ORIGINAL RESEARCH

Current airway management practices after a failed intubation attempt in Australian and New Zealand emergency departments

Isaac ARNOLD,[1] Hatem ALKHOURI [1,2,3] Helen BADGE,[3,4] Toby FOGG,[5,6] Sally MCCARTHY [1,2,7] and John VASSILIADIS[5,8]

[1]Faculty of Medicine, The University of New South Wales, Sydney, New South Wales, Australia, [2]Emergency Care Institute, Agency for Clinical Innovation, Sydney, New South Wales, Australia, [3]Ingham Institute for Applied Medical Research, Sydney, New South Wales, Australia, [4]School of Allied Health, Faculty of Health Science, Australian Catholic University, Sydney, New South Wales, Australia, [5]Emergency Department, Royal North Shore Hospital, Sydney, New South Wales, Australia, [6]CareFlight, Sydney, New South Wales, Australia, [7]Emergency Department, Prince of Wales Hospital, Sydney, New South Wales, Australia, and [8]Discipline of Emergency Medicine, Northern Clinical School, The University of Sydney Medical School, Sydney, New South Wales, Australia

Abstract

Objective: The aims of the present study were to describe current airway management practices after a failed intubation attempt in Australian and New Zealand EDs and to explore factors associated with second attempt success.
Methods: Data were collected from a multicentre airway registry (The Australian and New Zealand Emergency Department Airway Registry). All intubation episodes that required a second attempt between March 2010 and November 2015 were analysed. Analysis for association with success at the second attempt was undertaken for patient factors including predicted difficulty of laryngoscopy, as well as for changes in laryngoscope type, adjunct devices, intubator and intubating manoeuvres.
Results: Of the 762 patients with a failed first intubation attempt, 603 (79.1%) were intubated successfully at the second attempt. The majority of second attempts were

undertaken by emergency consultants (36.8%) and emergency registrars (34.2%). A change in intubator occurred in 56.5% of intubation episodes and was associated with higher second attempt success (unadjusted odds ratio [OR] 1.85; 95% confidence interval [CI] 1.29–2.65). In 69.7% of second attempts at intubation, there was no change in laryngoscope type. Changes in laryngoscope type, adjunct devices and intubation manoeuvres were not significantly associated with success at the second attempt. In adjusted analyses, second attempt success was higher for a change from a non-consultant intubator to a consultant intubator from any specialty (adjusted OR 2.31; 95% CI 1.35–3.95) and where laryngoscopy was not predicted to be difficult (adjusted OR 2.58; 95% CI 1.58–4.21).
Conclusions: The majority of second intubation attempts were undertaken by emergency consultants and registrars. A change from a non-consultant intubator to a consultant

Key findings

- First descriptive study of airway management manoeuvres following a failed intubation attempt in Australian and New Zealand EDs.
- A change in intubator occurred in just over half of intubation episodes.
- A predicted non-difficult airway, any change in intubator, and a change from a non-consultant to consultant intubator were associated with higher success at second intubation attempt while changes in intubation devices and other manoeuvres did not improve success at the second attempt.

intubator of any specialty for the second attempt and intubation episodes where laryngoscopy was predicted to be non-difficult were associated with a higher success rate at intubation. Participation in routine collection and monitoring of airway management practices via a Registry may enable the introduction of appropriate improvements in airway procedures and reduce complication rates.

Correspondence: Dr Hatem Alkhouri, Emergency Care Institute, Agency for Clinical Innovation, Level 3, 1 Reserve Road, St. Leonards, NSW 2065, Australia. Email: hatem.alkhouri@health.nsw.gov.au

Isaac Arnold, BMed, MD, Student; Hatem Alkhouri, BAppSci, MSc, PhD, ECI Research Fellow; Helen Badge, BOT, MSc, Lecturer in Occupational Therapy; Toby Fogg, BM, FACEM, FRCEM, Senior Staff Specialist, CareFlight Medical Director; Sally McCarthy, MBBS, FACEM, MBA, FIFEM, Former Clinical Director, Senior Staff Specialist, Conjoint Associate Professor; John Vassiliadis, MBBS, FACEM, Senior Staff Specialist, Clinical Associate Professor, Director Prevocational Education and Training, Director Hospital Non-Specialist Program.

