Successful endotracheal intubation following a failed first attempt during aeromedical retrieval

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ABSTRACT

Introduction First attempt intubation success is used by many prehospital services as a marker of quality and safety. An increasing complication rate is associated with repeated intubation attempts. The aim of this study was to identify changes to intubation technique following a failed intubation attempt.

Methods LifeFlight Retrieval Medicine provides aeromedical retrieval services in Queensland, Australia. This retrospective study identified cases of failed intubation attempts from an electronic database registry over a 41-month period from March 2015 to July 2018. These data were analysed using descriptive statistics.

Results Of the 762 patients who required intubation 758 (99.5%) were successfully intubated, with 684 intubated at the first attempt (89.8%; 95% CI: 0.87 to 0.92). There was no difference in first attempt success between direct and video laryngoscopy (511/563 (90.8%) vs 172/194 (88.6%) p=0.38), trauma or medical (374/419 (89.3%) vs 310/343 (90.4%), p=0.61), primary or interhospital missions (329/370 (88.7%) vs 355/392 (90.8%), p=0.33). 78 cases of failed first attempt intubations were identified. In 65 of these cases, intubation was successful at the second attempt. A single change was made to the intubation procedure prior to a second successful attempt in 28/78 cases (35.9%), and more than one change was made in 41/78 (52.6%). The changes included the operator, intubation device, patient position, intubating aid and external laryngeal manipulation. No change between attempts was recorded in 9/78 (11.5%). 9 cases were successfully intubated at the third attempt, and changes prior to the third attempt included operator, device and intubating aid.

Conclusion Although a high overall intubation success was found, one in ten patients who were intubated had a failed first attempt. The majority of successful subsequent attempts were preceded by at least one change to intubating technique. Intubating clinicians need the ability to identify and correct issues leading to a failed first attempt.

Key messages

What is already known on this subject

- More than one attempt at endotracheal intubation is associated with an increased complication rate.
- Intubation procedures target first attempt success, and changes to the intubation technique are recommended in the event of a failed attempt.

What this study adds

- In this retrospective database study of intubations performed by LifeFlight Retrieval Medicine over a 41-month study period, at least one change to the intubation procedure was made in almost three-quarters of failed intubations prior to a successful second attempt. These changes included a change of operator, patient position, device or intubation aid.
- Intubating clinicians need to maintain sufficient situational awareness to allow them to identify the issues leading to a failed intubation attempt, and have the experience, equipment and technical skill to implement the changes required to achieve successful intubation.

INTRODUCTION

Emergency endotracheal intubation is a necessary and common procedure in prehospital and retrieval medicine,[1] and is one that carries significant patient risk, even in a hospital environment.[2–4] When indicated, it has been recommended that this be carried out as soon as is safely possible.[5] First attempt intubation success rate is used by many prehospital services as a key performance indicator, and as a marker of quality and safety. An increasing complication rate has been reported with repeated intubation attempts.[6–8]

Factors associated with difficult intubation have previously been identified,[9–11]and guidelines have been published with recommendations for maximising safety during prehospital emergency anaesthesia.[5] Most prehospital and retrieval services have Standard Operating Procedures to maximise first attempt success, as well as strategies to employ in the event of a failed intubation attempt. There are few published data on the efficacy of these strategies to ensure success on subsequent attempts following a failed first intubation.

The aim of this study was to identify changes to intubation technique following a failed intubation attempt during aeromedical retrieval missions performed by LifeFlight Retrieval Medicine (LRM).

METHODS

LRM is a large not-for-profit organisation based in Queensland, Australia. LRM retrieval teams are either a doctor-critical care paramedic or doctor–nurse model. Retrievals are performed using rotary wing, fixed wing and road transport platforms from

eight bases around Queensland, Australia. The service undertakes over 6000 retrievals each year, approximately 30% of which are primary (scene) missions and 70% are interhospital transfers.

