Southern African Journal of Anaesthesia and Analgesia. 2021;27(6):278-285
https://doi.org/10.36303/SAJAA.2021.27.6.2657

South Afr J Anaesth Analg
ISSN 2220-1181 EISSN 2220-1173

ORIGINAL RESEARCH

Global airway management of the unstable cervical spine survey (GAUSS)

G Stegmann, R Llewellyn, R Hofmeyr

Department of Anaesthesia and Perioperative Medicine, University of Cape Town, South Africa
Corresponding author, email: *gstegmann@gmail.com*

Background: Rapid advancement in optical and video devices used for indirect visualisation of the airway has expanded the options for emergency and elective endotracheal intubation in patients with unstable fractures of the cervical spine. Aiming to ascertain whether videolaryngoscopy (VL) has replaced awake flexible intubation (AFI) as the preferred technique for airway management, we conducted a global survey to evaluate current clinical practice.

Methods: After obtaining ethics approval, we created a questionnaire featuring two hypothetical patients with unstable injuries of the cervical spine – one emergency and one urgent elective. Target sample sizes per country were estimated using data from the World Federation of Societies of Anaesthesiologists' (WFSA) Global Anaesthesia Workforce Survey. Respondents were asked about their training, experience, airway skills, current clinical setting and availability of airway equipment, as well as their preferred airway strategy in each case. The questionnaire was actively distributed for one year through the WFSA member societies and through social networks to physician anaesthesia providers (PAPs). Global and regional trends were assessed using descriptive statistics.

Results: Of a total of 1 904 responses, 1 153 (101 countries) were included in the final analysis. In the emergency case, 46.9% (95% confidence interval [CI] 44.0–49.8%) of respondents preferred VL and 39.8% (95% CI 38.0–42.6%) chose AFI. In the urgent elective case, 51.3% (95% CI 48.3–54.3%) selected VL as their preferred method, while 37.3% (95% CI 34.4–40.2%) indicated AFI. Significant regional variations in preference were found.

Conclusion: The results suggest that practice in airway management of unstable cervical spine fractures is changing. Currently PAPs tend to favour VL over AFI. There is a statistically significant preference for VL in elective cases which is traditionally considered to be a stronghold of AFI.

Keywords: airway management, cross sectional survey, spinal fractures, tracheal intubation, bronchoscopy

Introduction

Spinal cord injury accompanying cervical spine fractures is a major concern in the trauma patient. On average, 1.8% of patients with blunt trauma will have cervical spine injuries.[1] Spinal cord injury secondary to airway management is a rare but potentially devastating complication.[2-4]

Unstable cervical fractures pose a twofold challenge: patients may present with a difficult airway and the airway intervention itself could cause or exacerbate spinal cord injury. Reasons for a difficult airway may include limited mouth opening as well as limited movement due to spinal motion restriction techniques employed. Patients can be hypotensive, hypovolaemic, hypoxic, or present with a threatened airway due to spinal cord or associated injuries.[5] Maxillofacial injuries and/or intraoral bleeding may further complicate management while the mean blood pressure should be maintained at 90 mmHg, or above.[6] The clinician is tasked with multiple problems that require simultaneous management, so that these patients can often be challenging for the anaesthetist.

However, what are the worldwide trends when physician anaesthesia providers (PAPs) manage patients with unstable cervical fractures? Are videolaryngoscopes (VLs) preferred, and if so, are they used primarily for awake intubation? Surveys prior to 2000 found that anaesthetists favour awake flexible intubation (AFI) in cooperative, stable patients for elective surgery, and direct laryngoscopy (DL) for emergency surgery.[7-9] These surveys only targeted anaesthetists in a single country and were done well before VL became readily available. The only recent study was a survey targeting PAPs in India, and it showed that 80% of respondents preferred AFI in elective cases.[10] Respondents were divided in their decision to use VL or DL for emergency cases. Since this survey with 122 respondents may not have been representative of global trends, we undertook to assess current worldwide clinical practice. We hypothesised that most PAPs worldwide used VL for tracheal intubation in both emergency and elective surgery cases.

The primary outcome for this study was to determine the worldwide PAP preference in the choice of airway management strategy for patients with unstable cervical spine fractures, in their current clinical setting. Secondary outcomes included determining the rationale for the practitioners' choice of intervention, and the availability of equipment and level of training in various settings, as well as identifying variation in responses from different regions.

Methods

The study population was PAPs in current anaesthesia practice worldwide. PAPs were included if they provided anaesthesia at least once per week but excluded if they were not qualified medical doctors.

Ethics approval for the study was obtained from the University of Cape Town Human Research Ethics Committee (771/2018). The need for written consent was waived due to the nature of the study; agreeing to complete the survey was taken as evidence of consent. Investigators adhered to the ethical principles for medical research involving human subjects as outlined in the Declaration of Helsinki and amended by the World Medical Association.

An anonymous online questionnaire consisting of 29 multiple-choice questions was designed and piloted by sending it to a sample of airway experts for feedback. The aim was to ensure that all the likely responses to questions were included in the multiple-choice options and to mitigate any lack of clarity in the questions or possible answers.

The survey gathered basic demographic data from respondents including their training, level of experience, airway skills, current clinical setting and the availability of airway equipment. PAPs were then presented with two hypothetical scenarios and asked about their preferred airway management strategy in their current clinical setting, and the rationale for their choices. The first patient had an unstable cervical fracture presenting for emergency pelvic surgery, and the second patient also had an unstable cervical fracture presenting for urgent, semi-elective corrective surgery.

