Bed tilt and ramp positions are associated with increased first-pass success of adult endotracheal intubation in the emergency department : A registry study

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ORIGINAL RESEARCH

Bed tilt and ramp positions are associated with increased first-pass success of adult endotracheal intubation in the emergency department: A registry study

Samantha BENNETT,[1,2] Hatem ALKHOURI,[3,4] Helen BADGE,[5] Elliot LONG,[6] Trevor CHAN,[3,7] John VASSILIADIS[8,9] and Toby FOGG[8,10]

[1]Faculty of Medicine, The University of Notre Dame Australia, Sydney, New South Wales, Australia, [2]Sydney Children's Hospital, Sydney, New South Wales, Australia, [3]Emergency Care Institute, Agency for Clinical Innovation, Sydney, New South Wales, Australia, [4]Faculty of Medicine, The University of New South Wales, Sydney, New South Wales, Australia, [5]School of Allied Health, Faculty of Health Science, Australian Catholic University, Sydney, New South Wales, Australia, [6]The Royal Children's Hospital, Murdoch Children's Research Institute, The University of Melbourne, Melbourne, Victoria, Australia, [7]Emergency Department, St George Hospital, Sydney, New South Wales, Australia, [8]Emergency Department, Royal North Shore Hospital, Sydney, New South Wales, Australia, [9]Discipline of Emergency Medicine, Northern Clinical School, The University of Sydney Medical School, Sydney, New South Wales, Australia, and [10]CareFlight, Sydney, New South Wales, Australia

Abstract

Objective: Successful endotracheal intubation in the ED requires optimum body positioning. In patients with obesity, the ramp position was suggested to achieve better intubating conditions. However, limited data are available on the airway management practices for patients with obesity in Australasian EDs. The aim of this study was to identify current patient positioning practices during endotracheal intubation and its association with first-pass success (FPS) at intubation and adverse event (AE) rates in obese and non-obese populations.

Methods: Prospectively collected data from the Australia and New Zealand ED Airway Registry (ANZEDAR) between 2012 and 2019 were analysed. Patients were categorised into two groups according to their weight: <100 kg (non-obese) or ≥100 kg (obese). Four position categories were investigated; supine, pillow or occipital pad, bed tilt and ramp or head-up with relation to FPS and complication rate using logistic regression modelling.

Results: A total of 3708 intubations from 43 EDs were included. Overall, the non-obese cohort had a greater FPS rate (85.9%) compared to the obese group (77.0%). The bed tilt position had the highest FPS rate (87.2%), whereas the supine position had the lowest (83.0%). AE rates were highest in the ramp position (31.2%) compared to all other positions (23.8%). Regression analysis showed ramp, or bed tilt positions and a consultant-level intubator were associated with higher FPS. Obesity, in addition to other factors, was independently associated with lower FPS.

Conclusion: Obesity was associated with lower FPS, which could be improved through performing a bed tilt or ramp positioning.

Key findings

- Obesity is associated with lower first-pass success rate at intubation.
- Ramp position was used during intubation in one out of three (36%) obese patients.
- Bed tilt and ramp positions were associated with higher first-pass success rate in all patients who required endotracheal intubation.

Key words: *airway management, airway registry, emergency department, patient position, successful intubation.*

Introduction

Endotracheal intubation is a lifesaving procedure for critically unwell and injured patients presenting to the ED.[1,2] Prolonged time to successful

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

Samantha Bennett, BN, BEH (Pmed), PGCertNP (Periop), MD Student; Hatem Alkhouri, BAppSci, MSc, PhD, ECI Research Fellow; Helen Badge, BAppSc (OT), MAppSc, PhD, Lecturer; Elliot Long, BSc, BMBS, FRACP, PGCertEcho, PhD, Paediatric Emergency Physician; Trevor Chan, FACEM, Clinical Director, Senior Staff Specialist; John Vassiliadis, MBBS, FACEM, Senior Staff Specialist, Clinical Professor, Chair of Prevocational Education and Training HETI NSW; Toby Fogg, BM, FACEM, FRCEM, Senior Staff Specialist, CareFlight Medical Director.

