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Clinical Paper

Tracheal intubation in an urban emergency department in Scotland: A prospective, observational study of 3738 intubations

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ABSTRACT

Aim: The emergency department (ED) is an area where major airway difficulties can occur, often as complications of rapid sequence induction (RSI). We undertook a prospective, observational study of tracheal intubation performed in a large, urban UK ED to study this further.
Methods: We reviewed data on every intubation attempt made in our ED between January 1999 and December 2011. We recorded techniques and drugs used, intubator details, success rate, and associated complications. Tracheal intubation in our ED is managed jointly by emergency physicians and anaesthetists; an anaesthetist is contacted to attend to support ED staff when RSI is being performed.
Results: We included 3738 intubations in analysis. 2749 (74%) were RSIs, 361 (10%) were other drug combinations, and 628 (17%) received no drugs. Emergency physicians performed 78% and anaesthetists 22% of intubations. Tracheal intubation was successful in 3724 patients (99.6%). First time success rate was 85%; 98% of patients were successfully intubated with two or fewer attempts, and three patients (0.1%) had more than three attempts. Intubation failed in 14 patients; five (0.13%) had a surgical airway performed. Associated complications occurred in 286 (8%) patients. The incidence of complications was associated with the number of attempts made; 7% in one attempt, 15% in two attempts, and 32% in three attempts ($p < 0.001$).
Conclusion: A collaborative approach between emergency physicians and anaesthetists contributed to a high rate of successful intubation and a low rate of complications. Close collaboration in training and delivery of service models is essential to maintain these high standards and achieve further improvement where possible.

1. Introduction

Emergency airway management is often required in critically ill and injured patients who present to the emergency department (ED). Rapid sequence induction (RSI) and tracheal intubation is the method of choice for securing the airway in the majority of cases. Historically, ED RSI in the United Kingdom has been performed mostly by anaesthetists,[1] but it is increasingly becoming the responsibility of emergency physicians. RSI and tracheal intubation are considered core skills for trainees in emergency medicine.[2] However, previous UK studies have found emergency physicians are involved in only 20–50% of RSIs in the ED.[3–5]

Tracheal intubation in the critically ill and injured can be difficult.[6,7] The fourth National Audit Project (NAP4) from the Royal College of Anaesthetists found at least one in four major airway events occurred in the ED or intensive care unit (ICU), often with particularly adverse outcomes, and that most events in the ED were complications of RSI.[8] The need to scrutinise current practice to improve quality in ED airway management has been highlighted recently.[9]

Techniques and practices in emergency airway management vary internationally. Studies from North America and Asia have demonstrated variable success and complication rates of RSI performed by emergency physicians.[10–17] There are limited data from the UK[4,5] so we reviewed our continuous registry of intubations in a large UK ED to characterise intubation sequences, success and complications. Our aims were to describe why, how and by whom ED patients were intubated, and to document the rates of successful intubation and complications related to the procedure.

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2. Methods

The Scientific Officer of the South East Scotland Research Ethics Service stated that formal ethical approval was not required for this case series.

2.1. Setting and patients

The Royal Infirmary of Edinburgh (RIE) is a large, urban, teaching hospital which serves a population of around 800,000. In 1999 around 50,000 patients attended the ED; this has now risen to around 115,000 each year. Patients younger than 13 years of age are generally managed in a separate children's hospital. Emergency tracheal intubation is managed jointly by emergency physicians and anaesthetists. There is a protocol (see Appendix B) which requires that an appropriately senior anaesthetist is contacted to attend (if available) when drug-assisted intubation is being performed. The anaesthetist generally remains in reserve while the emergency physician proceeds with induction and tracheal intubation. However if the anaesthetist determines for an individual case that it would be more appropriate, they will perform induction and tracheal intubation themselves. We included all patients who underwent any attempt at tracheal intubation in the ED between January 1999 and December 2011, including those intubated without drugs.