The survey was constructed and the data collected using REDCap® (Research Electronic Data Capture, https://www.project-redcap.org/) and the gathered data were stored on our institution's secure servers.[11] Data access was restricted to the three investigators, and the anonymity of the respondents was preserved.

Conduct of the study

The questionnaire was preceded by an information screen stating the purpose of the study and that completion of the survey would be regarded as an indication of consent (Supplementary Questionnaire). The 29 questions were presented over three subsequent screens, kept relevant with piping logic. For example, a respondent would only be asked which VL blade they preferred if they chose VL as part of their management strategy. In questions dealing with reasoning for management choices, free text boxes were provided. The questionnaire was only available in English and was not incentivised. A check was performed on the completeness of data entered using the REDCap® software.

The survey was available online from 12 January 2019 to 11 January 2020. Links to the survey were distributed through multiple channels to achieve the maximum possible exposure to the study population. The World Federation of Societies of Anaesthesiologists (WFSA) was contacted directly for assistance in advertising the study among their member societies. In total, 136 member societies representing 153 countries were individually contacted for assistance in distributing the survey among their members. Thereafter, six updates were sent to the societies to remind them about the study. Societies could either share links to the survey with their members or provide the investigators with their membership contact information. It is estimated that in these 153 WFSA member countries, only 39% of the residing PAPs are members of the WFSA-affiliated society in that country.[12] To compensate, the survey was also widely distributed via social networks.

Sample size calculation

The WFSA has estimated the number of PAPs in the 153 member countries (out of a total of 197 countries included) to be 436 596. The 44 countries not included represent 2.5% of the world population.[12] Therefore, for sample size calculation, it was assumed that there are approximately 500 000 PAPs worldwide. To estimate the required sample size, the formula of Krejcie and Morgan was used.[13] Population proportion was taken as 0.5 to maximise sample size, degree of freedom was taken as 1, and the p-value was set at 0.05 (i.e. $X^2 = 3.8416$). If the margin of error was taken as 5%, the sample size needed was 384 respondents. For a margin of error of ± 3%, a sample size of 1 065 respondents would be needed.

Statistical analysis

The data were presented as numbers (%) and analysed using descriptive statistics. Pearson's chi-square test and Fisher's exact test were used where appropriate. The margin of error was calculated for all proportions and the confidence intervals (CIs) for differences between proportions were calculated using

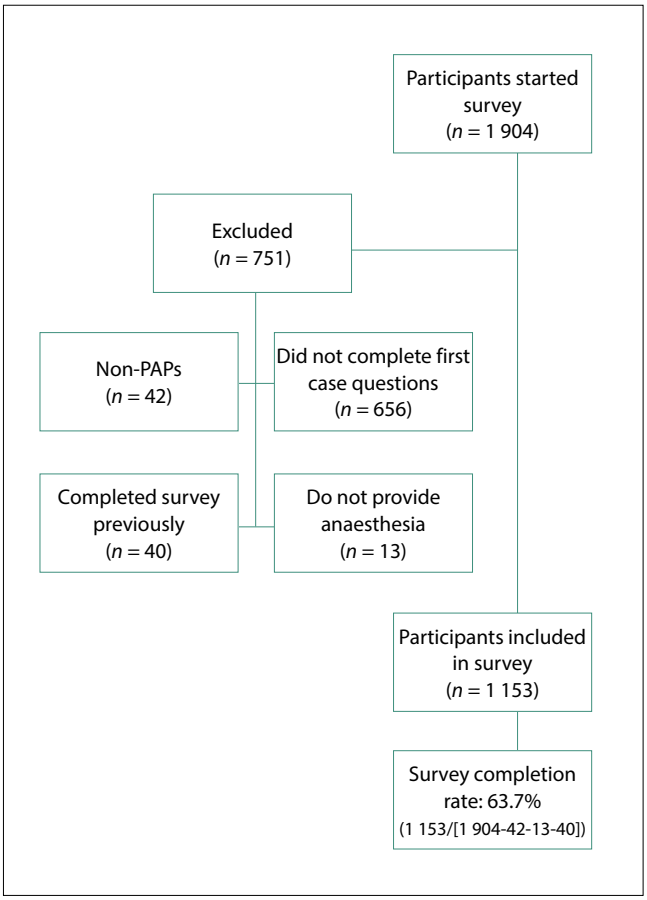

Figure 1: Respondent exclusion flowchart and survey completion rate calculation

the Newcombe method.[14,15] Correlations were sought between equipment availability and airway management skills, and the preference for equipment use. Countries were also analysed separately to identify regional differences. Criteria for a country's results to be reported on separately was a sample size of at least 25 respondents as well as a statistically significant difference between the proportions of the primary outcome (i.e. choice in airway intervention). MedCalc® statistical software (version 18.9.1 or later; MedCalc Software BVBA, Ostend, Belgium; http://www.medcalc.org; 2018) and Stata® statistical software (version 16 or later; StataCorp, College Station, Texas; http://www.stata.com; 2019) were used for analysis.

Results

Eleven of the 136 WFSA societies could not be contacted. From the 125 reachable societies, only 14 responded to emails and only nine agreed to participate in the study. Judging by response patterns, at least three of the societies who did not respond to our email communication did forward the study details to their members. Responses were a mixture of society members and PAPs receiving links to the survey via social networks (LinkedIn, Facebook and Twitter).

