid force application 2.54 (2.09–3.09), $p < 0.001$ as compared with respondents from higher income countries for a hypothetical patient with intestinal obstruction. This survey, which we believe is the largest of its kind, demonstrates that preferences for positioning, nasogastric tube use and cricoid force application during rapid sequence intubation vary substantially. Achieving agreed consensus may yield better training in the principles of rapid sequence intubation.

Correspondence to: M. Zdravkovic
Email: markozdravkovic@gmail.com
Accepted: 5 September 2019
Keywords: airway management; gastric ultrasound; pulmonary aspiration; rapid sequence intubation; supervision
*Presented in part at the European Airway Congress in Catania, Italy, December 2018.
This article is accompanied by an editorial by Charlesworth and El-Boghdadly, *Anaesthesia*, 2020; **75**: 298–300.
Twitter: @MZanaesthetist; @joanaberger3; @SorbelloMax; @CarinHagberg

[Correction added on 9 November 2019, after first online publication: Appendix 1 has been removed, Acknowledgements section and all citations within text have been updated in this current version.]

Introduction

Pulmonary aspiration of gastric content has long been recognised as a leading cause of death due to anaesthesia [1]. In the 1960s, anaesthetists developed improved techniques for airway management, including cricoid force and rapid sequence intubation (RSI) for selected patients [2, 3]. However, the 2011 4th UK National Audit Project (NAP4) revealed that aspiration of gastric content, rather than inability to oxygenate, remained the single most common cause of death related to airway management [4].

Best practices for the prevention of pulmonary aspiration have not yet been elicited by high-quality clinical trials [5, 6]. Additionally, the choice of induction agents for RSI likely depend on their availability; the experience and familiarity of the operator; and many other clinical factors [7]. A standardised approach in the more technical aspects of the RSI technique, including patient positioning, nasogastric tube insertion and cricoid force application, might be achievable [5, 6]. Three positions might include head-up (reverse-Trendelenburg); supine; and head-down (Trendelenburg). The head-up position provides better pre-oxygenation and possibly less reflux of gastric content, but the head-down position might be used in the event of vomiting [5, 8, 9]. The use of cricoid force is likewise controversial [10], as is the insertion and aspiration of a nasogastric tube before induction of anaesthesia [11].

The incidence of pulmonary aspiration is thought to be between 0.01% and 0.04% [4, 12]. This rises to 0.5% and 2.8% for RSIs conducted in and outside of the operating theatre, respectively [10, 13]. These incidences are greater than the incidence of a failure to oxygenate scenario, which is estimated to be 0.002% of all general anaesthetics [4, 14]. Few national guidelines on RSI practices exist and practice across and within departments likely varies [6, 15–17]. The extent of these clinical practice variations across the world has not been previously demonstrated [18–20]. Our survey aims to explore these variations and the influence of: departmental standards; patient factors; socio-economic factors; training; and supervision. We also wished to elicit areas for further research.

Methods

This international, Internet-based, cross-sectional, two-phased survey was approved by the Maribor University Medical Centre ethics committee, Slovenia. Respondents provided consent for participation at the end of the survey. We developed questions focusing on patient positioning, nasogastric tube insertion and the use of cricoid force during RSI. We explored four potential sources of practice variation, which included: departmental standards and guidelines; patient factors; socio-economic factors, as determined by national income groups defined by the World Bank [21]; and level of training.

We also asked about: supervision; personal experiences of pulmonary aspiration during anaesthesia; the use of and experience with pre-operative gastric ultrasound to assess pulmonary aspiration risk; and the number of team members present during RSI when cricoid force is applied.

A 19-item questionnaire was constructed (Appendix. S1). Three items were compulsory, including: participant consent; the existence of departmental guidelines, leading to a question on clinical decision-making for a hypothetical patient with intestinal obstruction; and the level of training of the respondent, which leads to questions about supervision. Respondents were then asked to include their city and country of practice, which was a non-compulsory field. Following the survey of clinically practicing anaesthetists (Phase 1), we sought the independent opinions of recognised international airway management experts (Phase 2). The experts received a content blueprinted version of the same questionnaire with slight modifications (Appendix. S2).

The draft Phase-1 questionnaire was piloted among eight external clinicians from all groups of interest, including: two trainees in the first half of training; two trainees in the second half of training; two consultants with less than 10 years' experience; and two consultants with more than 10 years' experience. All were requested to comment on the language used, which had to be simple enough to be understood globally. Google Forms (Google Inc, Mountain View, CA, USA) was chosen to host both questionnaires, as it is free to use and has branching possibilities, unlimited response collection and only records each response after the submit button is activated at the end of the survey. The clinician survey was available for completion for 56 weeks, from June 2018 to June 2019.

The survey link was primarily distributed through LinkedIn. A search was performed for individuals working as anaesthetists, and they were invited to connect with the lead author. We used other social media platforms such as Facebook and Twitter to a much lesser extent. We gained the support of several national and international societies by publishing the survey link on websites, newsletters and emails.

A 'snowballing' sampling technique was used [22]. As the primary mode of distribution was through social media, selection bias was reduced by the aim to collect between 7800 and 13,400 responses from at least 100 countries. This number was estimated from the World Federation of Societies of Anaesthesiologists as representing 10% of each national society's members, or as five responses per million population (Table S1). Only anaesthetists able to understand English, with Internet access to the Google Forms platform were able to participate.

