

A Prospective Audit of Airway Code Activations and Adverse Events in Two Tertiary Hospitals

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Abstract

Introduction: Airway management outside the operating room can be challenging, with an increased risk of difficult intubation, failed intubation and complications. We aim to examine airway practices, incidence of difficult airway and complications associated with airway code (AC) activation.

Methods: We conducted a prospective audit of AC activations and adverse events in two tertiary hospitals in Singapore. We included all adult patients outside the operating room who underwent emergency intubation by the AC team after AC activation. Adult patients who underwent emergency intubation without AC activation or before the arrival of the AC team were excluded. Data were collected and documented by the attending anaesthetists in a standardised survey form shortly after their responsibilities were completed.

Results: The audit was conducted over a 20-month period from July 2016 to March 2018, during which a total of 224 airway activations occurred. Intubation was successful in 218 of 224 AC activations, giving a success rate of 97.3%. Overall, 48 patients (21.4%) suffered an adverse event. Thirteen patients (5.8%) had complications when intubation was carried out by the AC team compared with 35 (21.5%) by the non-AC team.

Conclusion: Dedicated AC team offers better success rate for emergency tracheal intubation. Non-AC team attempted intubation in the majority of the cases before the arrival of the AC team. Increased intubation attempts are associated with increased incidence of adverse events. Equipment and patient factors also contributed to the adverse events. A multidisciplinary programme including the use of supraglottic devices may be helpful to improve the rate of success and minimise complications.

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Introduction

Airway management outside of the operating room (OR), such as in the intensive care unit (ICU) or the emergency department (ED), poses unique challenges.^{1,2} It is therefore not surprising that there is a higher incidence of failed intubation of approximately 1 in 50–100 in the ED and ICU compared with 1 in 2,000 in the elective OR setting.² There is also a higher risk of difficult intubation (9–10%),^{3–5} and complications (21–39%)^{3,6,7} outside the OR.^{2,8} Moreover, litigation arising from airway claims

are costly and forms the highest proportion of cases with poor clinical outcomes.²

Previous studies in the UK^{6,9–11} and the US^{4,5,8,12–14} have examined the indications for and complications associated with emergency intubations outside the OR, but such data are not available locally in Singapore. In Singapore, intubations in the ICU can be performed by intensivists or anaesthetists trained in critical care medicine. Airway training for non-anaesthetists is conducted throughout their intensive care training in the

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form of airway workshops. Basic airway equipment is available in the emergency cart. There is also a videolaryngoscope in every ICU.

An airway code (AC) activation is an emergency request by non-anaesthetists for the AC team to assist in airway management outside the OR. The AC team comprises an anaesthetic senior resident or associate consultant who has at least 36 months of anaesthetic experience, with or without support from an anaesthetic nurse or a respiratory therapist. The type of equipment that the AC team brings is at their discretion.

We conducted a prospective study on AC activations in 2 large tertiary hospitals in Singapore. The aims were to evaluate airway management after AC activation, in order to (1) report the indications and clinical context for AC activations; (2) report the incidence of difficult airway; (3) examine airway management practices; (4) report complications associated with airway management; and (5) identify areas for improvement.

Methods

This was a prospective study on emergency airway management outside the OR in Singapore General Hospital and Tan Tock Seng Hospital in Singapore for a 20-month period from July 2016 to March 2018. The study was approved by SingHealth Centralised Institutional Review Board and the National Health Group Domain Specific Review Board, respectively.

Inclusion and exclusion criteria

All adult patients outside the OR who underwent emergency intubation by the AC team after AC activation during the period of study were included in the study. Adult patients who underwent emergency intubation without AC activation or before the arrival of the AC team were excluded.