Introduction

Rapid sequence induction (RSI) is the standard approach for endotracheal intubation in the ED, whereby a sedative and paralytic agent are administered to allow insertion of an endotracheal tube with the goal of maintaining adequate oxygenation in the critically ill patient.[1] Emergency airway registries have been established globally, including in Australia and New Zealand, the UK, the USA, Canada, Japan and South Korea. Australasian first-pass success (FPS) rates (84.3%),[2] defined as successful placement of an endotracheal tube following the first pass of the laryngoscope into the mouth, are comparable to those in the USA (86% FPS for 2010–2012),[3] Japan (76% in 2016)[4] and South Korea (81% for 2006–2010),[5] with an average FPS rate of 84.1% across all registries.[6]

Although success rates for ED intubation are generally high, intubation episodes requiring multiple attempts have a higher incidence of adverse events.[7] Increased rates of desaturation, oesophageal intubation and post-intubation hypertension have been identified in patients requiring multiple intubation attempts.[8–10] In the UK, the Fourth National Audit Project (NAP4) triggered the development of new Difficult Airway Society (DAS) Airway Management guidelines and a re-evaluation of strategies for intubation failure after analysis of 15 ED airway management episodes, which resulted in serious adverse events.[11,12] The DAS recommendations included a maximum of three attempts at tracheal intubation; repeated attempts with no changes in personnel, patient positioning, laryngoscope or adjunct devices were not recommended.[12] A similar Australian analysis of 36 reported incidents with complications in ED airway management identified key lessons to improve communication, planning and equipment preparation which were consistent with the recommendations of the NAP4 study, including the mandatory use of capnography.[13]

A previous Australian and New Zealand Emergency Department Airway Registry (ANZEDAR) study found that the majority of intubations performed in ANZEDAR participating sites were by emergency medicine (EM) physicians, with FPS significantly higher for consultant intubators, and for operators who had performed at least 10 prior intubations.[2] Moreover, in episodes requiring multiple attempts, there was an increase in the incidence of intubation complications including desaturation, oesophageal intubation, vomit with aspiration and cardiac arrest.[2] Factors associated with success at the second attempt (SSA) identified from prospective registry data in South Korea included emergency physician and senior physician intubators, non-difficult airways and the use of RSI.[14] A recent analysis of changes in practice between the first and second attempts in Japan found that 43% of intubation episodes included a change in intubator, device or manoeuvres.[15] Factors associated with SSA were a change to an EM resident or attending physician intubator, and a change from non-RSI to RSI.[15]

In Australia and New Zealand, trainees in EM complete mandatory training in critical care and airway management developed by the Australasian College for Emergency Medicine (ACEM), which involves simulated exercises in challenging airways.[16,17] The training module guidelines emphasise tailoring the intubation approach to the clinical situation and formulating a clear plan for failure.[17] Although descriptive analysis of current intubation practice in Australasian EDs has been undertaken,[2,18–20] there has been no specific analysis of changes in intubator, devices and manoeuvres following a failed first attempt. The present study aims to describe current practice in Australasian EDs following a failed first attempt at intubation and to identify factors associated with success at second attempt.

Methods

This is a planned analysis of data prospectively collected from participating sites (n = 42) for all intubation episodes, which occurred in the ED during Phase II of the ANZEDAR study between March 2010 and November 2015. After each intubation, outcomes were self-reported by the intubating doctor or team leader using the ANZEDAR form.[2] At each ED, the Principal Investigator (PI) collated and transcribed data from all intubation attempts for submission to the Emergency Care Institute as previously described.[2,18–20] PIs inspected medical records for incomplete intubation outcomes and, where necessary, contacted the intubator to have it completed. Sites were required to maintain a dataset with ≥90% of all intubation episodes captured over a minimum of 6 months to be eligible for inclusion.

The definitions for variables used within the ANZEDAR dataset have been described previously.[2,18–21] In summary, an intubation attempt was defined as a single pass of the laryngoscope blade into the mouth, while an intubation episode was defined as the entirety of the intubation process including all intubation attempts.[2] An expert intubator was considered to have undertaken more than 100 previous intubations, while a novice intubator had undertaken less than 10. Intubators included resident medical officers (RMOs), senior resident medical officers (SRMOs), registrars and consultants. Predicted difficulty of laryngoscopy and whether a formal airway assessment was performed were recorded for each intubation episode. Laryngoscope type was defined as Macintosh (direct), video (including combined direct and video laryngoscopes) or other. Adjunct devices captured in this analysis included the use of a bougie or stylet. The use of cricoid pressure, external laryngeal manipulation and manual in-line stabilisation were captured for each attempt. Data for other intubation manoeuvres were not stratified for each attempt and were not included.