The expert questionnaire was sent to 30 airway experts from 23 countries between December 2018 and February 2019. Experts were contacted through email (either taken from their latest publications, online profiles or as suggested when asked which email address they could be contacted with). Two reminders were sent to non-responders.

Statistical analysis was performed using SPSS Statistics 20 (IBM Inc., Chicago, IL, USA). Pearson's Chi-square statistics were used for contingency table analysis. Effect size estimations were performed on '2 × 2' contingency tables (excluding 'uncertain' replies) and reported as OR with 95%CI and significance set at $p < 0.05$. Fisher's exact tests were used for the Phase-2 analysis. Content analysis and inductive coding of open-ended questions were analysed for nomothetic properties in clusters of 1000 responses. Emergent themes were cross-checked by both authors, to ensure consistency. Differences were resolved by discussion.

Results

Out of the 10,003 respondents from 141 countries (Fig. 1a), 382 (3.8%) withheld permission for analysis and 839 (8.4%) did not declare their country of practice. We achieved the set minimum target participants for 95 (67%) countries (Table S2). Although it was not possible to precisely determine the response rate, we estimate this to be between 40% and 60%, as more than 50% of respondents were recruited through LinkedIn (Fig. 1b). This was evident from LinkedIn notifications when respondents completed the survey.

There were 7235 (75.2%) respondents who reported the existence of departmental RSI guidelines. The existence of guidelines was weakly associated with: an individual preference for either head-up or -down positioning; nasogastric tube insertion; and the use of cricoid force (Table 1). There was an overall preference for, with OR (95% CI): using either a head-up or -down position, 1.16 (1.03–1.30), $p = 0.013$; nasogastric tube insertion 1.18 (1.04–1.33), $p = 0.012$; and cricoid force application 1.55 (1.38–1.74), $p < 0.001$ for a hypothetical patient with intestinal obstruction in those from departments with RSI guidelines or standards as compared with those without guidelines or standards.

Respondents were asked about their preferences for rapid sequence intubation in patients with and without intestinal obstruction (Table 2). For a hypothetical patient with intestinal obstruction, there was a preference for, with OR (95%CI): the head-up or -down position 4.26 (3.98–4.55), $p < 0.001$; nasogastric tube insertion 29.5 (26.9–32.3), $p < 0.001$; and cricoid force application 2.80 (2.62–3.00), $p < 0.001$ as compared with a patient without intestinal obstruction requiring rapid sequence intubation. Furthermore, for a hypothetical patient with intestinal obstruction, anaesthetists from lower income countries preferred the supine position, nasogastric tube insertion and cricoid force application as compared with respondents from higher income countries: OR (95%CI): 2.33 (2.00–2.63), $p < 0.001$; 1.29 (1.09–1.51), $p = 0.002$; and 2.54 (2.09–3.09), $p < 0.001$, respectively. For a hypothetical patient without intestinal obstruction but requiring RSI, there was less preference for the head-up position, nasogastric tube use and cricoid force application in all income categories (Fig. 2).

Preferences for RSI practices varied little as a function of level of training. Cricoid force application was slightly more preferred by consultants with more than 10 years' experience, and by trainees in the first half of training

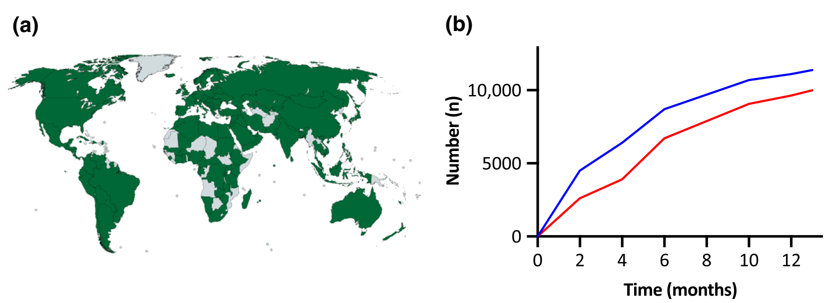

Figure 1 (a) World map (created at: www.mapchart.net) of the countries and territories from which responses were collected (green). (b) Rates of survey responses (red) and LinkedIn connections (blue).

Table 1 Respondent preferences for patient positioning, nasogastric tube insertion and cricoid force use for hypothetical patients with and without intestinal obstruction requiring rapid sequence intubation. Responses for those working in departments with and without guidelines are compared. Values are number (proportion).