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intubation and multiple failed attempts are associated with a higher incidence of life-threatening adverse events (AEs) such as hypoxia and hypotension.[1,2]

Successful endotracheal intubation is directly related to the glottic view visualised via direct or video-assisted laryngoscopy.[3] Cormack–Lehane grade based on the amount of glottic opening visible, from grade 1, where most of the glottis is visible to grade 4, if no glottic opening or epiglottis can be seen.[4] There are some airway manoeuvres that can be performed to manipulate the larynx and improve the glottic view or reduce view disruption from vomiting; these include patient positioning, external laryngeal manipulation, backwards upwards right pressure, suctioning or cricoid pressure.[5,6] Airway adjuncts can also be used to improve chances of first-pass success (FPS) in patients with anatomically difficult airways or poor view on laryngoscopy.[5,7]

The alignment of the external acoustic meatus (EAM) with the sternal notch is optimal for aligning the airway to provide the best view of the glottic opening.[8–10] In patients with a normal body mass index (BMI), this requires a slight head tilt and chin lift in what is termed the 'sniffing' head position.[10,11] In larger patients, this optimal airway positioning requires a 'ramp' position with bed tilting and pillows to elevate the head and shoulders to ensure the EAM and sternal notch are aligned.[10,12] The ramp position during intubation is commonly used in anaesthetic practices in obese patients and has been shown to improve intubation success when airway was predicted to be difficult.[13–15] Higher rates of hypoxaemic complications are associated with difficult intubations due to prolonged time to intubation and limited preoxygenation.[16] Hypoxaemic complications can be minimised with ramping.[16,17]

The prevalence of a difficult airway is more likely in obese patients due to functional and anatomical differences such as larger neck circumference, poor chest wall compliance, lower functional residual capacity, diaphragmatic excursion and obstructive sleep apnoea.[18,19] Moving obese patients into a ramp position can improve lung compliance and increase functional residual capacity, thereby improving ventilation and minimising the risk of hypoxia from prolonged intubation attempts.[15]

There is substantial evidence to support ramping of obese patients in an anaesthetic setting,[16] but evidence is limited and conflicting for its use in the ED. Current clinical guidelines by the New South Wales Emergency Care Institute[20] and the UK's Difficult Airway Society (DAS) recommend positioning obese patients in the ramp position prior to induction and intubation attempts.[21] In Australia, most local and state colleges refer to the DAS guidelines although there is no nationally agreed recommendation.[21] Clinicians in ED may be reluctant to use ramping due to lack of familiarity, the requirement for cervical spine immobilisation in trauma patients, or the lack of equipment and training.[22] A recent large scale meta-analysis and systematic review indicated no difference in view or intubation outcomes between the ramp position *versus* the flat position,[23] although a sub-group analysis by obesity or weight was not possible due to variation in obesity data and definitions.[24]

The aims of the present study were to identify the current intubation practices across Australia and New Zealand and explore different patient positions for patients with obesity and those with normal body habitus, factors associated with improved FPS and the complication rates associated with different positioning.