Data collection

Data were collected and documented by the attending anaesthetists in a standardised survey form shortly after their AC responsibilities were completed. The data were later entered into a Research Electronic Data Capture database system. Information collected included:

1. AC date, time and site
2. Indication for AC activation
3. Patient demographics, physiological parameters and airway assessment on arrival by the AC team. Airway assessment included predictors of difficult airway: interdental distance <3cm; thyromental distance <6.5cm; prominent upper teeth; receding lower jaw; reduced range of neck movement; previous head

and neck surgery; previous radiotherapy to the head and neck; and airway obstruction.¹⁵

4. Details of drugs and equipment taken and used by the attending AC team. Additional airway equipment or assistance that would be considered potentially helpful to manage the AC but was not present was also noted.
5. Airway management by non-AC and AC team, as well as any complications encountered. Difficulty in face mask ventilation was graded according to Han's classification.¹⁶ For tracheal intubation, laryngeal view grading was based on the Cormack–Lehane classification.¹⁷
6. Adverse events related to airway management: dental trauma, oropharyngeal soft tissue bleeding or trauma, oesophageal intubation, aspiration of gastric contents, and airway obstruction.

Data are presented as numbers and percentage of total AC activation cases.

Statistical analysis

Statistical analysis was performed with SPSS software version 25 (IBM Corp, Armonk, US). The continuous variables were analysed using t-test, and discrete variables were analysed using the chi-square test. A multivariate analysis using stepwise logistic regression was performed to look for significant factors, defined as those with $P < 0.05$ in the univariate analysis. A composite variable of adverse events that included dental injury, oropharyngeal soft tissue trauma or bleeding, oesophageal intubation, aspiration of gastric contents and airway obstruction was used. Univariate analysis was used to analyse significant factors that increased the risk of adverse events encountered by both the AC and non-AC teams.

Results

During the study period, there were a total of 224 airway activations, during which patients required emergency out-of-OR tracheal intubations by the AC team. The percentages were calculated using a denominator of 224 patients (even if there were missing documented data) unless otherwise stated. Characteristics of airway code activation patients are summarised in Table 1.

The majority of ACs were activated in the general ward setting ($n=98$; 43.7%) followed by ICU ($n=71$; 31.7%). Other locations included remote locations such as angiography suite or cardiac catheterisation laboratory ($n=40$; 17.9%), and ED ($n=14$; 6.3%). Just over half of the AC activations were between 8am and 8pm ($n=116$;

Table 1. Characteristics of airway code activation patients

Characteristics	Patients mean (95% CI) (n=224)
Weight, kg	64.2 (62.0–66.5)
Height, cm	160 (158.8–161.4)
Body mass index, kg/m ²	25.2 (24.3–26.1)
Heart rate on arrival, per min	82 (76.4–89.4)
Systolic blood pressure on arrival, mmHg	101 (92.3–111.3)
Diastolic blood pressure on arrival, mmHg	55 (50.5–60.9)
Oxygen saturation on arrival, %	74 (68.9–79.1)
American Society of Anesthesiologists physical status	No. (%)
1	1 (0.4)
2	12 (5.4)
3	115 (51.3)
4	90 (40.2)
5	6 (2.7)

51.8%). The most common reason for AC activations was failed intubation by non-AC team (n=53; 23.7%), followed by respiratory distress (n=48; 21.4%) and cardiovascular collapse (n=47; 21.0%) (Table 2).

Intubation was successful in 218 of 224 AC activations, giving a success rate of 97.3%. The majority of the patients who were intubated had Cormack–Lehane grade 1 laryngeal views (n=103; 46.0%), followed by grade 2 views (n=49; 21.9%), grade 3 views (n=49; 21.8%) and grade 4 views (n=1; 0.4%) (Table 2).

Table 2. Details of airway code (AC) activations

Detail	No. (%) (n=224)
Time category of AC	
8am to 8pm	116 (51.8)
8pm to 8am	103 (46.0)
Missing data	5 (2.2)
Location of AC	
General ward	98 (43.7)
Intensive care unit	71 (31.7)
Others (e.g. angiography suite, cardiac catheterisation lab)	40 (17.9)
Emergency department	14 (6.3)

Table 2. Details of airway code (AC) activations (Cont'd)