	Patient positioning				Nasogastric tube insertion				Cricoid force use			
Rapid sequence intubation indication	Head-up position	Head-down position	Supine	p value	Uncertain	Yes	No	p value	Uncertain	Yes	No	p value
Intestinal obstruction												
Guidelines	4498 (70.0%)	668 (10.4%)	1259 (19.6%)	0.011	1546 (21.4%)	4405 (61.0%)	1271 (17.6%)	< 0.001	622 (8.6%)	5355 (74.1%)	1250 (17.3%)	< 0.001
No guidelines	1641 (68.9%)	214 (9.0%)	526 (22.1%)		671 (28.2%)	1275 (53.6%)	433 (18.2%)		385 (16.2%)	1461 (61.5%)	530 (22.3%)	
Any other												
Guidelines	2695 (43.8%)	265 (4.3%)	3194 (51.9%)	0.260	1501 (20.8%)	650 (9.0%)	5067 (70.2%)	0.023	853 (11.8%)	3815 (52.8%)	2558 (35.4%)	< 0.001
No guidelines	1042 (43.8%)	83 (3.5%)	1254 (52.7%)		481 (20.2%)	124 (5.2%)	1776 (74.6%)		497 (20.9%)	954 (40.1%)	928 (39.0%)	

(Fig. 3). Out of 9527 respondents answering questions about supervision, 5998 (77%) consultants and 877 (51%) trainees reported that trainees were always closely supervised during RSI ($p < 0.001$). However, 1211 (71.2%) trainees felt they should always be closely supervised during RSI. Both groups expressed significantly different opinions on training in RSI and pulmonary aspiration risk assessment, (Table 3). Trainees and consultants perceived the RSI skills of trainees as better than their ability for pulmonary aspiration risk assessment.

The open-ended questions about experiences of pulmonary aspiration were answered by 6663 (69.3%) respondents. Of these, 2624 (39.4%) had experience of pulmonary aspiration for a patient under their care during anaesthesia. From these responses, we generated 4719 codes that were organised into nine major themes (Table 4). Each respondent answer could have up to four different codes. Ninety-eight answers were coded as 'other' because they did not fit into the previous major themes, and 351 were not included because they were not meaningful enough.

Although only 978 (10.2%) respondents were trained in the use of gastric ultrasound for pulmonary aspiration risk assessment, 1320 (13.8%) indicated that someone in their department knew how to use gastric ultrasound for this purpose. Of 5678 consultants who would use cricoid force for a hypothetical patient with intestinal obstruction, 3616 (63.7%) reported there are usually two team members present; 1741 (30.7%) reported three team members; and 321 (5.7%) more than three.

Table 2 Respondent preferences for positioning, nasogastric tube insertion and cricoid force use for a hypothetical patient with and without intestinal obstruction requiring rapid sequence intubation. Values are number (proportion).

	Rapid sequence intubation indication		
	Intestinal obstruction	Any other	p value
Patient positioning			
Head-up	6128 (70%)	3736 (44%)	<0.001
Supine	1791 (20%)	4446 (52%)	
Head-down	886 (10%)	352 (4%)	
Nasogastric tube use			
Yes	5678 (59%)	771 (8%)	<0.001
No	1709 (18%)	6845 (71%)	
Uncertain	2214 (23%)	1983 (21%)	
Cricoid force use			
Yes	6816 (71%)	4766 (50%)	<0.001
No	1782 (19%)	3491 (36%)	
Uncertain	1004 (10%)	1347 (14%)	

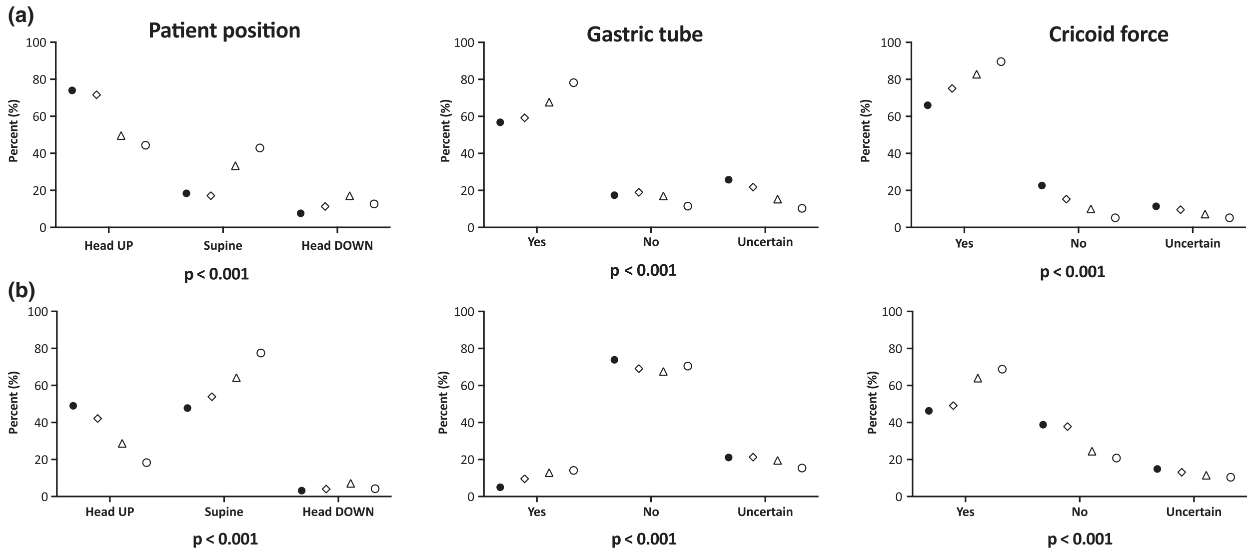

Figure 2 Preferences for rapid sequence intubation from respondents from high-income countries (filled circles), upper middle-income (diamond), lower middle-income (triangle) and low-income (empty circles). The upper three panels (a) are for a hypothetical patient with intestinal obstruction. The lower three panels (b) are for any other rapid sequence intubation indication.