Methods

The study is a planned analysis of prospectively collected data for

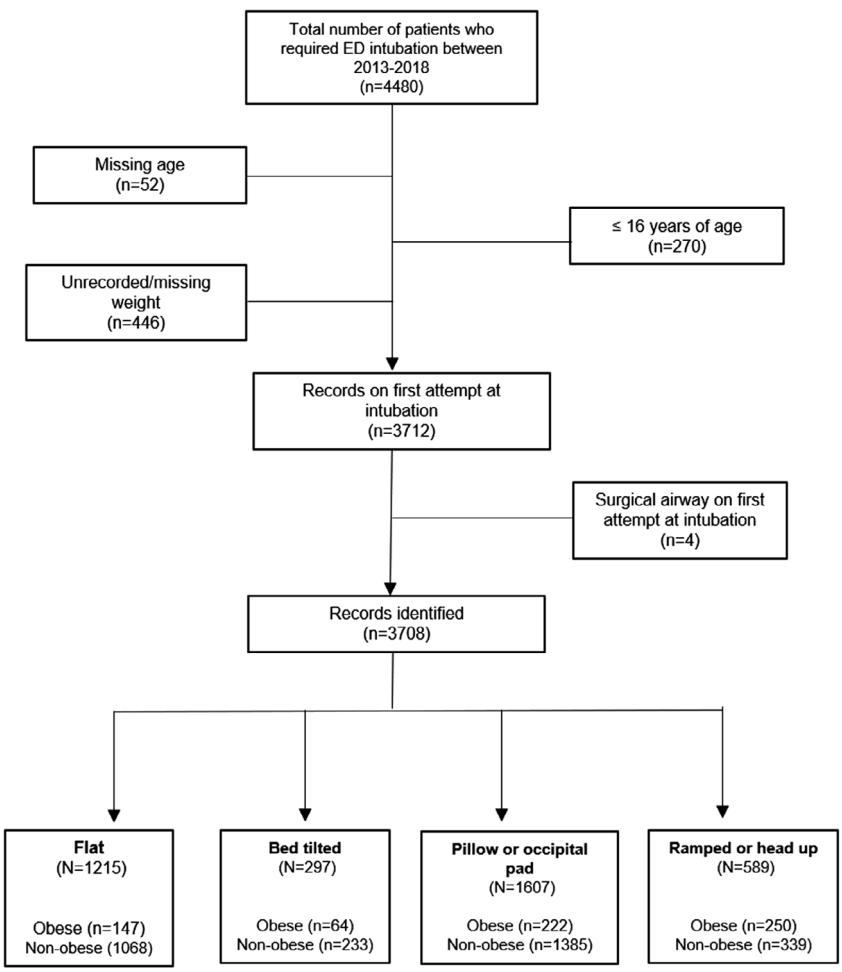

Figure 1. *Flow chart of study identification, inclusion and exclusion criteria.*

patients who underwent intubation between June 2012 and March 2019 inclusive across 43 EDs participating in the Australian and New Zealand ED Airway Registry (ANZEDAR). Registry forms were completed by intubating clinicians or team leaders, then unidentified data were entered by the principal investigator at each site. For the present study, data were extracted from the registry with a focus on patient position during the first intubation attempt.

Cases were excluded from analysis if they related to patients under 16 years, anyone requiring a surgical airway, presence of congenital syndromes, awake fibreoptic intubations, prehospital intubations, emergency cricothyroid intubations, death on arrival, and any entry with missing weight category (or absence of free text noting obese or obesity) or position data (Fig. 1). The study was reported in line with the Strengthening the Reporting of Observational Studies in Epidemiology guidelines for observational studies.[25]

Definitions for variables are consistent with previously reported ANZEDAR research.[7,26,27] Patient position categories were reported by the intubating clinician and included flat, bed tilt, pillow or occipital pad, and ramp or head-up. Participants were classified as obese if a clinician reported their estimated weight was 100 kg or over, or if the terms 'obese' or 'obesity' were documented in the free comment section. Neither height nor BMI data are available and the over 100 kg estimated weight classification of obesity is consistent among emergency field literature.[28] The best grade laryngeal view from either direct or video laryngoscopy was considered. The difficulty of the intubation was categorised as difficult (Cormack–Lehane grade of 3 or 4) or easy (Cormack–Lehane grade of 1 or 2). Intubator seniority and team leader seniority were dichotomised as Consultant (Consultant, Visiting Medical Officer [VMO]) or other. Intubator speciality was dichotomised as ED or other (intensive care, anaesthetics, general practitioner, paediatrics and other).