Intubators in this service are physicians (consultants or advanced trainees in the specialties of emergency medicine, anaesthesia or intensive care medicine) or critical care paramedics. A Standard Operating Procedure describes the recommended approach to the intubation procedure. This approach includes the use of a checklist to ensure a standard kit dump (intubation equipment prepared, tested and laid out on a 'shadow board'), preoxygenation with a non-rebreather mask and nasal prongs for self-ventilating patients (or bag-mask ventilation for patients with absent or inadequate ventilation), apnoeic oxygenation via nasal prongs, and with the first attempt intubation under direct vision with a videolaryngoscope (McGrath), and the use of a bougie as standard.

In the event of failed first attempt at intubation, a series of '30 s drills' (adjust operator's position, adjust patient's position, suction, insert blade to maximum and withdraw under vision, external laryngeal manipulation (ELM), use videolaryngoscopy) is recommended to implement changes to the intubation procedure to ensure success on the next attempt. Successful intubation is confirmed clinically (chest movement, tube fogging, audible air entry on auscultation) as well as with waveform capnography.

All cases are contemporaneously documented on paper notes, and post-mission data are collected on an electronic database (Air Maestro, Avinet, Australia). This database includes an airway registry, where all intubations performed by LRM retrieval teams are recorded. The data collected for this internal registry are based on the Australia and New Zealand Emergency Department Airway Registry, with extra data fields specific to retrieval medicine. In our service, an intubation attempt is defined as placing the laryngoscope in the mouth, with the intention to place an endotracheal tube.

In this retrospective study, all intubations performed by LRM teams over a 41-month study period from March 2015 to July 2018 were included. This study period was chosen for pragmatic reasons from the time of introduction of the electronic database until the beginning of data analysis by the authors. Cases requiring more than one intubation attempt were identified from the database, and both registry data and the original paper case sheet were examined for all of these cases. Descriptive statistics were collected on changes made to the airway management technique between failed first, second and third intubation attempts, as well as failed intubation. These were analysed by χ^2 testing with an alpha level of 0.05, and 95% CIs were calculated using Microsoft Excel. Ethics approval for this study was granted by the Human Research Ethics Committee at the Royal Brisbane and Women's Hospital.

RESULTS

In all, 762 cases requiring intubation were recorded in the airway registry: 345/762 (45.3%) intubations were for medical indications and 417/762 (54.7%) were trauma related. 370/762 (48.6%) were intubated on primary (scene response) missions, and 392/762 (51.4%) were performed during interhospital transfers (IHT). Case demographics are summarised in table 1.

The majority of patients (758/762 (99.5%)) successfully underwent endotracheal intubation; two cases required surgical airway, one patient had a cuffed tube placed via an existing tracheostomy and one patient was transported with a rescue laryngeal mask airway in situ.

Table 1 Demographics

Patient age	Range: newborn–85 years	
	Median 49.5 years	
	<2 years	18
	2–10	19
	11–16	23
	17–24	104
	25–49	233
	50–74	299
	>75	53
	Unknown	13*
Gender	Male	505/762 (66.3%)
	Female	240/762 (31.5%)
	Unknown/unstated	17/762 (2.2%)
Mission type	Primary	370/762 (48.6%)
	Interhospital	392/762 (51.4%)
Indication for intubation	Trauma	417/762 (54.7%)
	Medical	345/762 (45.3%)
Laryngoscopic technique (first attempt success, %)	Direct laryngoscopy (DL)	563 (511, 90.8%)
	Macintosh/Miller	384 (348, 90.6%)
	Videolaryngoscopy, direct view (VL-D)	179 (163, 91.1%)
	Videolaryngoscopy (VL)	194 (172, 88.7%)
	Awake fibreoptic	1 (1, 100%)

*13 patients were unidentified at the time of mission and their age could not be confirmed.
DL, Direct laryngoscopy; VL, Videolaryngoscopy; VL-D, Videolaryngoscopy, direct view.