Statistical analysis

All adult and paediatric intubation episodes requiring multiple attempts were eligible for inclusion in the study. For each variable in intubator and patient characteristics, devices and manoeuvres used at the second

attempt, and for changes in practice between intubation attempts, univariate analysis of intubation success rates was undertaken using χ^2 tests, with a P-value <0.05 considered significant. For each variable in the unadjusted analyses, SSA is reported as a proportion of entries for which valid data were provided.

A logistic regression was performed to adjust for confounding factors. Demographic variables (patient age, sex, indication for intubation and site role delineation level) were included in the model. Changes in intubator seniority (collapsed into two groups – non-consultant intubators and consultant intubators of any specialty), changes in laryngoscope type (between direct and video laryngoscopes), changes in the use of cricoid pressure and predicted difficulty of laryngoscopy were also included in the model on the basis of significant χ^2 analyses or where clinically relevant. Intubation episodes with no missing data for all of the included variables were included in the logistic regression. Odds ratios (ORs) with 95% confidence intervals (CIs) are presented for the logistic regression model. As a result of sample size constraints, intubation episodes in which a decrease in intubator seniority occurred were excluded from the regression, as were those where cricoid pressure was added for the second attempt and those which utilised a laryngoscope classified as 'Other'.

The Northern Sydney Local Health District Human Research Ethics Committee approved the ANZEDAR project, and the Human Research Ethics Committee at each site approved data collection. Data collection for Phase II of the ANZEDAR study concluded in 2015.

Results

Forty-two EDs provided data for 4806 intubation episodes between March 2010 and November 2015. Failure on the first attempt at intubation occurred in 762/4806 (15.9%) of the episodes. Overall, SSA was achieved in 603 (79.1%) of these episodes. Where percentages are listed, the denominator is valid intubation episodes requiring multiple attempts.

Patient demographics

Demographic data for the patients who required more than one attempt at intubation are summarised in Table 1. Median age was 52 years (IQR 34–67), with no significant variation in SSA by age group. Laryngoscopy was predicted to be difficult in 55.3% (n = 394) of intubation episodes for which data were recorded; in these intubation episodes, SSA was significantly lower ($P < 0.001$).

Unadjusted analyses: intubator, devices and manoeuvres

Characteristics of intubators, devices and manoeuvres at the first and second intubation attempts are listed in Table 2. Expert intubators (who previously have done more than 100 intubations) undertook 28.4% of first attempts (n = 210) and 64.0% of second attempts (n = 471). Emergency consultants performed 10.0% of first attempts (n = 76) and 36.8% of second attempts (n = 279) and had higher success rates than ED registrars at the second attempt (86.4% vs 75.6%; P = 0.005).

A video laryngoscope was used in 54.3% of first attempts (n = 404)

TABLE 1. *Characteristics of patients undergoing multiple intubation attempts* (n = 762)

	n (%)	SSA (%)	P-value†
Age group			0.471
≤18	53 (7.1)	75.5	
19–39	181 (24.1)	81.2	
40–64	303 (40.3)	76.9	
65–84	174 (23.2)	80.5	
≥85	39 (5.2)	87.2	
Total	750		
Sex			0.697
Male	529 (69.9)	79.0	
Female	228 (30.1)	80.3	
Total	757		
ACEM role delineation level			0.607
Major referral	586 (76.9)	78.3	
Urban district	88 (11.5)	81.8	
Rural/regional base	88 (11.5)	81.8	
Total	762		
Indication			0.489
Medical	558 (73.2)	79.7	
Trauma	204 (26.8)	77.5	
Total	762		
Difficult laryngoscopy predicted			<0.001
Yes	394 (55.3)	72.8	
No	318 (44.7)	85.8	
Total	712		

†P-values obtained using χ^2 tests.

TABLE 2. *Characteristics of intubators, devices and manoeuvres at the first and second intubation attempt for intubation episodes requiring multiple attempts*