Indications for intubation were categorised as trauma, airway compromise, neurological impairment, cardiac compromise, haemodynamic instability and others. AEs recorded included oxygen desaturation, bradycardia, tachycardia, hypotension,

TABLE 1. *First-pass success (FPS) rate at intubation for patient position, and clinician speciality and seniority for patients assessed as obese* versus *not obese*

	Whole sample ($N = 3708$)		Not obese		Obese	
	Total number	FPS, *n* (%)	Total number	FPS, *n* (%)	Total number	FPS, *n* (%)
Position						
Flat	1215	1008 (83.0)	1068 (35.3)	902 (84.5)	147 (21.5)	106 (72.1)
Bed tilt	297	259 (87.2)	233 (7.7)	208 (89.3)	64 (9.4)	51 (79.7)
Pillow/occipital pad	1607	1364 (84.9)	1385 (45.8)	1191 (86.0)	222 (32.5)	173 (77.9)
Ramp/head-up	589	492 (83.5)	339 (11.2)	296 (87.3)	250 (36.6)	196 (78.4)
Intubator experience ($N = 3633$)						
<10	469	324 (69.1)	397 (13.5)	279 (70.3)	72 (10.9)	45 (62.5)
10–100	1443	1291 (89.5)	1151 (39.0)	1048 (91.1)	292 (44.1)	243 (83.2)
>100	1700	1429 (84.1)	1402 (47.5)	1209 (86.2)	298 (45.0)	220 (73.8)
Intubator specialty						
ED	3246	2726 (84.0)	2665 (88.1)	2287 (85.8)	581 (85.1)	439 (75.6)
Not ED	462	398 (86.1)	360 (11.9)	310 (86.1)	102 (15.0)	87 (85.3)
Intubator grade ($N = 3695$)						
Consultant	589	520 (88.3)	453 (15.4)	453 (93.4)	126 (18.5)	97 (77.0)
Not consultant	3103	2588 (83.4)	2549 (84.6)	2146 (84.2)	554 (81.5)	426 (76.9)
Team leader specialty ($N = 3701$)						
ED	3617	3045 (84.2)	2952 (97.8)	2534 (85.8)	665 (98.2)	511 (76.8)
Not ED	78	65 (83.3)	66 (2.2)	56 (84.8)	12 (1.8)	9 (75.0)
Team leader grade ($N = 3694$)						
Consultant	2506	2087 (83.3)	2038 (67.7)	1732 (85.0)	468 (69.2)	355 (75.9)
Not consultant	1181	1018 (86.2)	973 (32.3)	854 (87.8)	208 (30.8)	164 (78.8)

hypertension, cardiac arrest, aspiration, laryngospasm, mainstem bronchus intubation, oesophageal intubation, airway trauma, dental trauma, equipment failure, or medication error. AEs were condensed into one category of any AEs due to low event rates.

Statistical analysis

All analyses were conducted using the R Statistical Computing Platform (version 3.6.1). Unadjusted (bivariable) analyses were undertaken for each outcome. Multiple logistic regression was used to assess the association between obesity, patient position and FPS. Factors identified on unadjusted analysis with a P value <0.25 were entered into a backwards, stepwise multiple logistic regression model to identify the association between obesity, patient position and FPS as relevant for each analysis. The main predictors (obesity and patient position) were forced into the model. Missing data were imputed using multivariate imputation by chained equations. Model selection was performed using one of the imputed datasets. Effect estimates were taken from the pooled estimates using the five imputed datasets. Interaction terms for the main predictors (obesity and patient position) against each other variable were tested in the final model for each analysis. Sensitivity analyses were performed using complete case analysis and Bayesian information criterion instead of Akaike information criterion for the stepwise regression modelling.

Results

Of the 4480 intubation records collected, 3708 met the inclusion criteria. In this cohort, 683 (18.4%) were assessed as being obese and 3025 (81.6%) were not.

FPS rate by position and weight category

The non-obese cohort had a greater FPS rate of 85.9% compared to the cohort with obesity (77.0%) (Table 1). The most utilised intubation position for patients with obesity was the ramp or pillow position, whereas the non-obese group was predominantly intubated in the pillow or flat position (Fig. 1). The ramp position was used in 36.6% of the cohort with obesity and only 11.2% of the non-obese cohort. The bed tilt position had a consistently higher FPS rate across both body habitus groups, followed by the pillow and ramp positions. Patients intubated in the flat position had the lowest FPS rate (Table 1).

Indication for intubation

Almost two-thirds (65.7%) of trauma patients were intubated in the flat position regardless of weight category. All other indications for intubation consistently showed pillow use as the most popular position choice by clinicians (Table 2).