The survey received 1 904 responses from 111 countries. After excluding responses from non-PAPs, those with incomplete demographic details and those who do not perform anaesthesia, 1 153 responses from 101 countries were included in analysis (Figure 1). Only 1 094 respondents completed all questions. Nine countries fulfilled the criteria to be reported on separately (Figure 2).

In web-based surveys, view rate, participation rate and completion rate are more relevant than response rate.[16] View rates and participation rates were however difficult to assess in this study, since distribution was over multiple social networks. Completion rate was calculated as 63.7% (Figure 1).

Table I shows the demographic details of respondents, who were predominantly male (62.3% [*n* = 718]) and over the age of 31. Most respondents were specialists working in tertiary and higher-level hospitals, the group likely involved in the management of patients with unstable cervical spine fractures.

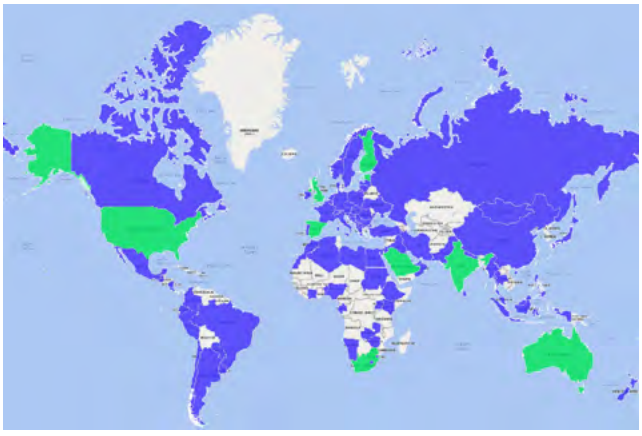

Figure 2: World map indicating countries from which responses were received in blue, green indicates countries that fulfilled criteria to be reported on separately

Table I: Demographics of respondents

Variable	*n* (%)
Gender	
Male	718 (62.3)
Female	433 (37.6)
Other	2 (0.2)
Age	
30 years old or younger	126 (11.0)
31–40 years old	446 (38.7)
41–50 years old	336 (29.1)
51–60 years old	193 (16.7)
61–70 years old	47 (4.0)
Older than 70 years	5 (0.4)
Highest qualification	
Medical degree	196 (17.0)
Diplomate anaesthetist	167 (14.5)
Specialist anaesthesiologist	790 (68.5)
Experience in anaesthesia	
0–5 years	271 (23.5)
6–10 years	273 (23.7)
11–15 years	205 (17.8)
16–20 years	166 (14.4)
More than 20 years	238 (20.6)
Hospital level of current practice	
Community health clinic/day hospital/ primary level hospital	76 (6.6)
Regional/secondary level hospital	185 (16.0)
Provincial/tertiary level hospital	342 (29.7)
National/quaternary level hospital	550 (47.7)
Frequency of anaesthesia administration	
Every day on duty	770 (66.8)
Three or four days per week	274 (23.8)
One or two days per week	85 (7.4)
Less than one day per week	24 (2.1)
Frequency of managing trauma cases	
Every day on duty	68 (5.90)
Three or four days per week	114 (9.9)
One or two days per week	378 (32.8)
Less than one day per week	593 (51.4)

Respondents were asked to estimate the number of patients with unstable cervical spine fractures whom they had treated during their career. The median (interquartile range) response was 20 (40) cases. The distribution of cervical cases was prominently skewed to the right and had several outliers. Twenty-four respondents estimated that they have been involved in 1 000 cases or more, of which one specialist respondent estimated involvement in 10 000 cases. On the other hand, 25 respondents reported never having managed a patient with an unstable cervical fracture. The median number of patients was higher in the subgroup that identified themselves as specialists (30 [90])