	Attempt 1, *n* (%)	Attempt 2, *n* (%)	SSA (%)	*P*-value†
Intubator # of previous intubations				0.134
<10	171 (23.1)	38 (5.2)	73.7	
10–100	359 (48.5)	227 (30.8)	75.3	
>100	210 (28.4)	471 (64.0)	81.3	
Total	740	736		
Intubator specialty and seniority				0.005
ED consultant	76 (10.0)	279 (36.8)	86.4	
ED registrar	460 (60.4)	258 (34.2)	75.6	
Anaesthetics/ICU	73 (9.6)	158 (20.8)	72.8	
RMO/SRMO	110 (14.5)	35 (4.6)	80.0	
Other‡	42 (5.5)	28 (3.7)	75.0	
Total	761	758		
Laryngoscope§				0.195
Direct	340 (45.7)	359 (49.7)	81.1	
Video	404 (54.3)	363 (50.3)	77.1	
Total	744	722		
Adjunct devices				0.375
Bougie	353 (50.9)	459 (63.3)	79.5	
Stylet	169 (24.4)	159 (21.9)	78.6	
Neither	172 (24.8)	107 (14.8)	85.0	
Total	694	725		
Cricoid pressure				0.010
Cricoid pressure	247 (35.1)	216 (30.6)	74.1	
No cricoid pressure	456 (64.9)	491 (69.4)	82.5	
Total	703	707		
ELM				0.007
ELM	244 (38.5)	240 (36.6)	74.6	
No ELM	389 (61.5)	415 (63.4)	83.4	
Total	633	655		
MILS				0.953
MILS	167 (23.6)	168 (24.0)	79.8	
No MILS	540 (76.4)	533 (76.0)	79.5	
Total	707	701		

†*P*-values obtained using χ^2 tests. ‡Includes CMOs, GPs, paediatricians and nurses. §'Other' laryngoscopes excluded. ELM, external laryngeal manipulation; ICU, intensive care unit; MILS, manual in-line stabilisation; RMO, resident medical officer; SRMO, senior resident medical officer; SSA, second attempt success rate.

and 50.3% of second attempts (*n* = 363), and there was no significant difference in SSA between the use of a direct or video laryngoscope. The application of cricoid pressure was associated with lower success at the second attempt (74.1% SSA compared to 82.5% without cricoid pressure; *P* = 0.01) (Table 2).

Changes in intubator, devices and manoeuvres

Results for paired data showing changes in intubator, laryngoscope

TABLE 3. *Changes in intubator, laryngoscope and manoeuvres between the first and second intubation attempts*

	n (%)	SSA (%)	P-value†
Change in intubator			0.001
No change in intubator	320 (43.5)	73.8	
Change in intubator	415 (56.5)	83.9	
Total	735		
Change in intubator seniority			0.001
Both non-consultant	406 (53.6)	73.9	
Non-consultant to consultant	241 (31.8)	87.1	
Consultant to non-consultant	14 (1.8)	85.7	
Both consultant	97 (12.8)	80.4	
Total	758		
Change in intubator specialty			0.081
Both non-EM	116 (15.3)	71.6	
Non-EM to EM	88 (11.6)	80.7	
EM to non-EM	93 (12.3)	75.3	
Both EM	462 (60.9)	81.6	
Total	759		
Change in intubator experience			0.004
Both ≤100 intubations	258 (35.4)	74.4	
Increase in experience	265 (36.4)	85.7	
Both >100 intubations	199 (27.3)	75.9	
Decrease in experience	6 (0.8)	100	
Total	728		
Change in laryngoscope‡			0.011
Both DL	232 (32.1)	79.7	
DL to VL	92 (12.7)	66.3	
VL to DL	127 (17.6)	83.5	
Both VL	271 (37.5)	80.8	
Total	722		
Change in cricoid pressure			0.065
Both no cricoid pressure	420 (62.3)	82.1	
Cricoid pressure added	15 (2.2)	60.0	
Cricoid pressure removed	43 (6.4)	79.1	
Both cricoid pressure	196 (29.1)	75.5	
Total	674		
Change in ELM			<0.001
Both no ELM	302 (49.5)	81.5	
ELM added	77 (12.6)	85.7	
ELM removed	85 (13.9)	88.2	
Both ELM	146 (23.9)	67.1	
Total	610		

(Continues)

and devices between the first and second attempts are reported in Table 3. A switch from one intubator to another after the first failed attempt occurred in 56.5% of intubation episodes (n = 415). Changing intubator resulted in a higher SSA than retaining the same intubator for both attempts (83.9% vs 73.8%; unadjusted OR 1.85 [95% CI 1.29–2.65]; P = 0.001).

The characteristics of the first intubation attempt, which were associated with a change in intubator, are detailed in Table 4. After the first failed attempt was undertaken by a novice intubator, a change in intubator occurred in 77.8% of intubation episodes (n = 133/171), compared to 35.7% of intubation episodes (n = 71/199) when the first attempt was undertaken by an expert intubator (P < 0.001). When an ED consultant undertook the first attempt, a change in intubator occurred in 26.3% of episodes (n = 20/76), compared to 72.7% when the first attempt was by an RMO or SRMO (n = 80/110), and 58.4% when the first attempt was by an ED registrar (n = 264/452) (P < 0.001).