In the Phase-2 questionnaire (Appendix. S2), 16 (53%) airway management experts independently provided their RSI preferences and opinions (Table 5). Fourteen (87.5%) agreed that all anaesthetic departments should have RSI guidelines. Additionally, seven (43.8%) agreed that all anaesthetists who might perform RSI should be trained in the use of gastric ultrasound for pulmonary aspiration risk assessment. However, the need for further validation and consensus on the clinical application of gastric ultrasound was emphasised.

One half of airway management experts stated there should be two team members for an RSI when cricoid force

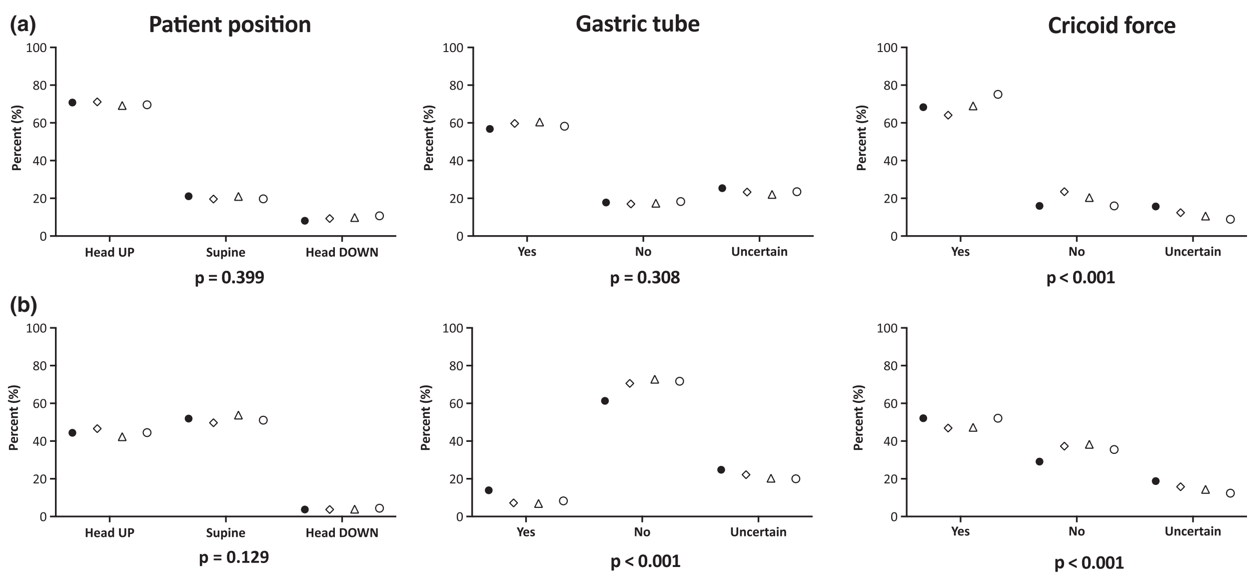

Figure 3 Preferences for rapid sequence intubation from respondents including trainees in the first half of the training (filled circle), trainees in the second half of the training (diamond), specialists for less than 10 years (triangle), and specialists for more than 10 years (empty circle). The upper three panels (a) are for a hypothetical patient with intestinal obstruction. The lower three panels (b) are for any other rapid sequence intubation indication.

Table 3 Respondent perception as trainee vs. consultant for adequacy of supervision and pulmonary aspiration prevention skills among trainees. Values are number (proportion).

	Level of training		
Perception	**Trainee**	**Consultant**	**p value**
Trainees always closely supervised			
Yes	877 (51%)	5998 (77%)	< 0.001
No	827 (49%)	1825 (23%)	
Trainees adequately trained in rapid sequence intubation			
Yes	855 (50%)	4328 (56%)	< 0.001
No	351 (21%)	1055 (14%)	
Uncertain	498 (29%)	2300 (30%)	
Trainees adequately trained in pulmonary aspiration risk assessment			
Yes	616 (36%)	3550 (46%)	< 0.001
No	550 (32%)	1526 (20%)	
Uncertain	535 (32%)	2581 (34%)	

is used and the other half responded, three. Fifteen (93.8%) believed that trainees should always be closely supervised during an RSI, which was the domain of highest agreement among the experts surveyed. When encountering pulmonary aspiration of gastric content in practice, they emphasised the importance of self-reflection and debriefing to reinforce ‘good practice’ and to avoid potential underperformance in the future.

Discussion

For respondents working in settings with RSI standards or guidelines, there was a small association with a preference for the use of cricoid force. The training level of respondents was not associated with preferences for patient positioning, nasogastric tube use and cricoid force application. Major differences were found among the four national income groups. With decreasing national income of the respondent’s location, the preference for using a head-up position decreased, with the supine position preferred among respondents from low-income countries. Likewise, preferences for nasogastric tube insertion and cricoid force application were more common among respondents from low-income countries. For a hypothetical patient with intestinal obstruction, respondents preferred the use of a head-up or -down position as compared with supine. Cricoid force application was also preferred as compared with a hypothetical patient without intestinal obstruction. This global survey reveals aspects of RSI practices that can now be the topic of further focussed research (Table 6).