Detail	No. (%) (n=224)
Outpatient clinics	1 (0.4)
AC category	
Failed intubation by non-AC clinicians	53 (23.7)
Respiratory distress	48 (21.4)
Cardiovascular collapse	47 (21.0)
Airway – others (e.g. failed extubation, dislodged tracheal tube)	21 (9.4)
Glasgow Coma Scale <8	20 (8.9)
Cardiovascular instability	19 (8.5)
Airway obstruction	12 (5.3)
Respiratory arrest	4 (1.8)
Intravenous hypnotic sedatives	
Midazolam	96 (42.9)
Propofol	39 (17.4)
Ketamine	4 (1.8)
Etomidate	3 (1.3)
No hypnotic sedatives used	82 (36.6)
Neuromuscular paralysis agents	
Succinylcholine	133 (59.4)
Non-depolarising agents (rocuronium, atracurium)	18 (8.0)
Not used	69 (30.8)
Missing data	4 (1.8)
No. of intubation attempts by non-AC clinicians	
0	61 (27.2)
1	67 (29.9)
2	43 (19.2)
3	25 (11.2)
>3	7 (3.1)
Missing data	21 (9.4)
Cormack–Lehane laryngeal grade	
1	103 (46.0)
2	49 (21.9)
3	49 (21.9)
4	1 (0.4)
Missing data	22 (9.8)

For the remaining 6 patients, it was recorded that ventilation was maintained using supraglottic airway device (SAD) owing to failed intubation; however, the subsequent outcomes of these patients were not recorded.

The most common airway intervention performed by the AC team was intubation using only direct laryngoscopy (n=69; 30.8%). This was followed by intubation using only videolaryngoscopy (n=62; 27.7%), intubation using direct laryngoscopy with a bougie (n=47; 21.0%) and intubation requiring both direct and videolaryngoscopy attempts (n=32; 14.3%), flexible bronchoscopic intubation (n=8; 3.6%) and ventilation via a SAD (n=6; 2.7%; Fig. 1).

After AC activation but prior to arrival of the AC team, non-AC clinicians performed none, 1, 2, 3 and >3 attempts at intubation in 27.2%, 29.9%, 19.2%, 11.2% and 3.1% of the 163 cases, respectively (Table 2). The most common airway intervention performed by the non-AC personnel was intubation using direct laryngoscopy with a bougie (n=79; 48.4%), followed by intubation using only direct laryngoscopy (n=46; 28.2%), intubation using only videolaryngoscopy (n=35; 21.5%), intubation requiring both direct and videolaryngoscopy attempts (n=2; 1.2%) and flexible bronchoscopic intubation (n=1; 0.6%; Fig. 1) A flow chart showing a breakdown of the equipment used to facilitate tracheal intubation is shown in Fig. 1.

In AC activations, 192 AC providers (85.7%) brought along an airway bag which included a videolaryngoscope (n=94; 42.0%) and a gum elastic bougie (n=47; 21.0%). Delays in obtaining equipment were reported in 30 cases (13.4%). The AC provider stated that additional equipment or assistance would have been helpful in 53 cases, with numbers and percentages of 53 as follows: videolaryngoscope (n=23; 43.4%), end-tidal carbon dioxide detector (n=12; 22.6%), trained assistance to assist with emergency intubation (n=7; 13.2%), troop elevation pillow (n=3; 5.7%), C-MAC D-Blade video laryngoscope (Karl Storz, Tuttlingen, Germany) (n=3; 5.7%), flexible bronchoscope (n=2; 3.8%), Yankauer suction (n=2; 3.8%) and gum-elastic bougie (n=1; 1.9%).

Overall, 48 patients (21.4%) suffered an adverse event. Thirteen patients (5.8%) had complications when intubation was carried out by the AC team compared with 35 (21.5%) by the non-AC team. The most common adverse event encountered by the AC team was oesophageal intubation (n=4; 30.8% of AC team's adverse events), followed by dental trauma (n=3; 23.1%) and aspiration of gastric contents (n=3; 23.1%). The remaining adverse events included 2 cases of oropharyngeal trauma and 1 case of airway obstruction. For the non-AC team, the most common adverse event was oropharyngeal soft tissue bleeding or trauma (n=18;

51.4% of non-AC personnel's adverse events), followed by oesophageal intubation (n=7; 20.0%) and dental trauma (n=4; 11.4%) (Table 3).

For AC providers, factors associated with increased risk of complications following tracheal intubation were interdental distance <3cm, prominent upper teeth and receding lower jaw. As for non-AC providers, reduced range of motion of the neck was found to be a statistically significant factor associated with increased risk of complications (Tables 4 and 5).