In 37.5% of intubation episodes (n = 271), the first and second attempts were both undertaken using a video laryngoscope, which resulted in 80.8% SSA (Table 3). A change from direct to video laryngoscope occurred in 12.7% of intubation episodes (n = 92) and intubation was less successful in the unadjusted model (SSA = 66.3%; P = 0.011) (Table 3).

Predicted difficulty of laryngoscopy

Expert intubators were more likely to undertake the first intubation attempt when difficulty was predicted; 65.5% of first attempts undertaken by expert intubators were predicted to be difficult (n = 127/194), compared to 41.7% of first attempts by novice intubators (n = 68/163) (P < 0.001). Choice of laryngoscope was also associated with predicted difficulty; 65.5% of intubation episodes that involved a change from direct to video

TABLE 3. *Continued*

	n (%)	SSA (%)	*P*-value†
Change in MILS			0.424
Both no MILS	508 (73.8)	79.3	
MILS added	10 (1.5)	70.0	
MILS removed	10 (1.5)	60.0	
Both MILS	160 (23.3)	80.0	
Total	688		

†*P*-values obtained using χ^2 tests. ‡'Other' laryngoscopes excluded. DL, direct laryngoscope; ELM, external laryngeal manipulation; EM, emergency medicine (registrars and consultants); MILS, manual in-line stabilisation; SSA, second attempt success rate; VL, video laryngoscope.

TABLE 4. *Change in intubator (%) versus characteristics of the first intubation attempt*

	Change in intubator, *n* (%)	*P*-value†
Intubator experience		<0.001
<10 intubations	133/171 (77.8)	
10–100 intubations	199/344 (57.8)	
>100 intubations	71/199 (35.7)	
Intubator specialty and seniority		<0.001
ED consultant	20/76 (26.3)	
ED registrar	264/452 (58.4)	
Anaesthetics/ICU	27/56 (48.2)	
RMO/SRMO	80/110 (72.7)	
Other‡	24/41 (58.5)	
Laryngoscope§		0.514
Direct	184/317 (58.0)	
Video	223/401 (55.6)	
Difficult laryngoscopy predicted		0.261
Yes	208/381 (54.6)	
No	179/304 (58.9)	

†*P*-values obtained using χ^2 tests. ‡Includes CMOs, GPs, paediatricians and nurses. §'Other' laryngoscopes excluded. ICU, intensive care unit; RMO, resident medical officer; SRMO, senior resident medical officer.

laryngoscope for the second attempt were predicted to be difficult (*n* = 55/84), while 47.2% of intubation episodes that retained direct laryngoscopy for both attempts were predicted to be difficult (*n* = 100/212) (*P* = 0.012).

Adjusted results

The logistic regression model included 566 intubation episodes. Adjusted SSA ORs for variables included in the logistic regression model are reported in Figure 1.

Relative to intubation episodes with both attempts undertaken by non-consultants (*n* = 303 [53.5%]), changing to a consultant of any specialty for the second attempt (*n* = 182 [32.2%]) yielded higher SSA (adjusted OR 2.31; 95% CI 1.35–3.95). When difficult laryngoscopy was not predicted (*n* = 253 [44.7%]), SSA was similarly increased (adjusted OR 2.58; 95% CI 1.58–4.21). When adjusted for other covariates, changes in laryngoscope type and the use of cricoid pressure were not significant predictors of SSA.

Discussion

This is the first registry-based study that has described changes in practice following a failed intubation attempt in Australasian EDs. The present study found that a change in intubator occurred in just over half of intubation episodes and was more likely to occur when the first failed attempt was undertaken by a novice intubator. A predicted non-difficult airway, any change in intubator and a change from a non-consultant to consultant intubator of any specialty were associated with higher SSA, while changes in intubation devices and manoeuvres yielded no significant differences.