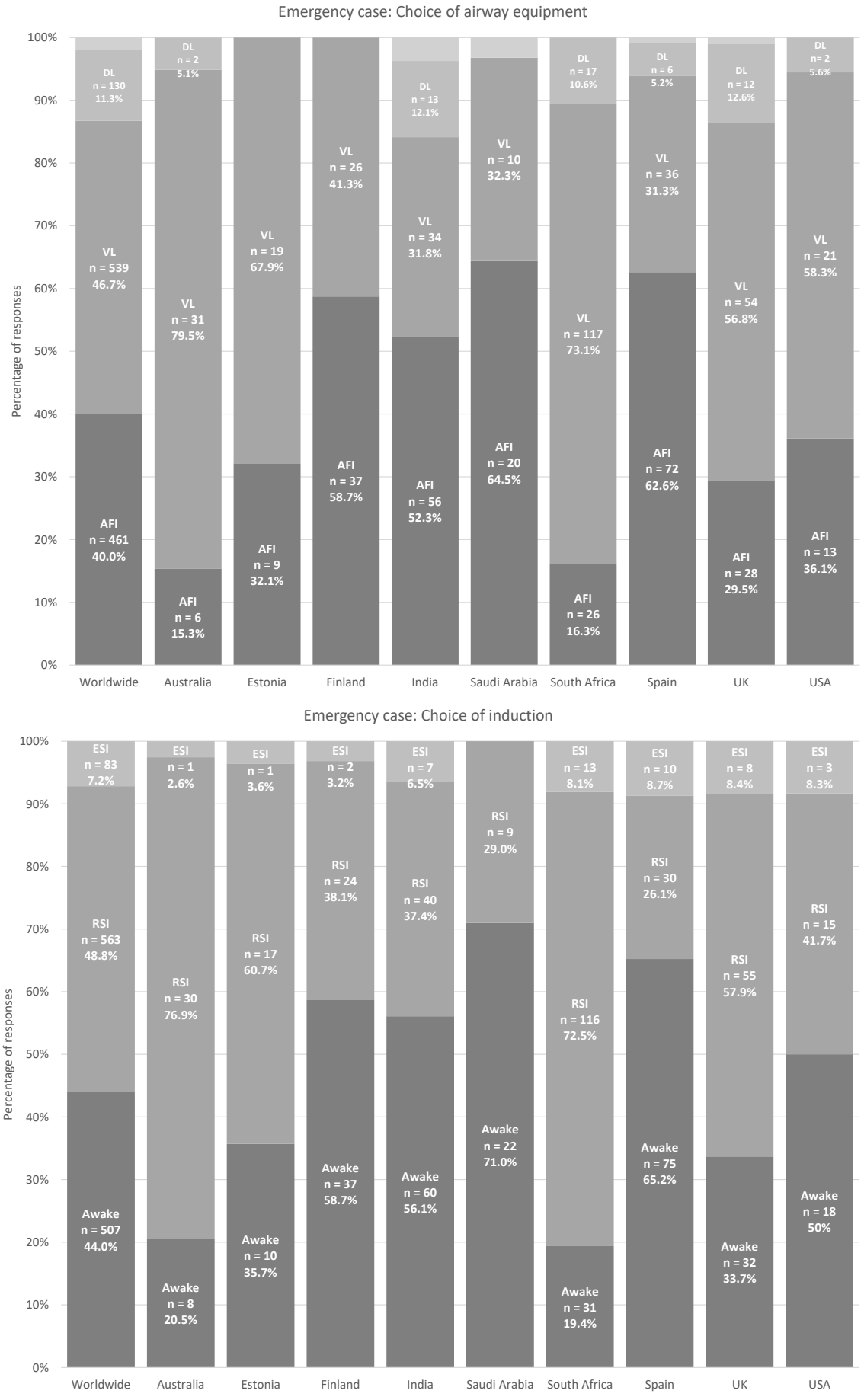

Figure 3: Respondent airway management preferences worldwide and per country for the emergency case

Note: Airway device preference is indicated in the left graph and induction method on the right. The light blue bars on the left graph are other devices, including supraglottic airways and emergency cricothyroidotomy. AFI – awake flexible intubation, VL – videolaryngoscopy, DL – direct laryngoscopy, RSI – rapid sequence induction, ESI – elective sequence induction, UK – United Kingdom, US – United States of America

Table II: 95% confidence intervals of the difference between the proportions of respondents selecting awake flexible intubation (AFI) and videolaryngoscopy (VL) in the emergency and elective cases

Country	Emergency case % (95% CI)	Elective case % (95% CI)
Preferred VL		
Australia	-64.1 (-76.8 to -43.3)	-65.8 (-78.2 to -44.8)
Estonia	-35.7 (-55.8 to -9.5)	-23.1 (-45.6 to 3.5)
South Africa	-56.9 (-64.8 to -47.1)	-58.4 (-66.4 to -48.5)
UK	-27.4 (-39.9 to -13.3)	-25.6 (-38.6 to -11.0)
USA	-22.2 (-42.1 to 0.01)	-25.7 (-45.4 to -2.4)
Preferred AFI		
Finland	17.5 (0.00 to 33.5)	10.0 (-7.7 to 26.8)
India	20.6 (7.3 to 32.8)	10.5 (-3.5 to 23.9)
Saudi Arabia	32.3 (7.4 to 52.1)	16.7 (-8.2 to 38.8)
Spain	31.3 (18.5 to 42.7)	24.0 (10.5 to 36.4)

Negative values denote VL > AFI

compared with those with anaesthesia diplomas (15 [44]) and only a basic medical degree (10 [42]).

DL was the most commonly available airway intervention (94.7%), followed by a supraglottic airway (SGA) (91.1%) and VL (80.6%). Flexible bronchoscopes were available to 76.6% of respondents. Ninety-two per cent of respondents were confident using DL, 81.1% with VL and 64.9% with flexible bronchoscopy.

In the emergency case, 46.7% (95% CI 43.8–49.6%) of respondents preferred VL, while 40.0% (95% CI 38.2–42.8%) chose AFI as management strategy. The remainder of respondents chose DL (11.2%) or other techniques (2.0%). Of the respondents who chose VL, 2.1% (n = 24) chose awake VL. In the elective case, 51.1% (95% CI 48.1–54.15) preferred VL, while 37.4% (95% CI 34.5–40.3%) chose AFI. DL was chosen by 9.1% of the respondents and other techniques by 2.3%. The differences in AFI and VL proportions were statistically significant in both the emergency (6.8% [95% CI 2.7–10.8%]) and elective cases (13.7% [95% CI 9.6–17.8%]).