Discussion

Our prospective study reveals that the nature of our AC activations were similar to those of other studies. They arose mainly from the ICU (38–70%),^{4,6,11} general ward (3–39%),^{4,6,11} and ED (1–37%),^{4,6,11} and mainly occurred during working hours (55–61%).^{3,11} The most common causes for our AC activations were failed intubation by the non-AC team, respiratory distress and cardiovascular collapse. Other studies show that airway protection as an indication for emergency intubation varies, depending on the out-of-OR site: ICU (11–21%)^{11,13} and ED (59–64%).¹⁴ Respiratory failure as an indication for emergency tracheal intubation is high in ICU (61–65%).¹³

The incidence of difficult intubation in patients considered to have normal airways and scheduled for elective surgery is 5.8%.¹⁵ However, in the emergency setting outside the operating theatre, studies reveal the incidence of difficult intubation to be 6–12% in the emergency setting.^{3–6,11} Our study showed a much higher incidence of almost 23%. Difficult airway related to out-of-OR patients may be due to anatomical, physiological and situational causes.¹⁸ Anatomical factors include standard difficult airway predictors; poor patient and operator positioning; blood, vomitus and secretions in the airway; facial and neck trauma; airway oedema; and cervical neck immobilisation.^{13,18} Physiological factors include haemodynamic instability, hypoxaemia, acidosis, inadequate fasting and patient agitation.¹³ Physiological causes identified in our study were American Society of Anesthesiologists status ≥ 3 , hypotension and hypoxaemia, as revealed by their high incidence in the patients. Situational factors include unfamiliar sites and team members, team members not familiar with airway management, after-hours AC activations and lack of equipment.¹⁸

The majority of airway interventions by the AC provider were direct tracheal intubation with or without videolaryngoscopy, and is similar to other studies (direct laryngoscope, 52–61%;⁶ videolaryngoscope, 45%).⁶ Videolaryngoscopy is increasingly being used as a first-line technique for tracheal intubation with its

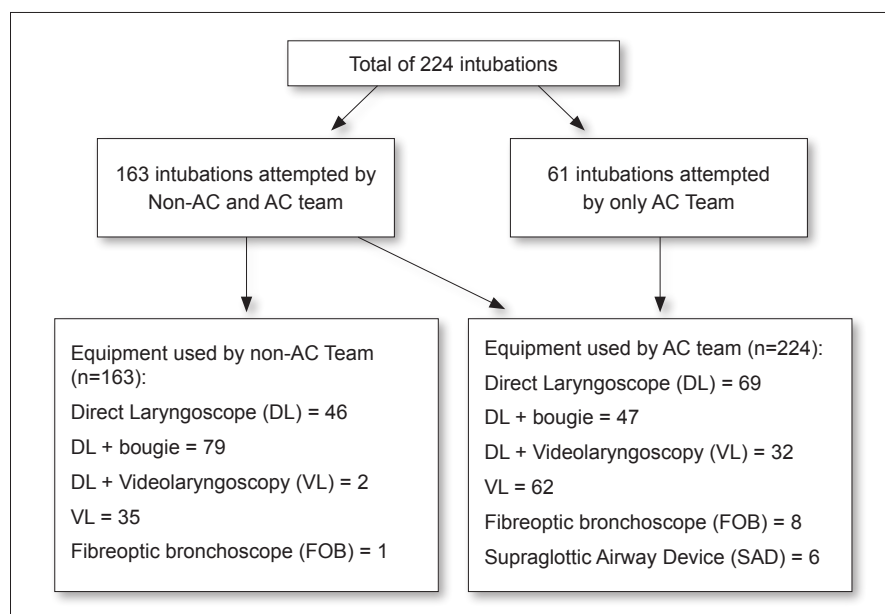


Fig. 1. Flow chart showing a breakdown of the equipment used to facilitate tracheal intubation by airway code (AC) and non-AC teams

Table 3. Presence of adverse events following airway management for airway code (AC) and non-AC clinicians