The results of the present study are consistent with airway registry studies in Japan and South Korea reporting on intubator characteristics and outcomes affecting SSA. Emergency consultants and registrars undertook a majority of second attempts in the present study (70.7%), compared to 89.1% and 54.6% in Korea and Japan, respectively.[14,15] Both international studies also identified intubator seniority as a predictor of second attempt intubation success, via a change to an EM attending physician in Japan (equivalent to an EM consultant in Australia and New Zealand) (adjusted OR 2.82; 95% CI 2.14–3.71; *P* < 0.001), and a senior physician with 4+ years of postgraduate training in Korea (adjusted OR 1.50; 95% CI 1.10–2.07; *P* = 0.012).[14,15] These results mirror our finding of improved SSA associated with a
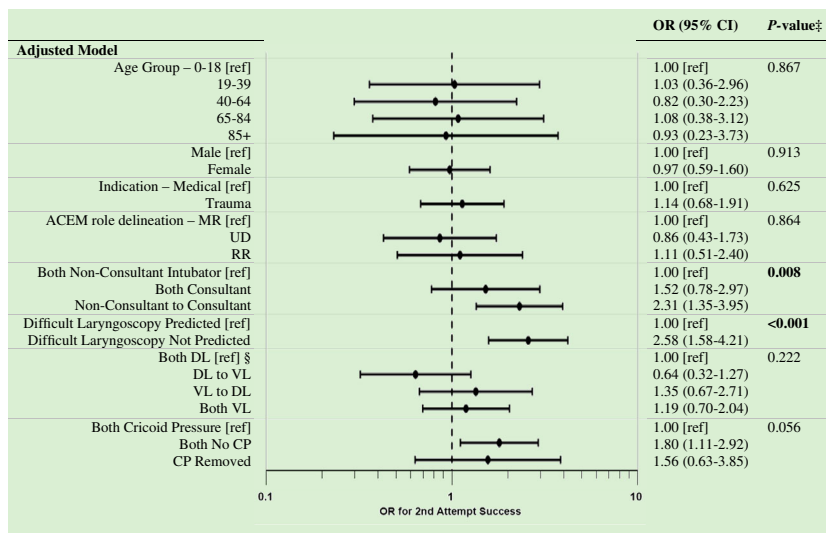
Figure 1. *Association of patient and intubator factors, and device and manoeuvre choices, with second attempt intubation success. ‡P-values obtained using χ^2 tests. §'Other' laryngoscopes excluded. CI, confidence interval; CP, cricoid pressure; DL, direct laryngoscope; MR, major referral; OR, odds ratio; RR, rural/regional; UD, urban district; VL, video laryngoscope.*

change from a non-consultant intubator to a consultant intubator of any specialty.

Goto *et al.* demonstrated that multiple attempts by the same intubator are less successful than a switch to an alternate intubator for the second attempt (adjusted OR 0.50; 95% CI 0.36–0.71).[22] Consistent with this previous research, our study also reported a greater likelihood of second-pass success associated with any change in intubator compared to no change in intubator. A change in intubator was significantly more likely to occur when the first attempt was undertaken by a novice intubator or RMO/SRMO than when it was undertaken by an expert intubator or ED consultant, so the resultant increase in intubator seniority for the second attempt could partially explain the higher SSA for any change in intubator. Although predicted difficulty of laryngoscopy was not itself significantly associated with a change in intubator, it could potentially confound the likelihood of a change in intubator by affecting the choice of intubator at the first attempt; it is plausible that more difficult first attempts were undertaken by more senior intubators.

Previous research has shown higher success rate at the first[2,23,24] and second[25] attempts when a video laryngoscope was used over traditional direct laryngoscopes. Sakles *et al.* reported that regardless of the laryngoscope type used at the first attempt, using video laryngoscopy at the second attempt at intubation was associated with a higher rate of SSA (adjusted OR 3.5; 95% CI 1.9–6.7).[25] Interestingly, this association did not manifest in the present study. Although univariate analysis showed no significant difference in SSA for laryngoscope choice at the second attempt, there was a significant reduction in SSA in the unadjusted model for the small proportion of intubation episodes, which switched from direct to video laryngoscopy. However, this association did not retain significance in the adjusted model, which is consistent with findings from the Japanese airway registry showing no significant association between changes in laryngoscope type and SSA.[15] In most intubation episodes, there was no change in laryngoscope type between attempts, but the decision to change is likely influenced by a complex array of

factors including changes in intubator seniority and personal preferences, and predicted difficulty of laryngoscopy. A number of recent studies have found that video laryngoscopy did not increase FPS in the ICU setting[26,27] or reduce intubation related complications in the ward setting[28] and it is likely that there is a complex interplay of factors influencing success. There was also a degree of ambiguity for some intubation episodes regarding the classification of laryngoscope type; due to the high proportion of missing data for the field reporting direct and video Cormack & Lehane grade, it was not always possible to determine whether an intubation attempt that listed the use of a combined direct/video laryngoscope was being used to obtain a direct or indirect view.