In patients with intestinal obstruction, gastric decompression is one possible strategy for the prevention of pulmonary aspiration [11]. With the insertion of a nasogastric tube, the driving pressure for regurgitation and the volume of the gastric content are decreased before anaesthesia, hence lowering the likelihood and severity of pulmonary aspiration [23]. Our data suggest an association between increasing nasogastric tube popularity in this

Table 4 Nine major themes obtained from qualitative analysis of open-ended questions on experience of pulmonary aspiration incidents.

1. Non-technical skills Anticipation; planning; situational awareness; team members; and team dynamics
2. Procedures Algorithms and protocols; cricoid force; achieving unconsciousness; adequate paralysis and intubating conditions; use of regional anaesthesia where appropriate
3. Risk Full stomach; anxiety; pregnancy; trauma; haemodynamic instability; sepsis; shock; pain
4. Aspiration management Repositioning; head-down; suction; bronchoscopy; lavage; steroids; antibiotics; bronchodilators
5. Gastric content Nasogastric tube insertion and aspiration; imaging; gastric ultrasound; ileus; premedication
6. Equipment Gastric ultrasound; suction catheters; laryngoscopy; second generation supraglottic airway device; transparent facemasks
7. Danger Underestimation of risk; consequences of aspiration
8. Education Regular training; reflection; debriefing; experience
9. Distress Clinical consequences; second victim

Table 5 Responses from 16 recognised international airway experts on practice preferences for a hypothetical patient with and without intestinal obstruction requiring rapid sequence intubation. Values are number (proportion).

	Indication for rapid sequence intubation		
Intervention	**Intestinal obstruction**	**Any other**	**p value**
Patient positioning			
Head-up	10 (63%)	13 (82%)	0.685
Supine	1 (6%)	1 (6%)	
Head-down	5 (31%)	2 (12%)	
Nasogastric tube use			
Yes	11 (69%)	1 (6%)	0.001
No	3 (19%)	12 (75%)	
Uncertain	2 (12%)	3 (19%)	
Cricoid force use			
Yes	9 (56%)	7 (44%)	0.626
No	4 (25%)	7 (44%)	
Uncertain	3 (19%)	2 (12%)	

Fisher's exact test reported comparing frequency distributions within 2 × 3 contingency tables.

Table 6 Key topics identified for further research and consensus.

Aspect of practice	Suggested topics for further research or consensus
Gastric decompression	The use of nasogastric tubes in patients with and without intestinal obstruction before anaesthesia The use of gastric ultrasound to monitor strategies for gastric decompression Consensus on gastric tube handling
Patient positioning	The difference between and outcomes associated with positioning preferences for low- and higher income countries
Cricoid force	Global registries on aspiration incidents Consensus on when and how cricoid force should be applied
Education	Consensus on and study of consultant supervision of trainees conducting rapid sequence intubations Improve awareness of the value of deliberate practice and its key elements
Team dynamics	The optimal number of team members, and their skill mix, for rapid sequence intubation
Management of pulmonary aspiration	Universal recommendations on how best to manage pulmonary aspiration during anaesthesia
Rapid sequence intubation	Consensus on the range of acceptable practices

context with decreasing national income. Reasons why this very affordable intervention, which is often considered a standard of care, might be omitted in clinical practice in higher income countries warrants further investigation [23, 24].

Regardless of whether the gastric tube is removed immediately before anaesthesia or not, it is reasonable to perform gastric decompression in patients with intestinal obstruction [11, 23]. Over 350 respondents reported that their major learning point from experiencing aspiration was to address gastric decompression before anaesthesia. This includes placing a nasogastric tube if not already present, applying suction through it, administering a small amount of saline to unblock a potentially obstructed tube, and changing the patient position on the operating table to facilitate gastric emptying.

In specific patient populations, the advantages of the head-up position appear to outweigh the risks of other positions [25]. For non-obese patients, opinions differ. The supine position was not popular amongst the airway experts. They preferred the head-up position, followed by the head-down position. Similarly, for respondents from high-income countries, head-up positioning was more popular for a hypothetical patient with intestinal obstruction. But for a hypothetical patient requiring RSI without intestinal obstruction, supine and head-up positioning were the most popular. Unfortunately, there is no high-quality evidence to support any of these choices.

Our survey demonstrates that cricoid force was popular among respondents, with 70% and 50% preferring to apply it to patients with and without intestinal obstruction, respectively. Nonetheless, this popularity varied between the countries of respondents. For example, it was less popular in Austria, Denmark, the Netherlands, Sweden and Switzerland as compared with the UK, which agrees with previous reports [18]. Its popularity probably reflects the potential legal repercussions of avoiding cricoid force use in patients with intestinal obstruction, who are a high-risk patient group, whereas clinicians might be more reluctant to apply it when the aspiration risk is perceived to be less [6].