For the induction technique in the emergency case, 48.8% (95% CI 45.9–51.7%) of respondents chose rapid sequence induction (RSI), 44.0% (95% CI 41.1–46.9%) chose awake techniques and 7.2% chose elective sequence induction (ESI). The difference between RSI and awake techniques was statistically significant (4.9% [95% CI 0.8–8.9%]). In the elective case, 51.6% (95% CI 48.7–54.4%) of the respondents preferred ESI, 40.3% (95% CI 37.5–43.1%) chose awake techniques and 1.6% chose RSI. The difference between awake techniques and ESI were also found to be statistically significant (11.2% [95% CI 7.1–15.4%]).

Considerable variation was seen between countries (Figure 3 and 4). Table II shows the CIs of the differences of the proportions between AFI and VL. Negative values indicate that the proportion of respondents who chose VL was larger and a CI not crossing zero was taken as statistically significant.

In the emergency case, of those respondents who chose AFI, 89% (n = 408) stated the need to minimise cervical movement as a reason for their airway management choice. All other reasons for the choice of AFI were given by < 40% of the respondents. Respondents who chose VL and RSI also valued the requirement to minimise movement of the cervical spine (83% [n = 321]). The need to secure the airway quickly (70% [n = 268]) and the fact that the patient was at risk of pulmonary aspiration (68% [n = 261]) were also stated as considerations. When asked whether respondents would change their strategy if the patient were fasted, 33% (n = 385) indicated that they would. Several of these (39% [n = 151]) changed their strategy from VL and RSI to VL and ESI. Forty-eight per cent (n = 272) of respondents who chose RSI techniques, indicated they would change their technique in a fasted patient. Of respondents who preferred AFI, 19% (n = 87) indicated that they would change their strategy from AFI if the patient were fasted. Of these 19%, 83% (n = 73) indicated they would use VL rather than AFI in these circumstances.

Regarding the elective case, of those choosing AFI, 90% (n = 366) cited the need to minimise cervical movement as a reason for their choice, and 43% (n = 174) chose the possibility that the patient would be cooperative as a reason for their answer. All other options in this subgroup were chosen by < 32% of the respondents. The respondents who chose VL and ESI cited the need to minimise cervical movement (83% [n = 383]), the patient being fasted (71% [n = 328]) and being most comfortable with the technique (57% [n = 263]) as the reasons for their choice.

Forty-one per cent of respondents indicated that they would remove the hard collar in the emergency case and 86% would perform manual in-line stabilisation (MILS).

Respondents who opted for VL for either case were asked about which blade type they would prefer. Sixty-two per cent (n = 465) indicated hyper-angulated blades (e.g. C-MAC® D-blade or Glidescope®) and 25% (n = 188) standard blades (Miller/Macintosh e.g. McGrath MAC). Eleven per cent (n = 85) preferred channeled blades (e.g. Airtraq®, King Vision®), while only 12 respondents chose rigid intubating endoscopes (e.g. Bonfils).

A correlation was noted between equipment availability and its preference in the elective and emergency cases (Pearson chi-squared = 345.8 and 300.4; p < 0.001). There was a correlation between preferred airway strategy and comfort with this strategy in the emergency case (Pearson chi-squared = 131.0; p < 0.001). The correlation was less significant in the elective case (Pearson chi-squared = 79.6; p = 0.158).

Discussion

Even though the ideal intubation technique remains an area of debate, AFI is traditionally regarded as the preferred technique in patients with unstable cervical fractures, especially in elective cases.[1,3,17-19] Advantages of AFI include a high success rate and the ability to evaluate neurological status before and after airway intervention.[3,5,17] Disadvantages include the need for patient cooperation, the requirement for special skills, the