	AC clinicians, No. (%) (n=224)	Non-AC clinicians, No. (%) (n=163)
Presence of adverse events following airway management	13 (5.8)	35 (21.5)
Dental trauma	3 (23.1)	4 (11.4)
Oropharyngeal soft tissue bleeding or trauma	2 (15.4)	18 (51.4)
Oesophageal intubation	4 (30.8)	7 (20.0)
Aspiration of gastric contents	3 (23.1)	3 (8.6)
Airway obstruction	1 (7.7)	3 (8.6)

Table 4. Factors associated with increased risk of complications for airway code physicians

	Total	Complications, No. (%)	No complications, No. (%)	P value
Delay in obtaining equipment	30	4 (13.3)	26 (86.7)	0.087
Interdental distance <3cm	9	3 (33.3)	6 (66.7)	0.011
Thyromental distance <6.5cm	28	4 (14.3)	24 (85.7)	0.063
Prominent upper teeth	12	3 (25.0)	9 (75.0)	0.025
Receding lower jaw	36	6 (16.7)	30 (83.3)	0.008

Table 5. Factors associated with increased risk of complications for non-airway code physicians

	Total	Complications, No. (%)	No complications, No. (%)	P value
Use of bougie	47	12 (25.5%)	35 (74.5%)	0.060
Reduced range of neck motion	21	7 (33.3%)	14 (66.7%)	0.028
Presence of airway obstruction	11	4 (36.4%)	7 (63.6)	0.074

many advantages over direct laryngoscopy: improved laryngeal view, decreased incidence of failed intubation, high rates of successful rescue after failure of direct laryngoscopy, less applied laryngoscopic force required, improved training of novice clinicians, improved operator ergonomics, enabling of real-time optimisation of cricoid force application and external laryngeal manipulation, and decreased airway trauma and voice hoarseness.^{1,19}

A systematic review found that the use of videolaryngoscopy showed no benefit when it is 'routinely used' for emergency intubation outside the OR, when compared with direct laryngoscopy.⁷ However, it was associated with a greater first-pass intubation in the ICU (78.3% vs 64.3%; odds ratio 2.02), but not in the ED or in the wards, and among less experienced clinicians (81.4% vs 71.5%; odds ratio 1.95); and with a reduction in oesophageal intubations (1.5% vs 4.7%; odds ratio 0.32). It was also associated with a greater incidence of arterial hypotension (7.8% vs 5.5%; odds ratio 1.49). In critically ill patients, videolaryngoscopy should be considered for first-attempt intubation if urgent intubation is performed by less experienced operators¹² or if difficult laryngoscopy is predicted.¹

Prior to the arrival of the AC team, the non-AC team attempted twice in 19.2% of cases and thrice or more in 14.3% of cases. One study showed that even more than 1 attempt at intubation was a significant predictor of adverse events (odds ratio 7.5).¹⁴ Difficult airway guidelines also recommend a limit on the maximum attempts at intubation: 3 attempts, but a 4th permissible by an experienced colleague.^{1,20} Other sources recommend 3 attempts,²¹ or 2 attempts but a third permissible by an experienced colleague²². In the context of out-of-OR cases, the 'experienced colleague' should be an AC provider.

Of note, none of the non-AC providers used a SAD to rescue failed intubation. The reason may be the lack of knowledge of its use as well as its limited availability in certain areas such as the angiography suite. However, after failed intubation in the OR, a SAD is the recommended plan B,²⁰ and provides successful rescue ventilation in 63%,²³ and 94% of cases.²⁴ Rescue techniques when used outside the OR (face-mask ventilation, SAD ventilation and cricothyroidotomy) have relatively high failure rates.¹⁰

The success rate in our study was 97.3%. One study showed a high success rate (91%) on the first tracheal intubation attempt and this was attributable partly to the high level of experience of intubators.¹¹ This is important as lack of education and training are causal factors of major airway complications outside the OR.¹⁰ The results

of our survey highlighted that emergency airway code activations were often due to failure to secure airway by non-anaesthetists. In addition, there was a higher incidence of oropharyngeal trauma and bleeding caused during attempts prior to AC team arrival, which may have worsened the situation. This observation may suggest the need for more airway training courses for non-anaesthetists to better manage emergency scenarios and to recognise a potential difficult airway so as to involve the AC team early during resuscitation and securing of airway.