684/762 (89.8%; 95% CI: 0.87 to 0.92) oral intubations were successful at the first attempt by LRM teams. 65/762 (8.5%) patients were intubated at the second attempt, and a further 9 (1.1%) were successfully intubated at the third attempt.

There was no difference in first attempt success rate between trauma and medical patients (374/419 (89.3%) vs 310/343 (90.4%), p=0.61), and no difference in first attempt success between primary and interhospital missions (329/370 (88.7%) vs 355/392 (90.8%), p=0.33).

There was no difference in first attempt success rate between techniques; direct laryngoscopy using a Macintosh or Miller blade (DL) 348/384 (90.7%); video laryngoscopy (VL) 172/194 (88.7%); VL with direct view (VL-D) 163/179 (91.1%) p=0.67. There was no overall difference between direct and VL 511/563 (90.8%) versus 172/194 (88.7%) p=0.38. A single patient was intubated by an awake fibreoptic technique using equipment available at the referring hospital.

Changes between intubation attempts

Clinicians made changes to the intubation attempt in the majority of cases following a failed first attempt (69/78, 88.4%). A single change in intubating procedure was recorded between a failed and successful subsequent attempts in 28/78 (35.9%) cases. More than one change was recorded in 41/78 (52.6%) cases, and no change between attempts was recorded in 9/78 (11.5%).

The recorded changes (figure 1) included intubating device, intubating aids (bougie or stylet), change of operator or patient position, ELM, suction and change in endotracheal tube size.

Changes between failed first and successful second attempts

The intubating clinician changed in 15 of the 65 (23.1%) cases that had a successful second attempt. A different intubating

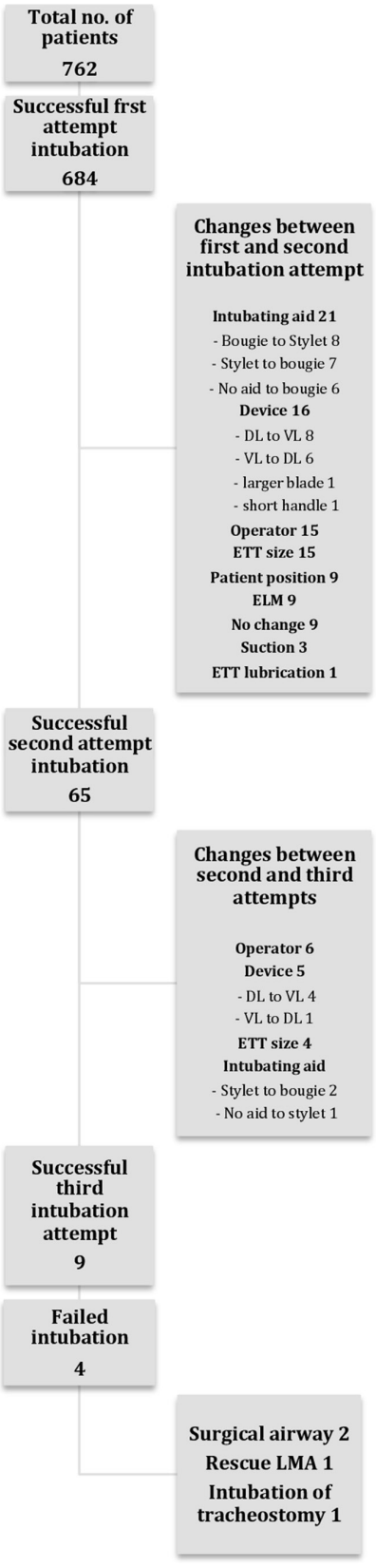

Figure 1 Changes to intubation technique between attempts. Over half of patients had more than one change. DL, direct laryngoscopy; ELM, external laryngeal manipulation; ETT, endotracheal tube; LMA, Laryngeal mask airway; VL, video laryngoscopy.