AEs

The ramp position was associated with the highest AE rate of 31.2%. All other positions had an AE rate ranging from 23.8% in the bed tilt position to 25.6% in the flat position (Table 2).

Regression model

Figure 2 reports the results of the multiple logistic regression model. The factors that were significantly associated with a higher FPS rate were bed tilt (odds ratio [OR] 1.5, 95% confidence interval [CI] 1.0–2.4, $P = 0.003$) or ramp position (OR 1.7, 95% CI 1.2–2.4, $P = 0.002$), intubation performed by a consultant level clinician (OR 1.5, 95% CI 1.1–2.0, $P = 0.022$), and when the intubator had performed at least 10 previous intubations (10–100 intubations [OR 2.6, 95% CI 2.1–3.5, $P \leq 0.001$] and >100 intubations [OR 4.1, 95% CI 3.0–5.6, $P = 0.022$]; Fig. 2). As expected, patients intubated for medical reasons were associated with a greater chance of FPS when compared to the trauma cohort, the two indications for intubation with the strongest FPS association were cardiac compromise (OR 1.4, 95% CI 1.0–2.1, $P = 0.039$) and haemodynamic instability (OR 1.8, 95% CI 1.0–3.1, $P = 0.041$). Factors significantly associated with a decreased FPS rate were obesity (OR 0.7, 95% CI 0.5–0.9, $P < 0.001$), Cormack–Lehane grade 3 or 4 (OR 0.1, 95% CI 0.1–0.1,

TABLE 2. *Patients intubated in different positions, by indication and the incidence of adverse events*

	Flat	Bed tilt	Pillow/occipital pad	Ramp/head-up
Indication				
Trauma, *n* (%)	461 (65.9)	71 (10.1)	126 (18.0)	42 (6.0)
Airway compromise, *n* (%)	104 (21.6)	54 (11.2)	200 (41.6)	123 (25.6)
Neurological impairment, *n* (%)	227 (21.4)	93 (8.7)	541 (50.9)	202 (19.0)
Cardiac compromise, *n* (%)	178 (38.0)	25 (5.3)	201 (42.9)	65 (13.9)
Haemodynamic compromise, *n* (%)	33 (25.2)	9 (6.9)	60 (45.8)	29 (22.1)
Other,† *n* (%)	188 (22.6)	44 (5.3)	472 (56.8)	127 (15.3)
Any complication	307 (25.3)	72 (24.2)	394 (24.5)	183 (31.1)

†Other; overdose or ingestion, procedural, transport, tube change, chemical restraint and pain management.