Finally, for cricoid force, there was no consensus on the number of anaesthetic team members required for RSI. Experts were split between two and three team members, while 3616 (63.7%) of anaesthetists reported working in a two-member team model as originally described in 1961 [2]. Given the current evidence, it remains unknown whether cricoid force can be successfully applied and sustained by the same person who also might be delivering drugs or assisting with intubation. It would be reasonable to expect that one person remains solely focused on cricoid force application [26, 27]. When designing further research on the effectiveness and safety of cricoid force, key design elements should be considered, such as: the definition of pulmonary aspiration; adequate training of the participating anaesthetists; appropriate power calculations; and assessing the volume and nature of gastric content [6].

The variable popularity of cricoid force and patient positioning for a hypothetical patient with and without intestinal obstruction conflicts with deliberate practice, which is an essential principle for the development of clinical expertise [26]. Performance improvement through deliberate practice is based on four key elements: a motivated learner; a well-defined task; detailed and immediate feedback; and ample opportunities to improve through repetition [28]. This regular, focused practice is required for the acquisition of reproducible expert performance and its maintenance [28]. Every anaesthetic provider expected to undertake RSI should perhaps be an RSI expert, as slight deviations from optimal practice might adversely affect outcome [29].

Personalised medicine opposes, to some extent, the deliberate practice principle. Although individual patient adjustment emerges as modern clinical practice, only when mastery in all RSI variants is achieved can the practitioner truly safely individualise patient care [30]. Although it might be reasonable to individualise the choice of pharmacological agents with consideration of their side-effects, there is good evidence otherwise that without regular training, cricoid force might not be applied correctly [31, 32]. Surveyed experts were much more consistent in avoiding the supine position and cricoid force use for RSI.

Surveyed experts agreed that trainees should always be closely supervised during RSI, but this would have important implications for departments, personnel and training. Some might argue that 'close supervision' is only possible if the supervisor is present in the same room. Close supervision of this kind has many advantages [33], but some may argue it is not always necessary, and may instead have a negative resource implication. As some respondents noted, supervision for tracheal extubation should not be overlooked, as this is also a high-risk time for pulmonary aspiration [4, 34]. Only half of trainee respondents were confident in their RSI skills, and only 36% had confidence in their ability to correctly assess aspiration risk. We argue better supervision together with more guidance and consensus on the range of acceptable techniques are the best options to improve confidence with RSI practices [35].

Pre-operative gastric ultrasound is a new tool that may allow precise estimation of pulmonary aspiration risk in patients deemed neither high nor low [6, 36–38]. Currently, although only 10% of respondents are familiar with its use in clinical practice, 44% of experts believe those who perform RSIs should be trained in this simple bed-side technique. Surprisingly, almost one-third of the respondents mentioned the use of at least one non-technical skill as a learning point after an aspiration event. These include a set of social and cognitive abilities that encompass: situational awareness; risk assessment; clinical decision-making; leadership; communication skills; and teamwork [39, 40]. Their use in crisis management scenarios in operating theatres has been increasingly recognised over the last 20 years [41].

Our study has strengths and limitations. The response rate calculation is a rough approximation, but given that most respondents were recruited through LinkedIn, a reasonable estimation is 40–60%. Additionally, the pre-calculated minimum target number of respondents was met. We did not reach the minimum target number of responses in some countries, and although most continents were well covered, there was a poor response from countries in Asia. We were also unable to collect some responses due to country-specific site access restrictions or language barriers. Nevertheless, for the main analysis, we compared countries by income categories rather than individually. An important strength is allowing respondents to opt for or against inclusion at the end of the survey, rather than inferring consent from survey completion. As with all anonymous surveys, duplicate responses were a possibility and we were not able to characterise or count non-responders. Inviting more than 30 experts for the Phase 2 survey could have been attempted, but the pooling of respondents from specific countries would emerge as a major confounder. Finally, there were many other aspects of RSI practice that were not included. However, the scope of this survey was on selected topics and increasing its length would have compromised the response rate [42]. Overall, this was one of the largest numbers of anaesthetists surveyed to date [43, 44].

In conclusion, pulmonary aspiration prevention strategies vary among anaesthetists worldwide. The level of training of respondents and the existence of national or local guidelines seem to influence preferences less than the national income of the country of respondents and patient factors. We identified several areas for further focused research (Table 6) which are of importance to all clinically practicing anaesthetists [6, 45, 46]. It is our belief that we now need consensus on the best range of acceptable practices for rapid sequence intubation and on education strategies to reduce the incidence of pulmonary aspiration.

Acknowledgements

CH has received funding for clinical research from Ambu, Karl Storz Endoscopy and Vyaire Medical. Additionally, she has received honoraria from UpToDate and Elsevier. MS has received paid consultancies from Teleflex Medical, Athlone, Ireland, MSD and DEAS Italia. He is also patent co-owner (no royalties). We acknowledge the assistance provided by national societies of anaesthetists from: Bosnia and Herzegovina; Cyprus; Egypt; Hong Kong; Hungary; Iran; Israel; Japan; Kenya; Latvia; Lebanon; Lithuania; Maldives; Malta; Morocco; New Zealand; Nigeria; Oman; Paraguay; Serbia; Singapore; Slovenia; Sudan; and Tunisia. We also acknowledge the assistance of: All India Difficult Airway Association; European Airway Management Society; European Society for Regional Anaesthesia; and Society for Airway Management.