Airway management complications can lead to serious morbidity and mortality.^{2,8-10} More than 60% of ICU airway complications have shown to lead to death or brain damage compared with 14% in the OR.¹⁰ The unique challenges of airway management outside the OR contribute to serious complications and stem from many causes.^{1,2} Systemic factors include poor environment and ergonomics, as well as lack of guidelines, resources and training, and specialist staff. Human factors include poor clinical judgment, poor communication and teamwork; poor airway assessment; lack of, and unfamiliarity with, equipment and monitoring; and limited training in airway emergencies. Patient factors include obesity, low physiological functional reserve, difficult airways, suboptimal positioning of patients and aspiration risk.

The incidence of complications from various studies are hypoxia, 9–29%;^{3,6,11,14} hypotension, 5.5–21%;^{3,6,7,11} arrhythmia, 3.4%;⁶ cardiac arrest, 0.1–2%;^{3,11,14} aspiration, 2–2.8%;^{3,4} oesophageal intubation, 1.3–16%;^{3,4,7,11,14} dental injury, 0.2–0.4%;^{4,14} and pneumothorax, 0.1%.^{4,14} Unlike other studies, we did not document the subsequent effects of AC airway management on blood pressure or oxygen saturation (SpO₂). Studies have shown that tracheal intubation may contribute to patient morbidity: an increase in the number of patients with SpO₂ <80% (2-fold) and systolic blood pressure <80mmHg (3-fold).¹¹ Adequate pre-oxygenation is therefore recommended before attempts at intubation,²⁵ and the use of concomitant vasopressors at induction of anaesthesia may be helpful.

In the Fourth National Audit Project, complications of airway management led to emergency surgical airway in 33% of cases in ICU and 67% in ED, with 25% and 0% failure rate, respectively.¹⁰ Needle cricothyroidotomy, however, had a high failure rate (63%), but it was performed in patients who were in extremis. Owing to the challenges of airway management outside the OR and its associated morbidities, the concept of priming for 'front-of-neck access' was recently introduced.¹ This is the formalised transition from a 'cannot intubate, cannot oxygenate' scenario to performing front-of-neck access.

Fortunately, we did not encounter any ‘cannot intubate, cannot oxygenate’ scenarios in our 224 AC activations.

In 1 study, there were 4 independent predictors of the composite airway complication outcome: 3 or more intubation attempts (odds ratio 6.7), grade 3 or 4 direct laryngoscopy view (odds ratio 1.9), and patient location on the general care floor (odds ratio 1.9) or ED (odds ratio 4.7).⁴ Not surprisingly, we found that factors associated with increased risk of complications are similar to those predicting a difficult airway, that is, interdental distance <3cm, prominent upper teeth and receding lower jaw, and limited range of motion of neck. We note that the use of bougie was associated with more complications due probably to a difficult airway encountered instead of the bougie causing direct injury.

In the Fourth National Audit Project report, equipment or resource-related causal and contributory factors in major airway complications occurred in 36% of cases and included non-availability, lack of training in their use, and failure to consider using the right equipment.¹⁰ Another study showed that various equipment was not available for out-of-OR intubation: suction (2%), bougie (4%), alternative airways such as a SAD (12%) and capnography (32%).³

In our study, portable capnography was initially unavailable but was later included as part of the emergency airway response kit. There is also increased training in the use of this equipment in areas outside of

operating theatres, especially for paramedical staff, such as ward nurses, in the event of emergency airway events. The lack of, or failure to use, capnography is a major factor in airway mortality and morbidity outside the OR, contributing to 74% of cases of death or persistent neurological injury.¹⁰ Continuous capnography is therefore recommended for use in all locations, in patients who are intubated or ventilated via SADs or similar devices.^{2,10,26,27} However, despite the availability of portable capnography devices, capnography is not consistently used in airway management in the ICU (54–72%)^{3,11} and the general wards (20%).³ The ICU should have a difficult airway trolley identical in content and layout as that in the OR,^{1,2,10} but only 50% of units have such a trolley.²⁸

Delays in obtaining equipment were reported in 30 cases (13.4%) in our study. We have now equipped our AC team with a difficult airway box that contains a videolaryngoscope, SAD, and airway adjuncts.