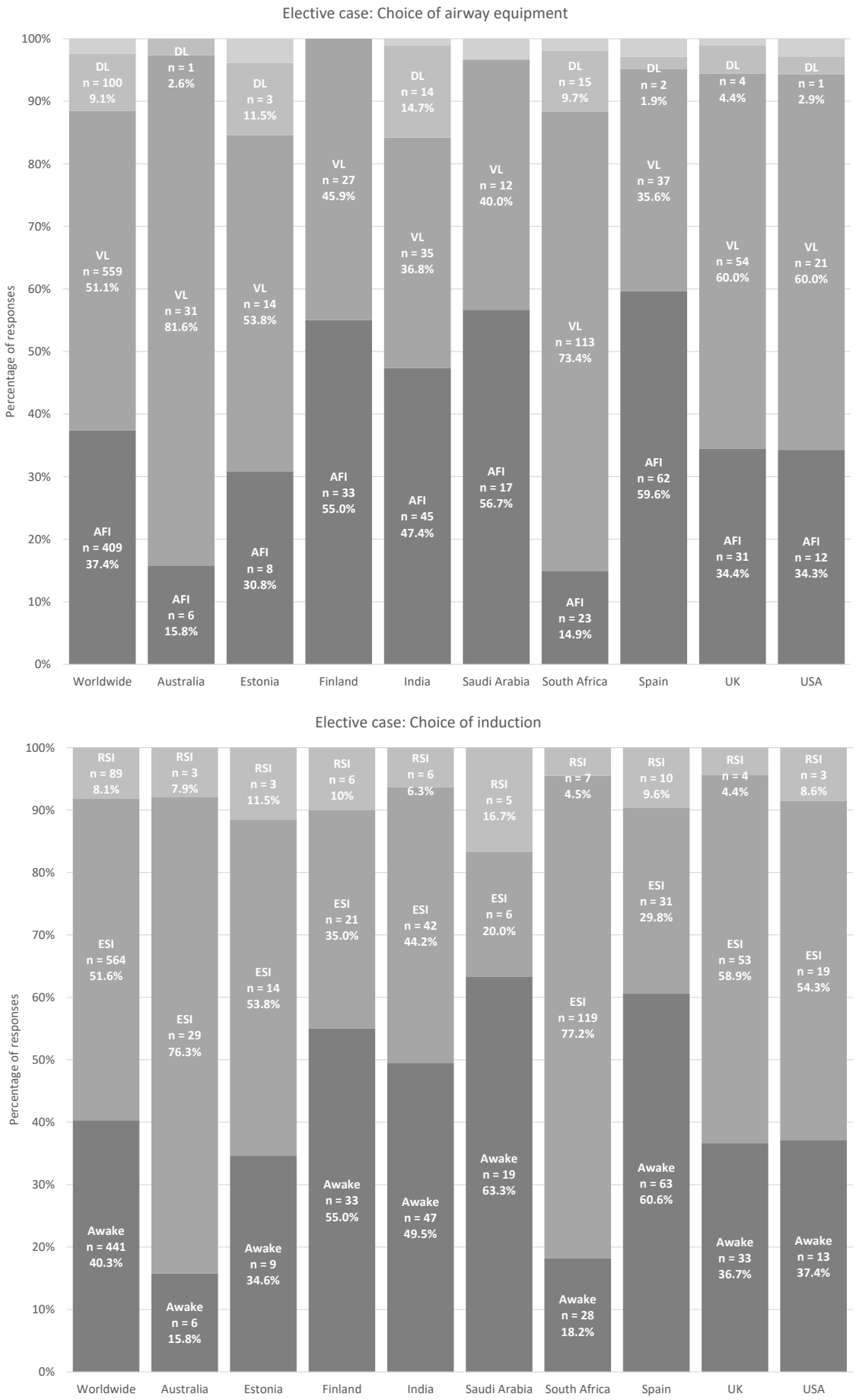

Figure 4: Respondent airway management preferences worldwide and per country for the elective case

Note: Airway device preference is indicated on the left graph and induction method on the right. The light blue bars on the left graph are other devices, including supraglottic airways and emergency cricothyroidotomy. AFI – awake flexible intubation, VL – videolaryngoscopy, DL – direct laryngoscopy, RSI – rapid sequence induction, ESI – elective sequence induction, UK – United Kingdom, US – United States of America

longer duration of the procedure, the risk of airway irritation with coughing, and obstruction of the airway. The choices of airway size are also limited and cannot be changed easily mid-procedure.[17] AFI may not be available in under-resourced areas. For these reasons, AFI may be underutilised, which in turn erodes familiarity and competence with the technique.[3]

Compared with AFI, VL is an easier technique and quicker to master. The choice of endotracheal tubes is also unlimited and these can be changed mid-procedure.[17] A few cadaver studies suggest that both Airtraq® and Glidescope® VL cause less motion of the lower cervical spine in unstable injuries than DL. Motion at the atlanto-occipital and atlanto-axial joints is comparable.[20,21]

Several authors suggest that awake VL should be taught and utilised to a greater extent.[17,22,23] Some even argue that AFI may soon become obsolete, since this skill is not adequately practiced.[22] A recent meta-analysis compared the use of VL and the flexible bronchoscope for awake intubation in patients with a difficult airway. VL was associated with shorter intubation times and compared favourably with the flexible bronchoscope in terms of success rate, safety profile and patient satisfaction.[17]

This survey suggests that in most clinical settings the introduction of VL has changed clinical practice in the management of unstable cervical fractures. AFI still predominates in some areas, but VL has become at least as popular. It appears that DL, while still favoured by some respondents, is used less often when more modern alternatives are available. Awake VL may be a future alternative, but it is not currently widely used.

Owing to ease of use, availability and lack of feasible alternatives, semi-rigid collars are often used to stabilise the cervical spine.[5] When correctly applied, these devices can greatly limit mouth opening and make intubation very difficult, and they are thought to be ineffective in preventing cervical spine movement during intubation when compared with MILS.[24,25] It is thus interesting to note that 46% of the respondents in our study indicated that they would not remove the cervical collar but would apply MILS.

Immobilisation of the cervical spine prohibits normal positioning of the head and neck for intubation ('flextension'). It follows that a prerequisite for airway intervention techniques employed in these patients is efficacy in the presence of limited mouth opening and limited or abnormal position and mobility of the neck. The chosen technique should allow for the airway to be secured in a controlled, definitive and timeous manner, with minimal cervical movement.[3]

A recent similar survey conducted in India found that AFI was preferred in patients scheduled for elective surgery with unstable cervical fractures, while DL was favoured in emergency cases.[10] In our study, AFI was the preferred choice in both cases in the India subgroup (the difference between VL and AFI did not reach statistical significance in the elective case). A reason for this discrepancy could be that both studies had relatively small sample sizes in a large population of 16 500 PAPs in India. Studies conducted 15 to 20 years ago found that either AFI or DL was generally preferred,[7-9] but these studies did not specify VL as this technology was not yet widely available. It is noteworthy that none of these studies involved more than one country and sample sizes were relatively small.

Study limitations

Firstly, the survey instrument has not been validated. Secondly, the validity of some answers may be questioned since respondents may have given 'academically correct' answers instead of recording their current clinical practice. One example of this is the question concerning availability of technology in a particular setting. Of the respondents who indicated that they do not have flexible bronchoscopes available, 26% in the emergency and 28% in the elective case still chose AFI as their preferred airway strategy. A similar pattern was recorded among respondents who indicated that they do not have VL readily available, where 23% in the emergency and 27% in the elective case still chose VL as their preferred method. However, this could also have been due to misinterpretation of the question.