The removal of cricoid pressure after an unsuccessful attempt was not observed with high enough frequency to determine a significant effect, because of the vast majority of intubation episodes used cricoid pressure at both attempts or at neither attempt. Given the remaining controversy over the role of cricoid pressure in emergency airway management, the cricoid pressure variable was retained in the regression model despite non-significant differences in the univariate analyses because of its potential clinical relevance.[29,30] Further research is needed to determine the effectiveness of the removal of cricoid pressure following intubation failure during emergency RSI.

Limitations

There are several limitations to the present study. The nature of prospective observational data limits the extent to which causal links can be established, compounded by the impact of missing data and the potential variation in clinical practice across participating sites, which are inherent to multicentre registries. The use of an online data collection form in ANZEDAR Phase III will likely reduce the proportions of missing data and provide uniformity in the data reporting process. It was also

not possible to identify changes in RSI use between attempts, since medications administered were not strictly stratified by each attempt. Similarly, bag valve mask use and changes in patient positioning were reported on the ANZEDAR form but not linked to specific attempts, which prevented analysis of changes in practice after the first attempt. More generally, the present study analysed for association with SSA but did not address adverse outcomes, which are demonstrated to increase in frequency with multiple intubation attempts.[2]

Conclusions

Following a failed intubation attempt, a change to a consultant intubator of any specialty is associated with SSA. Although intubation success rates in Australasian EDs are high, the increased risk of adverse events associated with multiple attempts warrants further research to maximise success rates after the first failed attempt. Training pathways must consider the higher rates of intubation failure for less experienced intubators and balance adequate exposure of trainees to difficult airway management while maximising patient safety through senior intubator oversight. Further research may investigate the implications of practice after a failed attempt and its impact on mortality and adverse events.

Acknowledgements

Author contributions

IA and HA drafted the manuscript with HB. HA coordinated the study, provided data and statistical analysis. IA and HB provided data and statistical analysis. All authors revised the manuscript and approved the final draft. TF is Principal Investigator of the ANZEDAR.

Competing interests

SM is a section editor for *Emergency Medicine Australasia*.

Data availability statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

References

1. Edelman DA, Perkins EJ, Brewster DJ. Difficult airway management algorithms: a directed review. *Anaesthesia* 2019; **74**: 1175–85.

2. Alkhouri H, Vassiliadis J, Murray M *et al.* Emergency airway management in Australian and New Zealand emergency departments: a multicentre descriptive study of 3710 emergency intubations. *Emerg. Med. Australas.* 2017; **29**: 499–508.

3. Brown CA 3rd, Bair AE, Pallin DJ, Walls RM, Investigators NI. Techniques, success, and adverse events of emergency department adult intubations. *Ann. Emerg. Med.* 2015; **65**: 363–70.

4. Goto Y, Goto T, Hagiwara Y *et al.* Techniques and outcomes of emergency airway management in Japan: an analysis of two multicentre prospective observational studies, 2010-2016. *Resuscitation* 2017; **114**: 14–20.

5. Cho YS, Cho J, Chung HS, Korean Emergency Airway Registry I. Assessment of emergency airway management techniques in Korea using an online registration system: a multicenter study. *J. Emerg. Med.* 2015; **48**: 1–9.

6. Park L, Zeng I, Brainard A. Systematic review and meta-analysis of first-pass success rates in emergency department intubation: creating a benchmark for emergency airway care. *Emerg. Med. Australas.* 2017; **29**: 40–7.

7. Sakles JC, Chiu S, Mosier J, Walker C, Stolz U. The importance of first pass success when performing orotracheal intubation in the emergency department. *Acad. Emerg. Med.* 2013; **20**: 71–8.

8. Hasegawa K, Shigemitsu K, Hagiwara Y *et al.* Association between repeated intubation attempts and adverse events in emergency departments: an analysis of a multicenter prospective observational study. *Ann. Emerg. Med.* 2012; **60**: 749–54.e2.

9. Bodily JB, Webb HR, Weiss SJ, Braude DA. Incidence and duration of continuously measured oxygen desaturation during emergency department intubation. *Ann. Emerg. Med.* 2016; **67**: 389–95.

10. Inoue A, Okamoto H, Hifumi T *et al.* The incidence of post-intubation hypertension and association with repeated intubation attempts in the emergency department. *PLoS One* 2019; **14**: e0212170-e.

11. Cook TM, Woodall N, Harper J, Benger J, Fourth National Audit Project. Major complications of airway management in the UK: results of the Fourth National Audit Project of the Royal College of Anaesthetists and the Difficult Airway Society. Part 2: intensive care and emergency departments. *Br. J. Anaesth.* 2011; **106**: 632–42.