2.2. Data collection and analysis

We have recorded prospectively data about all tracheal intubation attempts performed in the ED in an intubation registry since January 1999. This registry was initially established as part of a 2-year multi-centre observational study of RSI in seven Scottish emergency departments.[5] The intubating doctor records data on a specifically designed proforma immediately after attempting tracheal intubation. Investigators regularly check the resuscitation room log and electronic records to ensure all patients are included. If a proforma is not completed, a form is sent to the intubating doctor for completion; if the intubating doctor cannot be identified, an investigator completes the form using data from the patient's ED clinical notes. Records are reviewed by a senior emergency physician (AJO) and senior anaesthetist (DCR or DWMcK) to identify trends and patients for discussion. We document details in three main sections: patient details and pre-induction physiology; details of the intubation procedure; and immediate complications or events associated with tracheal intubation (Table 1). We recorded desaturation or hypotension as a complication only if SpO_2 was >90% or systolic blood pressure >90 mmHg before intubation was performed. We did not record oesophageal intubation as a complication if it was recognised immediately. Data were entered by independent audit staff from the Scottish Trauma Audit Group into a Microsoft Excel™ database. We used GraphPad Prism™ to perform basic descriptive statistical analyses and used the X^2 test or Fishers exact test as appropriate to compare differences between groups. We considered a p value of <0.05 as significant.

3. Results

During the study period approximately 1.1 million patients attended the ED and 3988 patients had tracheal intubation attempted; this equates to almost six intubations per week and 1 in 275 (0.36%) ED attendances. In 250 patients there was no record of whether drugs were given to facilitate tracheal intubation; we excluded these patients from further analysis. Thus, we analysed data from 3738 patients. 2749 patients (74%) received RSI (administered an induction drug and suxamethonium or rocuronium), and a further 361 patients (10%) received other drug combinations (27 induction drug and atracurium or vecuronium; 184 induction drug but no neuromuscular blocking drug; 12 neuromuscular blocking drug and an opioid; 77 suxamethonium but no induction drug and eight another neuromuscular blocking drug but no induction drug; 27 inhalational induction with sevoflurane; four only an opioid; four topical administration of lidocaine spray; and 18 were recorded as "non-RSI" where drugs were given but not specified). 628 patients (17%) had intubation performed without administration of any induction, opioid or neuromuscular blocking drug; 496 of these patients (30 of whom were in traumatic cardiac arrest) underwent attempted tracheal intubation during resuscitation for cardiac arrest.

Table 1
Data collected for each tracheal intubation attempt.

Patient details and pre-induction physiology
Age and gender of the patient
Primary diagnosis – classed as trauma; medical; neurological; cardiorespiratory; toxicology; in cardiac arrest; other
Heart rate <40 or >140 beats per minute
Respiratory rate <6 or >30 breaths per minute
Oxygen saturation <90% despite supplemental oxygen
Systolic blood pressure <90 mmHg
Glasgow coma scale score <9
Any anticipated difficulty of intubation
Details of the intubation procedure
Time of intubation
Use of pre-oxygenation (3 min with a tight-fitting face-mask)
Use of cricoid pressure
Use of induction drugs and neuromuscular blocking drugs (dose not recorded)
Grade and specialty of intubating doctor
Grade and specialty of supervising doctor
Best laryngoscopic view obtained (Cormack and Lehane classification)
Adjuncts used – classed as stylet; bougie; external laryngeal manipulation; capnography; other
Immediate complications or events associated with tracheal intubation
Hypoxaemia (SpO_2 < 90%)
Hypotension (SBP < 90 mmHg)
Cardiac arrest
Vomiting or regurgitation of gastric contents
Need for surgical airway

3.1. All intubations

The median age (range) of patients was 48 years (1–102), and 64% were male; nine patients were aged less than 13 years. Three quarters of intubation attempts occurred between the hours of 0800 and 2400. The presenting diagnostic categories for patients are shown in Table 2. More than 50% of patients had a medical diagnosis, a further one-fifth was in cardiac arrest, and one-quarter had a diagnosis of trauma.