device was used in 16 cases (26.2%). Direct laryngoscopy (DL) was replaced with VL in eight cases and VL was changed to DL in six cases. A larger blade was used on one occasion and a short laryngoscope handle was used on one patient. The patient position was changed in nine cases (13.8%). A change to the intubating aid was made on 21 occasions (stylet to bougie 7, bougie to stylet 8, no aid to bougie 6). ELM was added in three cases and ELM was removed in three cases. The ETT size was decreased on 15 occasions. Intubation was successful after the addition of suction in seven cases. Manual-In-Line-Stabilisation of the cervical spine was removed in one case. These changes led to a successful second attempt in 65 of the failed 78 first attempt cases.

Changes between failed second and successful third attempts

Following a failed second attempt, further changes were made prior to a successful third attempt. In six cases, the operator changed. A different device was used in five cases; DL changed to VL in four cases, VL changed to DL in one case. A smaller ETT was used in four cases. A stylet was exchanged for a bougie in two cases, and in one case a stylet was used where no intubating aid was used on the previous attempt. ELM was added in one case, and removed in one case. Dentures were removed in a single case. Intubation was successful on the third attempt in nine cases.

DISCUSSION

Successive intubation attempts are associated with an increasing complication rate,[6 8 12] and first attempt success has been used as a marker of quality and safety in emergency intubation.[13] While first attempt success is no guarantee of an absence of complications,[14 15]every effort should be made to achieve endotracheal intubation at the first attempt.[5 16] Close monitoring of first attempt success rates may be detrimental, due to clinicians persisting with prolonged attempts at achieving first attempt success, rather than on managing the peri-intubation physiology to avoid hypoxia, hypotension and bradycardia.[17] First attempt success is only one measure of successful prehospital airway management; however, it remains sensible to minimise the number of failed first intubation attempts.

The majority of patients (99.4%) in this series were successfully intubated, in keeping with previously published data.[18] The reported first attempt success is variable in physician-led HEMS (Helicopter Emergency Medical Service), ranging from 84.5%[19] to 98.2%.[20] A first look success of 89.8% (98.3% successful intubation following a second attempt) is comparable with previously published international figures[12 21] but leaves some room for optimisation of systems. The success percentage was consistent across primary and IHT with no difference between trauma and medical indications. This may suggest that first attempt success is influenced by system factors rather than patient subgroups.

Many of the critically ill patients in our clinical setting require intubation prior to transport, and waking the patient up following a failed intubation attempt is often not a practical option. The LRM intubation Standard Operating Procedure mandates a change in operator or technique between intubation attempts. An attempt to further optimise intubating conditions was recorded in the majority of failed first intubation attempts.

The majority of LRM clinical crews are comprised of two clinicians who are trained to intubate. Following a failed first intubation attempt, the intubating clinician changed prior to one-quarter of second attempts, and before two-thirds of third attempts. It has been demonstrated in an emergency department

setting that repeated attempts by the same operator are associated with decreased success rates.[22] The most experienced available clinician should perform the intubation wherever practicable. Changing the operator may be a worthwhile strategy in the event of failed intubation attempt, but conversely the original operator may be best placed to perform the second attempt if the cause of the failed previous attempt has been identified and can be rectified. This could also avoid a delay incurred during the change in position of the team members.

In our service, use of a videolaryngoscopy device (McGrath™. Medtronic, Boulder, Colorado) is encouraged with the first view being under direct vision using a VL device, then changing to VL if unable to obtain an adequate glottis view. The majority of cases were intubated using direct laryngoscopy. In our cohort, there was no difference in first attempt success rate between direct and indirect laryngoscopy. The role of videolaryngoscopy in prehospital care remains unclear, although Angermann[20] *et al* and Rhode[23] *et al* report a significant improvement in first attempt success following the introduction of videolaryngoscopy. Gellerfors[19] also reports higher first attempt success with videolaryngoscopy than with direct laryngoscopy.