We acknowledge the contribution of the following: J. Kompan; O. Loskutov; N. Beley; T. Vymazal; A. Sargsjan; M. Abdelaziz; I. Ahmad; T. Cook; R. Cooper; R. Greif; C.A. Hagberg; R.E. Hodgson; J.M. Huitink; A.M. Lopez; P. Michalek; S.N. Myatra; R. Noppens; T. Saracoglu; M. Sorbello; K. Toker; and R. Urtubia.

References

1. Edwards G, Morton HJ, Pask EA, Wylie WD. Deaths associated with anaesthesia. *Anaesthesia* 1956; **11**: 194–220.
2. Stept WJ, Safar P. Rapid Induction/intubation for prevention of gastric-content aspiration. *Anesthesia and Analgesia* 1970; **49**: 633–6.
3. Sellick BA. Cricoid pressure to control regurgitation of stomach contents during induction of anaesthesia. *Lancet* 1961; **2**: 404–6.
4. Cook T, Woodwall N, Frerk C. 4th National Audit Project of The Royal College of Anaesthetists and The Difficult Airway Society: Major complications of airway management in the United Kingdom. Report and Findings. London, The Royal College of Anaesthetists and The Difficult Airway Society, 2011. https://www.rcoa.ac.uk/system/files/CSQ-NAP4-Full.pdf (accessed 06/07/2019).
5. El-Orbany M, Connolly LA. Rapid sequence induction and intubation: current controversy. *Anesthesia and Analgesia* 2010; **110**: 1318–25.
6. Zdravkovic M, Rice MJ, Brull SJ. The clinical use of cricoid pressure – first, do no harm. *Anesthesia and Analgesia* 2019. Published online ahead of print.
7. Whitaker D, Brattebø G, Trenkler S, et al. The European Section and Board of Anaesthesiology of the UEMS: the European Board of Anaesthesiology recommendations for safe medication practice: first update. *European Journal of Anaesthesiology* 2017; **34**: 4–7.
8. Apfel CC, Roewer N. Ways to prevent and treat pulmonary aspiration of gastric contents. *Current Opinion in Anaesthesiology* 2005; **18**: 157–62.
9. St Pierre M, Krischke F, Luetcke B, Schmidt J. The influence of different patient positions during rapid induction with severe regurgitation on the volume of aspirate and time to intubation: a prospective randomised manikin simulation study. *BMC Anesthesiology* 2019; **19**: 16.
10. Birenbaum A, Hajage D, Roche S, et al. Effect of cricoid pressure compared with a sham procedure in the rapid sequence induction of anesthesia. The IRIS randomized clinical trial. *Journal of the American Medical Assocation - Surgery* 2019; **154**: 9–17.
11. Mellin-Olsen J, Fasting S, Gisvold SE. Routine preoperative gastric emptying is seldom indicated. A study of 85,594 anaesthetics with special focus on aspiration pneumonia. *Acta Anaesthesiologica Scandinavica* 1996; **40**: 1184–8.
12. Landreau B, Odin I, Nathan N. Pulmonary aspiration: epidemiology and risk factors. *Annales françaises d'anesthèsie et de rèanimation* 2009; **28**: 206–10.
13. Martin LD, Mhyre JM, Shanks AM, Tremper KK, Kheterpal S. 3,423 emergency tracheal intubations at a university hospital: airway outcomes and complications. *Anesthesiology* 2011; **114**: 42–8.
14. Kheterpal S, Martin L, Shanks MA, Tremper KK. Prediction and outcomes of impossible mask ventilation: a review of 50,000 anesthetics. *Anesthesiology* 2009; **110**: 891–7.
15. Frerk C, Mitchell VS, McNarry AF, et al. Difficult Airway Society 2015 guidelines for management of unanticipated difficult intubation in adults. *British Journal of Anaesthesia* 2015; **115**: 827–48.
16. Jensen AG, Callesen T, Hagemo JS, Hreinsson K, Lund V, Nordmark J. Clinical Practice Committee of the Scandinavian Society of Anaesthesiology and Intensive Care Medicine: Scandinavian clinical practice guidelines on general anaesthesia for emergency situations. *Acta Anaesthesiologica Scandinavica* 2010; **54**: 922–50.
17. Wetsch WA, Hinkelbein J. Current national recommendations on rapid sequence induction in Europe, How standardised is the 'standard of care'? *European Journal of Anaesthesiology* 2014; **31**: 437–44.
18. Sajayan A, Wicker J, Ungureanu N, Mendonca C, Kimani PK. Current practice of rapid sequence induction of anaesthesia in the UK – a national survey. *British Journal of Anaesthesia* 2016; **117**(S1): i69–74.
19. Rohsbach C, Wirth S, Lenz K, Priebe H. Survey on the current management of rapid sequence induction in Germany. *Minerva Anestesiologica* 2013; **79**: 716–26.