The specialty of the primary intubator was emergency medicine in 78% and anaesthesia in 22%. Tracheal intubation was successful in 3724 patients (99.6%). Overall first-time successful tracheal intubation rate was 85% (anaesthetists 92%, ED consultants 94%, ED trainees 83%; $p < 0.001$). The rate of first-time successful intubation was related to the presenting diagnosis (trauma 84%; cardiac arrest 79%; medical 87%; neurological 88%; cardiorespiratory 86%; toxicology 91%; and other 96%, $p < 0.001$). We separated patients into one of three groups according to drugs: RSI; other drug combinations; and no drugs given. Details for successful tracheal intubation rates and specialty of the primary intubator are shown in Table 3. Successful intubation was more likely on the first attempt if RSI was used ($p < 0.001$). Unsurprisingly anaesthetists were involved most commonly in patients given RSI and least commonly in patients given no drugs to facilitate intubation. Tracheal intubation was achieved within two attempts in 98% of patients. Three patients (0.1%) had more than three attempts to successfully intubate the trachea. Intubation was not successful in a further 14 patients; one

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Table 2
Diagnoses for patients undergoing tracheal intubation (250 excluded as missing data). Data shown as *n* (%).

Diagnosis	All *n* = 3738	RSI *n* = 2749	Other drug combinations *n* = 361	No. drugs given *n* = 628
Trauma	853(23)	767(28)	65(18)	21(3)
Cardiac arrest[a]	710(19)	67(2)	147(41)	496(79)
Medical	705(19)	578(21)	95(26)	32(5)
Neurological	616(16)	592(21)	16(4)	8(1)
Cardiorespiratory	364(10)	285(10)	23(6)	56(9)
Toxicology	432(12)	414(15)	8(2)	10(2)
Other	50(1)	41(1)	6(2)	3(<1)
Not recorded	8	5	1	2

[a] Includes 33 patients in traumatic cardiac arrest.

Table 3
Success rates for tracheal intubation. Data shown as %, or as number.

	RSI	Other drug combinations	No. drugs given
Specialty of primary intubator			
Anaesthesia	26%	23%	5%
Emergency medicine	73%	74%	93%
Missing specialty	1%	3%	2%
Number of intubation attempts			
1	87%	78%	80%
2	12%	16%	15%
3	1%	5%	3%
Failed intubation (*n*)	2	3	9
Surgical airway (*n*)	2	2	1

patient had a laryngeal mask airway inserted, five (0.13%) had a surgical airway performed, and resuscitation from pre-existing cardiac arrest was discontinued in eight patients.

Nine patients in our study were aged less than 13 years. Five received RSI, one had another drug combination and three received no drugs to facilitate intubation. All had successful tracheal intubation at the first attempt. Emergency physicians performed eight of the intubations which were all supervised by senior staff. No complication related to intubation was recorded for any patient.

Three hundred and thirteen complications associated with tracheal intubation occurred in 286 (8%) patients (Table 4). Hypoxaemia occurred in 62 (1.7%) patients; hypotension in 170 (4.5%); vomiting/regurgitation in 40 (1.1%); cardiac arrest in 30 (0.8%); and other complications in 11 (four airway trauma, two bronchial main stem intubation, and one each of lobar collapse, tracheal tube dislodged above vocal cords, supraventricular tachycardia, tracheal cuff leak, and tension pneumothorax). There were 100 (2.7%) instances of oesophageal intubation all of which were recognised immediately. The incidence of complications was associated with the number of intubation attempts: 7% in patients who required one attempt; 15% in those who required two attempts; and 32% in those who required three attempts ($p < 0.001$). The incidence of specific complications related to the number of intubation attempts is shown in Fig. 1.

Details of supervision were recorded in 2655 (71%) of initial intubation attempts and in 2133 (78%) of RSIs. In 891 (22%) attempts, trainees were supervised by both a senior (defined as a year 4 registrar or above) anaesthetist and emergency physician. In a further 800 (20%) supervision was by a senior anaesthetist and in 964 (24%) by a senior emergency physician. Thus at least two-thirds of initial intubation attempts were supervised by senior doctors and at least 45% of attempts were supervised by a consultant. The rates of successful first-time intubation, multiple intubation attempts, failed intubation, and complications were not related to whether intubation was supervised or not.