12. Frerk C, Mitchell VS, McNarry AF *et al.* Difficult Airway Society 2015 guidelines for management of unanticipated difficult intubation in adults. *Br. J. Anaesth.* 2015; **115**: 827–48.

13. Crock C, Hansen K, Fogg T, Cahill A, Deakin A, Runciman WB. Lessons learnt from incidents involving the airway and breathing reported from Australasian emergency departments. *Emerg. Med. Australas.* 2018; **30**: 55–60.

14. Kim JH, Kim Y-M, Choi HJ, Je SM, Kim E, Korean Emergency Airway Management Registry I. Factors associated with successful second and third intubation attempts in the ED. *Am. J. Emerg. Med.* 2013; **31**: 1376–81.

15. Goto Y, Goto T, Okamoto H *et al.* Factors associated with successful

rescue intubation attempts in the emergency department: an analysis of multicenter prospective observational study in Japan. *Acute Med. Surg.* 2019; **7**: e462-e.

16. Australasian College for Emergency Medicine. Resource Manual for Airway Management in the Emergency Department [Resource Manual]. 2017.

17. Doshi D, McCarthy S, Mowatt E *et al.* Review article: critical care airway management eLearning modules. *Emerg. Med. Australas.* 2018; **30**: 743–8.

18. Ferguson I, Alkhouri H, Fogg T, Aneman A. Ketamine use for rapid sequence intubation in Australian and New Zealand emergency departments from 2010 to 2015: a registry study. *Emerg. Med. Australas.* 2019; **31**: 205–10.

19. Ghedina N, Alkhouri H, Badge H, Fogg T, McCarthy S. Paediatric intubation in Australasian emergency departments: a report from the ANZEDAR. *Emerg. Med. Australas.* 2020; **32**: 401–8.

20. Alkhouri H, Richards C, Miers J, Fogg T, McCarthy S. Case series and review of emergency front-of-neck surgical airways from The Australian and New Zealand Emergency Department Airway Registry. *Emerg. Med. Australas.* 2020; https://doi.org/10.1111/1742-6723.13678

21. Fogg T, Annesley N, Hitos K, Vassiliadis J. Prospective observational study of the practice of endotracheal intubation in the emergency department of a tertiary hospital in Sydney, Australia. *Emerg. Med. Australas.* 2012; **24**: 617–24.

22. Goto T, Watase H, Morita H *et al.* Repeated attempts at tracheal intubation by a single intubator associated with decreased success rates in emergency departments: an analysis of a multicentre prospective observational study. *Emerg. Med. J.* 2015; **32**: 781–6.

23. Vassiliadis J, Tzannes A, Hitos K, Brimble J, Fogg T. Comparison of the C-MAC video laryngoscope with direct Macintosh laryngoscopy in the emergency department. *Emerg. Med. Australas.* 2015; **27**: 119–25.

24. Min BC, Park JE, Lee GT *et al.* C-MAC video laryngoscope versus conventional direct laryngoscopy for endotracheal intubation during cardiopulmonary resuscitation. *Medicina (Kaunas)* 2019; **55**: 225.

25. Sakles JC, Mosier JM, Patanwala AE, Dicken JM, Kalin L, Javedani PP. The C-MAC® video laryngoscope is superior to the direct laryngoscope for the rescue of failed first-attempt intubations in the emergency department. *J. Emerg. Med.* 2015; **48**: 280–6.

26. Lascarrou JB, Boisrame-Helms J, Bailly A *et al.* Video laryngoscopy vs direct laryngoscopy on successful first-pass orotracheal intubation among ICU patients: a randomized clinical trial. *JAMA* 2017; **317**: 483–93.

27. Janz DR, Semler MW, Lentz RJ *et al.* Randomized trial of video laryngoscopy for endotracheal intubation of critically ill adults. *Crit. Care Med.* 2016; **44**: 1980–7.

28. Baek MS, Han M, Huh JW, Lim C-M, Koh Y, Hong S-B. Video laryngoscopy versus direct laryngoscopy for first-attempt tracheal intubation in the general ward. *Ann. Intensive Care* 2018; **8**: 83.

29. Salem MR, Khorasani A, Zeidan A, Crystal GJ. Cricoid pressure controversies: narrative review. *Anesthesiology* 2017; **126**: 738–52.

30. Algie CM, Mahar RK, Tan HB, Wilson G, Mahar PD, Wasiak J. Effectiveness and risks of cricoid pressure during rapid sequence induction for endotracheal intubation. *Cochrane Database Syst. Rev.* 2015; **11**: CD011656.