20. Koerber JP, Roberts GE, Whitaker R, Thorpe CM. Variation in rapid sequence induction techniques: current practice in Wales. *Anaesthesia* 2009; **64**: 54–9.
21. The World Bank Data: GNI per capita, Atlas method. https://data.worldbank.org/indicator/NY.GNP.PCAP.CD (accessed 22/08/2019).
22. Baltar F, Brunet I. Social research 2.0: virtual snowball sampling method using Facebook. *Internet Research* 2012; **22**: 57–74.
23. Salem MR, Khorasani A, Saatee S, Crystal GJ, El-Orbany M. Gastric tubes and airway management in patients at risk of aspiration: history, current concepts, and proposal of an algorithm. *Anesthesia and Analgesia* 2014; **118**: 569–79.
24. Mencke T, Zitzmann A, Reuter DA. Certain and controversial components of "rapid sequence induction". *Anaesthesist* 2018; **67**: 305–20.
25. Petrini F, Di Giacinto I, Cataldo R, et al. Perioperative and periprocedural airway management and respiratory safety for the obese patient: 2016 SIAARTI Consensus. *Minerva Anestesiologica* 2016; **82**: 1314–35.
26. Himi SA, Bühner M, Schwaighofer M, Klapetek A, Hilbert S. Multitasking behavior and its related constructs: executive functions, working memory capacity, relational integration, and divided attention. *Cognition* 2019; **189**: 275–98.
27. Pandit JJ, Irwin MG. Airway management in critical illness: practice implications of new Difficult Airway Society guidelines. *Anaesthesia* 2018; **73**: 544–8.
28. Ericsson KA. Deliberate practice and the acquisition and maintenance of expert performance in medicine and related domains. *Academic Medicine* 2004; **79**(Suppl): S70–81.
29. Hastings RH, Rickard TC. Deliberate practice for achieving and maintaining expertise in anesthesiology. *Anesthesia and Analgesia* 2015; **120**: 449–59.
30. Joyner MJ, Prendergast FG. Chasing Mendel: five questions for personalized medicine. *Journal of Physiology* 2014; **592**: 2381–8.
31. Johnson RL, Cannon EK, Mantilla CB, Cook DA. Cricoid pressure training using simulation: a systematic review and meta-analysis. *British Journal of Anaesthesia* 2013; **111**: 338–46.
32. Lee D, Czech AJ, Elriedy M, Nair A, El-Boghdadly K, Ahmad I. A multicentre prospective cohort study of the accuracy of conventional landmark technique for cricoid localisation using ultrasound scanning. *Anaesthesia* 2018; **73**: 1229–34.
33. Schmidt UH, Kumwilaisak K, Bittner E, George E, Hess D. Effects of supervision by attending anesthesiologists on complications of emergency tracheal intubation. *Anesthesiology* 2008; **109**: 973–7.
34. Sorbello M, Frova G. When the end is really the end? The extubation in the difficult airway patient. *Minerva Anestesiologica* 2013; **79**: 194–9.
35. Krackov SK, Pohl H. Building expertise using the deliberate practice curriculum-planning model. *Medical Teacher* 2011; **33**: 570–5.
36. Zieleskiewicz L, Bouvet L, Einav S, Duclos G, Leone M. Diagnostic point-of-care ultrasound: applications in obstetric anaesthetic management. *Anaesthesia* 2018; **73**: 1265–79.
37. Gagey A, Queiroz Siqueira M, Monard C, et al. The effect of pre-operative gastric ultrasound examination on the choice of general anaesthetic induction technique for non-elective paediatric surgery. A prospective cohort study. *Anaesthesia* 2018; **73**: 304–12.
38. Charlesworth M, Wiles MD. Pre-operative gastric ultrasound – should we look inside Schrödinger's gut? *Anaesthesia* 2019; **74**: 109–12.
39. Gaba DM, Fish KJ, Howard SK, Burden A. *Crisis management in anesthesiology*, 2nd edn. Philadelphia: Elsevier/Saunders, 2015: 6–78.
40. Sorbello M, Afshari A, De Hert S. Device or target? A paradigm shift in airway management: implications for guidelines, clinical practice and teaching. *European Journal of Anaesthesiology* 2018; **35**: 811–14.
41. Flin R, Fioratou E, Frerk C, Trotter C, Cook TM. Human factors in the development of complications of airway management: preliminary evaluation of an interview tool. *Anaesthesia* 2013; **68**: 817–25.
42. Kelley A, Clark B, Brown V, Sitzia J. Good practice in the conduct and reporting of survey research. *International Journal for Quality in Health Care* 2003; **15**: 261–6.
43. Leifer S, Choi SW, Asanati K, Yentis SM. Upper limb disorders in anaesthetists – a survey of Association of Anaesthesia members. *Anaesthesia* 2019; **74**: 285–91.
44. Mungroop TH, Geerts BF, Veelo DP, et al. Fluid and pain management in liver surgery (MILESTONE): a worldwide study among surgeons and anesthesiologists. *Surgery* 2019; **165**: 337–44.
45. Ahmad I, Onwochei DN, Muldoon D, Keane O, El-Boghdadly K. Airway management research: a systematic review. *Anaesthesia* 2019; **74**: 225–36.
46. McGrenaghan E, Smith AF. Airway management research: what problem are we trying to solve? *Anaesthesia* 2019; **74**: 704–7.

Supporting Information

Additional supporting information may be found online via the journal website.

Appendix S1. Questionnaire sent to clinically practicing anaesthetists.

Appendix S2. Questionnaire sent to recognised international airway experts.

Table S1. Sample size calculations.

Table S2. Achieved and minimum target survey responses, level of training of respondents and cricoid force use in their practice, as per individual country.