The relatively low usage rate of videolaryngoscopy in our study reflects our SOP, which states that the first look should use direct laryngoscopy. The experience of individual clinicians with various intubation devices, concerns about potential obscuration of the camera due to airway contamination, or perceived difficulties with visualisation of the screen in the high ambient light conditions common in our environment may be other factors in this finding.

Seven cases were successfully intubated after the addition of an intubating aid. The use of an intubating bougie is recommended by the LRM SOP for the first intubation attempt. A pre-shaped stylet is recommended for VL if using a hyperangulated blade (McGrath™ X Blade. Medtronic, Boulder, Colorado). The use of a bougie has been shown to increase intubation success rate, but also increases the time taken to achieve intubation when compared with no intubating aid in an emergency department setting.[24] This extra time should be minimal in a well-trained team, and the clinical significance of this potential delay is unknown. Adherence to the intubating guideline in regard to the use of a bougie or stylet may increase the first attempt success.

On a substantial number of occasions, a smaller endotracheal tube was used following a failed intubation attempt. The use of a smaller size ET tube has been shown to be a predictor of intubation success.[25] While every effort should be made to achieve the best possible view at laryngoscopy, visualisation of the glottis and placement of a bougie do not guarantee successful intubation—the placement of the endotracheal tube can also present difficulties. The intubating clinician should have strategies to achieve tracheal intubation in this situation, and to overcome difficulties in passing a tube over a successfully placed bougie.

Optimising patient position is recommended to facilitate intubation of critically ill patients.[26] In the prehospital setting, this may involve moving the patient from the ground onto a stretcher at a suitable height for the intubator, as well as ensuring ear-to-sternal notch, neutral position or ramping where clinically appropriate. In this study, patient position was changed in a minority of cases. All position changes occurred between a failed first and successful second attempts. Optimising patient position is an important part of the LRM intubation preparation, and is included in the pre-intubation checklist.[27] It is likely that the relatively small number of patients who were repositioned is due to the fact that the best positioning possible in the situation had already been achieved prior to the first failed attempt. Strict adherence to guidance on patient positioning may achieve further improvements in first attempt success.

The role and benefit of cricoid pressure in emergency intubation is unproven[28] and the use of cricoid pressure is not recommended by LRM; however, ELM is used when deemed necessary by individual clinicians. ELM has previously been shown to improve the laryngeal view on the first intubation attempt in an Emergency Department setting.[29 30]

Just over one in ten of the failed first attempts in this series were successfully intubated on subsequent attempts with no recorded change in operator or technique to explain the successful intubation. We were unable to clearly identify a reason for this. It is possible that experienced clinicians can identify and enact subtle differences to finesse their technique for a successful second attempt. In our service, we predominantly use rocuronium as the paralytic agent, and it may be that some intubation attempts were commenced prior to complete neuromuscular blockade. The lack of an identified reason may be simply a limitation of our recording system or poor data entry by the intubating clinicians, but it is possible that there are more complex human factors involved in this finding.

This study is limited in that it is a retrospective analysis of paper-based case notes as well as an electronic database. Data entry is completed retrospectively (although shortly after the event) by the clinician who performed the intubation, and is thus subject to self-reporting bias.[31] In the majority of cases of failed first attempt, more than one change to the intubation procedure was recorded. We were unable to ascertain whether a single change or combination of these changes led to successful intubation when more than one change was recorded. Further evaluation of the most effective change would be useful for the development of failed intubation procedures.

CONCLUSION

In this study of intubation during aeromedical retrieval, a high overall intubation success was found. A failed first intubation attempt was recorded in one in ten patients. Changes to the intubating procedure instituted by clinicians led to a high success with a second attempt. Adherence to all aspects of a standardised approach may lead to further improvements in first attempt success. Intubating clinicians need to maintain sufficient situational awareness to allow them to identify the issues leading to a failed intubation attempt, and have the experience, equipment and technical skill to implement the changes required to achieve successful intubation.

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