3.2. RSI intubations

2749 patients (0.25%, 1 in 400 ED attendances) received RSI, many of whom had significant physiological compromise. Two-thirds had depressed conscious level with Glasgow Coma Scale score less than 9. A total of 1313 physiological abnormalities were recorded in 460 patients before intubation: 319 (12%) had oxygen saturation <90% despite receiving oxygen supplementation; 237 (9%) had systolic blood pressure <90 mmHg; 427 (16%) had a respiratory rate <10 or >30 breath/min; and 330 (12%) had a heart rate <40 or >140 bpm. Predictors of potentially difficult airway management were recorded in 889 (32%) patients; 573 (21%) had cervical spine immobilisation, 284 (10%) had abnormal airway anatomy, and 188 (7%) were obese. The incidence of Cormack & Lehane (C&L) grade 3 or 4 laryngoscopic view[18] in these patients

Table 4
Immediate complications/associated events related to RSI and tracheal intubation. All data are shown as percentages.

	RSI	Other drug combinations	No. drugs given
Desaturation SpO_2 <90%[a]	2.1	1.4	0.6
Hypotension SBP <90 mmHg[b]	5.7	3.0	0.5
Vomiting/regurgitation	0.7	3.0	1.4
Cardiac arrest	0.5	2.5	1.0
Other	0.4	0.6	0
Total	9.4	10.5	3.5

[a] Only if SpO_2 > 90% before intubation; desaturation was not recorded if SpO_2 was <90% before intubation.
[b] Only if SBP > 90 mmHg before intubation; hypotension was not recorded if SBP was <90 mmHg before intubation.

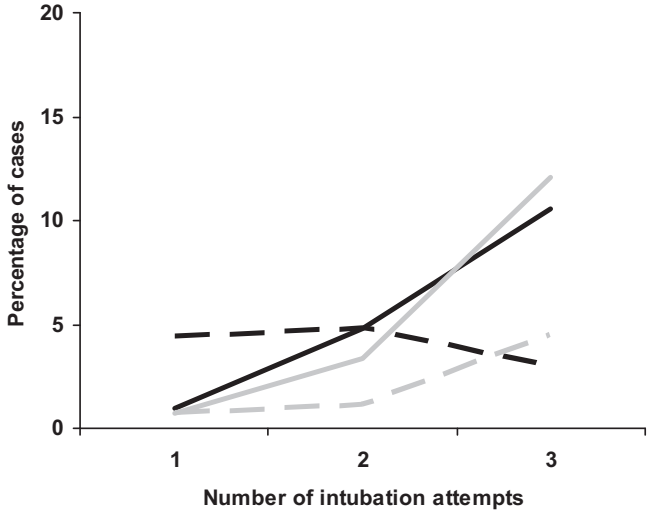

Fig. 1. Incidence of specific complications versus number of intubation attempts. desaturation, aspiration, hypotension, cardiac arrest.

Table 5
Induction characteristics for patients undergoing RSI ($n = 2749$).

	Number	%
Preparation		
Formal preoxygenation	2569	93
Cricoid pressure	2620	95
Induction drug given		
Thiopental	1792	65
Etomidate	693	25
Propofol	212	8
Ketamine	14	0.5
Midazolam	23	1
Not recorded	15	0.5
Neuromuscular blocker given		
Suxamethonium	2607	95
Rocuronium	134	5
Neuromuscular blocker given but not specified	2	<1
Not recorded	6	<1
Opioid given		
Fentanyl	607	22
Morphine	8	<1
Alfentanil	3	<1
Opioid given but not specified	274	10

was 13% compared with 4% in those patients with no predictors of difficult airway management ($p < 0.001$). Details of formal preoxygenation, cricoid pressure and drugs used for intubation are shown in Table 5. An anaesthetist was present in three quarters of cases but was the primary intubator in only 26% of initial attempts and in 54% of second attempts. When an initial intubation attempt by an emergency medicine trainee was unsuccessful, an anaesthetist was the "rescue" operator for subsequent attempts in 132 (36%) cases, and a consultant emergency physician in 41 (11%). Tracheal intubation was successful at the first attempt in 87% of patients (anaesthetists 92%, ED consultants 93%, ED trainees 84%; $p < 0.001$). C&L grade 1 or 2 laryngoscopic view was obtained in 92%; there was no difference in grade of views obtained by anaesthetists and emergency physicians ($p = 0.872$).