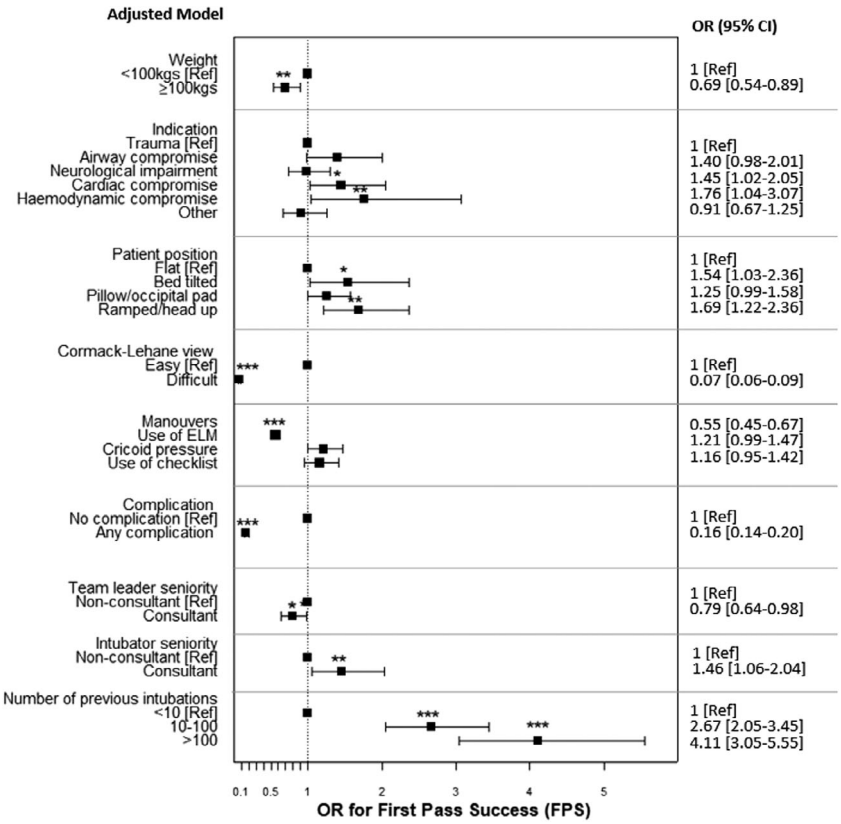

Figure 2. *Output of multiple logistic regression of factors associated with first-pass success at intubation. ELM, external laryngeal manipulation.* *P < *0.05*, **P < *0.01*, ***P < *0.001*.

$P < 0.001$), use of external laryngeal manipulation (OR 0.5, 95% CI 0.4–0.7, $P < 0.001$), the presence of any complications (OR 0.2, 95% CI 0.1–0.2, $P < 0.001$), and consultant level team leader (OR 0.8, 95% CI 0.6–1.0, $P = 0.030$). There was minimal missing data (2%).

Discussion

This is the first study to compare FPS of emergency intubations for patients with and without obesity in four categories of patient positions across Australia and New Zealand. It builds on the conclusions from recent meta-analysis and systematic reviews to include comparison between obese and non-obese populations.

FPS, position and obesity

The present study demonstrates that obesity is associated with a lower FPS rate for intubation in the ED. This can be optimised by implementing a bed tilt or ramp position, and by using an experienced consultant. The ramp position was associated with the largest odds of FPS (OR 1.7, 95% CI 1.2–2.4, $P = 0.002$) irrespective of body habitus or indication for intubation. This may result from improved alignment of the EAM and improved glottic view for the intubator.[8–10] This is consistent with previous findings[29] based on 232 intubations, with a mean weight of 84.6 kg, that demonstrated improved FPS of all patients for every 5° increase in the 'head of bed' angle. Although this was isolated to a single centre without weight delineation, it does support the use of ramping to improve intubation success in the ED. Similarly, in a study of 202 difficult airway patients, Lee *et al.* established improved success rate and laryngeal views in the ramp position when compared to the supine position, irrespective of weight.[15]

Other evidence does not support the protective benefits of the ramp position for obese patients; Pacheco *et al.* showed that anatomically difficult airways were associated with a reduced 'FPS without AEs' rate.[30] Although obesity itself was included in the anatomically difficult category, it was not shown to be independently associated with a change in 'FPS without AEs' in the regression model. Interestingly, the National Emergency Airway Registry (NEAR) study[29] found no significant difference in FPS between supine and non-supine positioning, or between obese and non-obese sub-groups, although the group did not report the criteria for obesity. Possible explanations for this difference may be the greater number of intubations included in their study (11 480), or the larger proportion of 'obese' patients (32.9%) compared to 18.4% in our study.[29] A recent metanalysis and systematic review representing 18 371 intubations across all clinical areas showed no significant difference in FPS between supine and inclined positioning.[23] Despite improved view, Turner *et al.* noted two studies that demonstrated no difference in FPS although were limited again by varying definitions for obesity.[23]

View

An easy Cormack–Lehane grade view (1 or 2) had a strong independent association with FPS. Yet there is a the high a degree of variability in clinician skill level, poor intra-observer reliability regarding interpretation of view,[31] and inconsistent evidence regarding its use in evaluating the effectiveness of the ramped position. As we only evaluated the view on first attempt, we are unable to assess if a position change would have yielded better views in each patient. For this reason, we chose not to evaluate view with FPS, position, or obesity in the present study.

External laryngeal manipulation (ELM) is performed to improve larygoscopic view and subsequent ease of intubation during laryngoscopy attempt. Our results showed that ELM was associated with a

decreased FPS, likely due to its use during established difficult intubations. As the present study only analysed manoeuvres on first attempt, we were unable to assess whether FPS analysis pre- and post-ELM use would have yielded different results.