Our study reinforced that increased intubation attempts are associated with an increased incidence of adverse events. Hence, we should consider reducing the number of intubation attempts by novice intubators.

To help coordinate airway management between various personnel, the mnemonic ‘PREPARE’ may be helpful: P: pre-oxygenate/position; R: reset/resist; E: examine/explicit; P: plan A/B; A: adjust/attention; R: remain/review; E: exit/explore.¹⁸ The details are described in Fig. 2.

P	– Pre-oxygenate; Position
	Do not remove oxygen. Increase supplemental oxygen. Align the patient’s airway axes.
R	– Reset; Resist
	Increase frequency of vitals. Do not prematurely lie the patient flat. Empty the stomach.
E	– Examine; Explicit
	Examine the airway. Identify the cricothyroid membrane. Avoid vague commands; escalate assertiveness.
P	– Plan A, Plan B
	Identify, announce, share plan A/B/C. Ensure it is the right plan. Gather equipment and personnel.
A	– Adjust; Attention
	Adjust anaesthetic agents and doses. Consider ‘push-pressors’. Ensure system-1 and -2 attention.
R	– Remain; Review
	Do not leave the patient prematurely. Perform a head-to-toe review. Announce future concerns.
E	– Exit; Explore
	Announce when you need to change the plan. Coordinate transfer/hand-over. Debrief entire team.

Fig. 2. PREPARE: coordination of airway management between various personnel

One institution developed the Difficult Airway Response Team (DART), that consists of a multidisciplinary difficult airway response team operating on a model with 3 core components: operations, safety and education.⁵ During the first 5 years of the DART programme, there were no airway management-related deaths, sentinel events or malpractice claims. However, further studies are required to evaluate its effect on patient outcome and the cost effectiveness.

Limitations

There are several limitations to this observational study. First, airway management was not standardised across all AC providers. We were able to record the types of equipment used but not the order in which they were used. There were still missing data despite our best efforts at collection. Airway code categories for AC activation, such as respiratory distress and cardiovascular instability, were also not defined and were left to the individual interpretation by clinicians. Although the primary reason for AC activation in our study was because of failed intubation by a non-AC team, the underlying reason was not recorded. We recognise that this may not truly reflect the medical reason behind the need for intubation. Also, we note that there is potential for overestimating the incidence of difficult airway because adult patients who underwent emergency intubation without AC activation are excluded. As the forms were anonymous, there is a possibility of under-reporting of adverse events. Definition of adverse events was not standardised and was left to the interpretation of clinicians.

Conclusion

This study offers insight into patient, equipment and human factors that impact the outcome of emergency out-of-theatre airway management in 2 of our local tertiary institutions. Future multicentre studies will be useful to further validate these findings and extrapolate the results to improve emergency airway outcomes.