The survey was also susceptible to different forms of bias. It automatically excluded all PAPs who were unable to complete it in English. Furthermore, PAPs who do not participate in social media, who are not WFSA society members or who live in non-WFSA member states were less likely to have taken part. In addition, the data revealed that some PAPs prefer airway techniques not given as options in the questionnaire (e.g. blind nasal intubation was mentioned by two respondents in the free text questions). Lastly, as can be expected in any survey, the validity of our results could have been affected by a general response bias.

Conclusion

The results of our survey suggest that practice in airway management of unstable cervical spine fractures is changing, and currently tends to favour VL over AFI. There is a statistically significant preference for VL in elective cases, traditionally considered to be a stronghold of AFI. Future similar studies may attempt to increase the sample size by using multilingual questionnaires and more sophisticated distribution methods. It would also be worthwhile to investigate whether the recently introduced Difficult Airway Society guidelines on awake intubation and SARS-CoV-2 aerosolisation have changed clinical practice.[26] Those attempting similar surveys in future should note that LinkedIn was the most effective means of recruitment in our study and has been used in large surveys with great success.[27,28]

Preliminary results from this study were presented at the World Airway Management Meeting 2019 and were published as an abstract in *Trends in Anaesthesia and Critical Care* Volume 30, February 2020.

Acknowledgements

The authors thank the following anaesthesiologists for participating in the pilot survey: Andrie Alberts, Arnd Timmermann, Carin Hagberg, Imran Ahmad, Kariem El-

Boghdadly, Eric Hodgson, Johannes Huitink, John Law, James DuCanto, John Roos, Massimiliano Sorbello, Nesrine El-Refai, Nicholas Chrimes, Tino Greif and William Rosenblatt. We would also like to thank the WFSA for their assistance, as well as the following national societies: Australian Society of Anaesthetists (Australia), Society for Anesthesia and Resuscitation of Belgium (Belgium), Estonian Society of Anaesthesiologists (Estonia), Israel Society of Anesthesiologists (Israel), Japanese Society of Anesthesiologists (Japan), Kenya Society of Anaesthesiologists (Kenya), Nederlandse Vereniging voor Anesthesiologie (Netherlands), Nigerian Society of Anaesthetists (Nigeria), Russian Federation of Anaesthesiologists and Reanimatologists (Russia), Serbian Association of Anaesthesiologists and Intensivists (Serbia), South African Society of Anaesthesiologists (South Africa), Sociedad Española de Anestesiología, Reanimación y Terapéutica del Dolor (Spain), Association of Anaesthesiologists of Uganda (Uganda). A very special thanks to Marko Zdravkovic for his assistance in distributing the survey, to Leon du Toit and Anneli Hardy for their assistance with statistical analysis, and to Robert Dyer and Johan Coetzee for their valuable inputs in the editing of the manuscript.

Conflict of interest

Prof. R Hofmeyr is the UCT-Storz Lead of the Fellowship in Airway and Thoracic Anaesthesia funded in part by KARL STORZ Endoscopy (South Africa).

Funding source

All expenses of the study were covered by the authors. Armstrong Medical contributed towards costs of G Stegmann attending the World Airway Management Meeting 2019 to present initial findings.

Ethical approval

Ethics approval for the study was obtained from the University of Cape Town Human Research Ethics Committee (771/2018).

ORCID

G Stegmann https://orcid.org/0000-0002-6117-1028
R Llewellyn https://orcid.org/0000-0002-5629-0399
R Hofmeyr https://orcid.org/0000-0002-9990-7459