Indication for intubation

Trauma patients were predominantly intubated in the flat position as expected due to standardised cervical spine precautions of all trauma patients. In these circumstances, a 'bed tilt' manoeuvre may achieve elevated head of bed whereas still maintaining c-spine precautions, but this was rarely observed in clinical practice (10.1%). Pacheco *et al.* showed that 94.9% of trauma patients presented an anatomically difficult airway, likely due to deformity and obstruction of the airway. Supine positioning can exacerbate these difficult airways, further supporting the use of bed tilt in these patients.[30]

Intubator seniority, experience and specialty

Consistent with current literature, FPS was higher among more experienced intubators and senior consultant clinicians. Surprisingly, we found a strong association between a consultant level team leader and a low FPS rate. This is likely due to the supervision of a more junior, inexperienced clinician conducting the actual intubation. It is unclear whether senior clinicians were intubating in more optimal positions based on pre-identified patient factors, thus having better success on first attempt, but this was outside the scope of the present study. Lee *et al.* found that consultant level intubators achieved a higher FPS than less experienced intubators in the ramp position but not in the supine position.[15] This may be because consultant intubators had more experience with the correct ramping position technique, or advanced skills in anticipating difficult airways that require ramp positioning and implementing additional airway optimisation techniques. This may also explain the incongruous nature of our results.

AEs

Although the ramp position was associated with the highest AE rate, this is likely due to a larger proportion of patients identified as anatomically or physiologically difficult on pre-intubation assessment, being placed in the ramp position. These patients are anticipated to have a higher AE rate regardless of the position used due to underlying comorbidities or declining clinical status. The potential risk of AEs needs to be considered against complications associated with prolonged time to intubation, or intubation failure in the supine positioning for these patients clinically.

These results are consistent with the NEAR study that also demonstrated increased peri-intubation AEs in the non-supine position.[29] Their non-supine and supine AE rates were 18.3% and 11.9%, respectively, both of which are lower than our total AE rate of 27.0%. This is likely due to our inclusion of additional AEs including tachycardia, hypertension, laryngospasm, oesophageal intubation airway trauma, dental trauma, equipment failure and medication error. In contrast, a study of emergency intubations outside the perioperative environment showed a significant reduction in complication rate in the ramp position of 9.3% when compared to supine positioning of 22.6%,[17] with an independent OR of 0.47 (95% CI 0.26–0.83; $P = 0.01$).

Limitations

From the initial data collection there were some missing data despite the efforts to follow up with intubating clinicians and patient records that had to be excluded from our study. With only 42 EDs across Australasia being included this may not be a true capture of all Australian airway management practices. Estimation of weight was a significant limitation for the present study, with a large potential for clinician error and variability. Additionally, with no height measurement we were unable to calculate BMI. The restriction of the 100 kg cut-off, whereas beneficial to assess overall trends, may miss some shorter people with obesity or over capture non-obese taller people. This figure was selected based on data collected, previous emergency study's obese definition, and clinician advice. Data collection could have been improved by inclusion of height to enable BMI calculation purposes. To address this, we conducted sensitivity testing for various weight categories which supported the choice of over 100 kg cut-off for the definition of obesity. There was also no correlation of position with degree of head of bed elevation or alignment of the EAM with the sternal notch. All are measures of optimal positioning that could lead to improved data collection and increased reliability of results. In addition, as an observational study, position selection was at the discretion of the intubating clinician and thus allowed selection bias based on multiple patient and clinician variables which allows assessment of association and not causation. Although the regression model has attempted to eliminate confounding factors, there may be some additional external influence not accounted for. Last, position was only documented for the first attempt at intubation, thereby limiting our ability to assess if a change in position was associated with improved success.

Conclusion

Obesity was associated with a lower FPS which could be improved with utilisation of a bed tilt or ramp positioning.

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Author contributions

SB, HB and HA drafted the manuscript. HA coordinated the study. 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

EL 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.

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