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REFERENCES

- Higgs A, McGrath BA, Goddard C, et al. Guidelines for the management of tracheal intubation in critically ill adults. *Br J Anaesth* 2018;120:323-52.
- Cook TM, MacDougall-Davis SR. Complications and failure of airway management. *Br J Anaesth* 2012;109 Suppl 1:i68-i85.
- Bowles TM, Freshwater-Turner DA, Janssen DJ, et al. Out-of-theatre tracheal intubation: prospective multicentre study of clinical practice and adverse events. *Br J Anaesth* 2011;107:687-92.
- Martin LD, Mhyre JM, Shanks AM, et al. 3,423 emergency tracheal intubations at a university hospital: airway outcomes and complications. *Anesthesiology* 2011;114:42-8.
- Mark LJ, Herzer KR, Cover R, et al. Difficult airway response team: a novel quality improvement program for managing hospital-wide airway emergencies. *Anesth Analg* 2015;121:127-39.
- Reid C, Chan L, Tweeddale M. The who, where, and what of rapid sequence intubation: prospective observational study of emergency RSI outside the operating theatre. *Emerg Med J* 2004;21:296-301.
- Arulkumaran N, Lowe J, Ions R, et al. Videolaryngoscopy versus direct laryngoscopy for emergency orotracheal intubation outside the operating room: a systematic review and meta-analysis. *Br J Anaesth* 2018;120:712-24.
- Mort TC. Emergency tracheal intubation: complications associated with repeated laryngoscopic attempts. *Anesth Analg* 2004;99:607-13.
- Cook TM, Woodall N, Frerk C, et al. 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 1: anaesthesia. *Br J Anaesth* 2011;106:617-31.
- Cook TM, Woodall N, Harper J, et al. 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.
- Simpson GD, Ross MJ, McKeown DW, et al. Tracheal intubation in the critically ill: a multi-centre national study of practice and complications. *Br J Anaesth* 2012;108:792-9.
- Kory P, Guevarra K, Mathew JP, et al. The impact of video laryngoscopy use during urgent endotracheal intubation in the critically ill. *Anesth Analg* 2013;117:144-9.
- Mosier JM, Whitmore SP, Bloom JW, et al. Video laryngoscopy improves intubation success and reduces esophageal intubations compared to direct laryngoscopy in the medical intensive care unit. *Crit Care* 2013;17:R237.
- Sakles JC, Chiu S, Mosier J, et al. The importance of first pass success when performing orotracheal intubation in the emergency department. *Acad Emerg Med* 2013;20:71-8.
- Shiga T, Wajima Z, Inoue T, et al. Predicting difficult intubation in apparently normal patients: a meta-analysis of bedside screening test performance. *Anesthesiology* 2005;103:429-37.
- Han R, Tremper KK, Kheterpal S, et al. Grading scale for mask ventilation. *Anesthesiology* 2004;101:267.
- Cormack RS, Lehane J. Difficult tracheal intubation in obstetrics. *Anaesthesia* 1984;39:1105-11.
- Brindley PG, Beed M, Law JA, et al. Airway management outside the operating room: how to better prepare. *Can J Anaesth* 2017;64:530-9.
- Cook TM, Kelly FE. A national survey of videolaryngoscopy in the United Kingdom. *Br J Anaesth* 2017;118:593-600.
- 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.
- Law JA, Broemling N, Cooper RM, et al. The difficult airway with recommendations for management—part 1—difficult tracheal intubation encountered in an unconscious/induced patient. *Can J Anaesth* 2013;60:1089-18.

22. Mushambi MC, Kinsella SM, Popat M, et al. Obstetric Anaesthetists' Association and Difficult Airway Society guidelines for the management of difficult and failed tracheal intubation in obstetrics. *Anaesthesia* 2015;70:1286-306.
23. Thomsen JLD, Nørskov AK, Rosenstock CV. Supraglottic airway devices in difficult airway management: a retrospective cohort study of 658,104 general anaesthetics registered in the Danish Anaesthesia Database. *Anaesthesia* 2019;74:151-7.
24. Parmet JL, Colonna-Romano P, Horrow JC, et al. The laryngeal mask airway reliably provides rescue ventilation in cases of unanticipated difficult tracheal intubation along with difficult mask ventilation. *Anesth Analg* 1998;87:661-5.
25. Jaber S, Jung B, Corne P, et al. An intervention to decrease complications related to endotracheal intubation in the intensive care unit: a prospective, multiple-center study. *Intensive Care Med* 2010;36:248-55.
26. Checketts MR, Alladi R, Ferguson K, et al. Recommendations for standards of monitoring during anaesthesia and recovery 2015: Association of Anaesthetists of Great Britain and Ireland. *Anaesthesia* 2016;71:85-93.
27. Association of Anaesthetists of Great Britain & Ireland (AAGBI). AAGBI statement: capnography outside the operating room. https://anaesthetists.org/Portals/0/PDFs/Guidelines%20PDFs/New%20archived/Archived_guidelines_Safety_Statement_capnography_outside_operating_theatre_2009_.pdf?ver=2020-12-01-093910-953. Published January 2009. Accessed on 24 May 2011.
28. Jeanrenaud P, Girotra V, Wharton T, et al. Difficult airway trolleys for the critical care unit. *Pediatr Crit Care Med* 2010;11:98-103.