References

1. Crosby E, Lui A. The adult cervical spine: implications for airway management. Can J Anaesth. 1990;37:77-93. https://doi.org/10.1007/BF03007488.
2. Duggan LV, Griesdale DEG. Secondary cervical spine injury during airway management: beyond a 'one-size-fits-all' approach. Anaesthesia. 2015;70(7):769-73. https://doi.org/10.1111/anae.13163.
3. Holmes MG, Dagal A, Feinstein BA, Joffe AM. Airway management practice in adults with an unstable cervical spine: the Harborview Medical Center experience. Anesth Analg. 2018;127(2):450-4. https://doi.org/10.1213/ANE.0000000000003374.
4. Epaud A, Levesque E, Clariot S. Dramatic cervical spine injury secondary to videolaryngoscopy in a patient suffering from ankylosing spondylitis. Anesthesiology. 2021;135(3):495-6. https://doi.org/10.1097/ALN.0000000000003866.
5. Austin N, Krishnamoorthy V, Dagal A. Airway management in cervical spine injury. Int J Crit Illn Inj Sci. 2014;4(1):50-6. https://doi.org/10.4103/2229-5151.128013.
6. Bao F-P, Zhang H-G, Zhu S-M. Anesthetic considerations for patients with acute cervical spinal cord injury. Neural Regen Res. 2017;12(3):499-504. https://doi.org/10.4103/1673-5374.202916.
7. Jenkins K, Wong DT, Correa R. Management choices for the difficult airway by anesthesiologists in Canada. Can J Anesth. 2002;49(8):850-6. https://doi.org/10.1007/BF03017419.
8. Lord SA, Boswell WC, Williams JS, et al. Airway control in trauma patients with cervical spine fractures. Prehosp Disaster Med. 1994;9(1):44-9. https://doi.org/10.1017/S1049023X00040838.
9. Rosenblatt WH, Wagner PJ, Ovassapian A, Kain ZN. Practice patterns in managing the difficult airway by anesthesiologists in the United States. Anesth Analg. 1998;87(1):153-7. https://doi.org/10.1213/00000539-199807000-00032.
10. Sriganesh K, Busse JW, Shanthanna H, Ramesh VJ. Airway management in the presence of cervical spine instability: a cross-sectional survey of the members of the Indian Society of Neuroanaesthesiology and Critical Care. Indian J Anaesth. 2018;62(2):115-20. https://doi.org/10.4103/ija.IJA_671_17.
11. Harris PA, Taylor R, Thielke R, et al. Research electronic data capture (REDCap) - a metadata-driven methodology and workflow process for providing translational research informatics support. J Biomed Inform. 2009;42(2):377-81. https://doi.org/10.1016/j.jbi.2008.08.010.
12. Kempthorne P, Morriss WW, Mellin-Olsen J, Gore-Booth J. The WFSA global anesthesia workforce survey. Anesth Analg. 2017;125(3):981-90. https://doi.org/10.1213/ANE.0000000000002258.
13. Krejcie RV, Morgan DW. Determining sample size for research activities. Educ Psych Meas. 1970;30:607-10. https://doi.org/10.1177/001316447003000308.
14. Altman DGM, Machin D, Bryant TN, Gardner MJ. Statistics with confidence: confidence intervals and statistical guidelines. Bristol: BMJ Books; 2000.
15. Coetzee JF, Kluyts H. Burnout and areas of work-life among anaesthetists in South Africa. Part 1: Burnout. South Afr J Anaesth Analg. 2020;26(2):73-82. https://doi.org/10.36303/SAJAA.2020.26.2.2358.
16. Eysenbach G. Improving the quality of web surveys: the checklist for reporting results of internet e-surveys (CHERRIES). J Med Internet Res. 2004;6(3):e34. https://doi.org/10.2196/jmir.6.3.e34.
17. Alhomary M, Ramadan E, Curran E, Walsh SR. Videolaryngoscopy vs. fibreoptic bronchoscopy for awake tracheal intubation: a systematic review and meta-analysis. Anaesthesia. 2018;73(9):1151-61. https://doi.org/10.1111/anae.14299.
18. Apfelbaum JL, Hagberg CA, Caplan RA, et al. Practice guidelines for management of the difficult airway: an updated report by the American Society of Anesthesiologists task force on management of the difficult airway. Anesthesiology. 2013;118(2):251-70. https://doi.org/10.1097/ALN.0b013e31827773b2.
19. Jain D, Bala I, Gandhi K. Comparative effectiveness of McCoy laryngoscope and CMAC® videolaryngoscope in simulated cervical spine injuries. J Anaesthesiol Clin Pharmacol. 2016;32(1):59-64. https://doi.org/10.4103/0970-9185.173349.
20. Turkstra TP, Craen RA, Pelz DM, Gelb AW. Cervical spine motion: a fluoroscopic comparison during intubation with lighted stylet, GlideScope, and Macintosh laryngoscope. Anesth Analg. 2005;101(3):910-5. https://doi.org/10.1213/01.ane.0000166975.38649.27.
21. Prasarn ML, Conrad B, Rubery PT, et al. Comparison of 4 airway devices on cervical spine alignment in a cadaver model with global ligamentous instability at C5-C6. Spine. 2012;37(6):476-81. https://doi.org/10.1097/BRS.0b013e31822419fe.
22. Wilson WM, Smith AF. The emerging role of awake videolaryngoscopy in airway management. Anaesthesia. 2018;73(9):1058-61. https://doi.org/10.1111/anae.14324.
23. Drenguis AS, Carlson JN. GlideScope vs. C-MAC for awake upright laryngoscopy. J Emerg Med. 2015;49(3):361-8. https://doi.org/10.1016/j.jemermed.2015.02.014.
24. Goutcher CM, Lochhead V. Reduction in mouth opening with semi-rigid cervical collars. Br J Anaesth. 2005;95(3):344-8. https://doi.org/10.1093/bja/aei190.
25. Manoach S, Paladino L. Manual in-line stabilization for acute airway management of suspected cervical spine injury: historical review and current questions. Ann Emerg Med. 2007;50(3):236-45. https://doi.org/10.1016/j.annemergmed.2007.01.009.
26. Ahmad I, El-Boghdadly K, Bhagrath R, et al. Difficult airway society guidelines for awake tracheal intubation (ATI) in adults. Anaesthesia. 2019;75(4):442-6. https://doi.org/10.1111/anae.14904.
27. Zdravkovic M, Berger-Estilita J, Sorbello M, Hagberg CA. An international survey about rapid sequence intubation of 10 003 anaesthetists and 16 airway experts. Anaesthesia. 2020;75(3):313-22. https://doi.org/10.1111/anae.14867.
28. Zdravkovic M, Osinova D, Brull SJ, et al. Perceptions of gender equity in departmental leadership, research opportunities, and clinical work attitudes: an international survey of 11 781 anaesthesiologists. Br J Anaesth. 2020;124(3):e160-e70. https://doi.org/10.1016/j.bja.2019.12.022.

Supplementary file available online