An airway adjunct such as a stylet or bougie was used in 56% of intubation attempts. A stylet was used in 45% of first attempts and a bougie in 11%. A bougie was used more frequently in subsequent intubation attempts – 29% in second attempts and 39% in third attempts. External laryngeal manipulation was performed in 3% of all attempts; its use increased with additional attempts to 6% in second attempts and 8% in third attempts.

The overall rate of complications associated with RSI was 9.4% (Table 4). There was no difference in rate of complications between anaesthetists and emergency physicians ($p = 0.192$).

4. Discussion

In this prospective, observational study we found that 98% of tracheal intubations in the emergency department were successful on the first or second attempt, that only 0.1% of patients had more than three attempts at intubation, that the rate of performing a surgical airway was 0.13%, and that the complication rate was 8%. Rapid sequence induction was used in almost three-quarters of attempts but nearly one-fifth of patients (most of whom were in cardiac arrest) received no drugs to facilitate tracheal intubation. In contrast to the findings of an earlier census of UK EDs which found almost 80% of intubations were performed by anaesthetists,[3] emergency physicians performed almost three-quarters of intubations in our study. These figures suggest a high degree of technical skill in intubation, confirming that the collaborative approach with anaesthetists works well.

Our data compare well with previously reported studies from North America,[10,16,19] Japan,[12] and Korea,[11] where first attempt success rates ranged from 71 to 81%, the rates of more than three attempts ranged from 0.85% to 6%, and the rates of surgical airway ranged from 0.11 to 1.7%. Our RSI rate of 74% is much higher, and our 17% rate of intubation without drugs is much lower, than these other studies where RSI rate ranged from 20 to 69%, and the rate for intubation using no drugs ranged from 20 to 58%. These differences reflect the variable approaches to emergency airway management internationally. In our study successful first-time intubation was more likely when RSI was used, and the incidence of failed intubation was 0.1% in RSIs, 0.8% for other drug combinations and 1.4% when no drugs were given. These findings give a potential indication for the value of using drugs (particularly RSI) to facilitate intubation.

We found that ED RSI was not frequently associated with significant complications, particularly oxygen desaturation and aspiration of gastric contents, and there were no deaths related to airway management. The NAP4 report identified four deaths in ED, all of which were related to poor airway management.[8] It is important to avoid multiple attempts at intubation which are associated with greatly increased rates of oxygen desaturation and aspiration.[19,20] Complication rates increase with increasing numbers of attempts. Analysis of a Japanese registry found a 9% complication rate in patients who required two or fewer attempts compared to 35% in patients who had multiple attempts.[21] In an American study the rate of complications increased five-fold from the first attempt to the third attempt (14% compared to 64%); the incidence of oxygen desaturation increased from 9% on the first attempt to 44% on the third, and the rate of aspiration increased from 0.8% on the first attempt to 12% if more than three attempts were made.[19] We found a similar pattern, but with a much lower incidence of desaturation. In our study 98% of intubations were successful on the first or second attempt and only three patients underwent more than three attempts.

For RSI, emergency physicians achieved similar laryngoscopic views but lower initial intubation success rates than anaesthetists over the 13-year period of our review. Since 2007 however, the difference in initial success rate is no longer apparent (first time successful intubation: anaesthetists 88%, emergency physicians 87%, $p = 0.909$). There are several possible explanations for this, but we believe that emergency physicians are now better at intubation than previously, and that anaesthetists are now involved more frequently in initial attempts where intubation is anticipated to be difficult. This further highlights the advantages of a collaborative approach to airway management in the ED. It is not just about emergency physicians gaining competence in tracheal intubation but also maintaining these skills. In our ED where the rate of RSI is almost twice the UK national rate, an ED consultant might be involved in 10–20 RSIs each year, but only perform intubation personally in two to five of these. Anaesthetists also need to become more comfortable performing RSI out of theatre. Close liaison between specialties allows a strong collaborative approach in the delivery of improved emergency airway care.

Supervision of inexperienced practitioners is obviously important. The NAP4 report identified several events where a practitioner had insufficient experience to manage the airway and highlighted the need for senior involvement and supervision.[8] In their census of practice in UK EDs, Benger and Hopkinson found that only 36% of intubations were supervised.[3] Our supervision rate was at least 71%, and in reality was probably higher, when missing data are considered. Having a senior practitioner present can reduce complications related to intubation[22,23]; it is important to distinguish between competence and expertise.[24] A period of formal training in anaesthesia is also beneficial in out-of-theatre intubation.[7] Around 95% of practitioners in our study had spent at least three months in formal anaesthesia training. This may help to explain the intubation success rate for emergency medicine trainees.

There are some limitations to our study. We excluded from analysis 250 (6%) of intubation attempts owing to missing data. It is unlikely that data from these attempts would alter the main findings substantially but we cannot be certain about this. There are also a small number of patients who were taken to the operating theatre to have formal fibreoptic laryngoscopy and intubation performed – these are not included in our study. We did not grade the severity of complications related to tracheal intubation but simply recorded if SpO_2 was <90% and systolic blood pressure was <90 mmHg. We cannot comment on whether patients who had physiological abnormality before intubation became worse after intubation and therefore the actual frequency of adverse events could be higher than we have reported. The data were gathered prospectively, were simply observational and from a single centre. However, it is the largest prospective study of ED tracheal intubation in the UK and one of the largest in the world, and the results have important implications for other EDs.

In conclusion, we found 98% of attempts at tracheal intubation were successful in fewer than three attempts, a surgical airway rate of 0.13%, and a complication rate of 8%. Emergency physicians performed 78% of initial attempts, and there was a high rate of supervision by senior staff. We believe that a collaborative approach between anaesthetists and emergency physicians has contributed greatly to the high rate of success and low rate of serious complications. Close collaboration in training and delivery of service models is essential to maintain these high standards and achieve further improvement where possible.

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Conflict of interest statement

Dr. Ray and Dr. McKeown have assisted Aircraft Medical in the development of the McGrath® videolaryngoscopes. The employing authority of the investigators (NHS Lothian) has received payment from Aircraft Medical for professional advice given by Dr. Ray and Dr. McKeown on a consultative basis. Dr. McKeown has received payment from Aircraft Medical for professional advice. The other authors have no conflicts to declare.

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Appendix A. Emergency Department Intubation Registry (EDIR) investigators

Emergency Department Intubation Registry (EDIR) investigators are Jacqueline Beale, Mark J Dunn, Heather MacColl, Alice Murray, Lindsay Reid and Emma-Beth Wilson.

Appendix B. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.resuscitation.2015.01.005.

References

1. Clancy M, Nolan J. Airway management in the emergency department. Emerg Med J 2002;19:2–3.
2. College of Emergency Medicine. Curriculum Assessment System for Core Specialty Training ACCS CT1-3 and Higher Specialty Training ST4-6. http://www.collemergencymed.ac.uk/Training-Exams/Curriculum/Curriculum%20from%20August%202010 [accessed 22.05.14].
3. Benger J, Hopkinson S. Rapid sequence induction of anaesthesia in UK emergency departments: a national census. Emerg Med J 2011;28:217–20.
4. Stevenson AGM, Graham CA, Hall R, Korsah P, McGuffie AC. Tracheal intubation in the emergency department: the Scottish district hospital perspective. Emerg Med J 2007;24:394–7.
5. Graham CA, Beard D, Oglesby AJ, et al. Rapid sequence intubation in Scottish urban emergency departments. Emerg Med J 2003;20:3–5.
6. Martin LD, Mhyre JM, Shanks AM, Tremper KK, Kheterpal S. 3423 emergency tracheal intubations at a University hospital: airway outcomes and complications. Anesthesiology 2011;114:42–8.
7. Simpson GD, Ross MJ, McKeown DW, Ray DC. Tracheal intubation in the critically ill: a multi-centre national study of practice and complications. Br J Anaesth 2012;108:792–9.
8. Cook TM, Woodall N, Harper J, Benger J, On Behalf of the Fourth National Audit. 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.
9. Carlson JN, Wang HE. Emergency airway management: can we do better? Resuscitation 2013;84:1461–2.
10. Walls RM, Brown CA, Bair AE, Pallin DJ. Emergency airway management: a multi-center report of 8937 emergency department intubations. J Emerg Med 2011;41:347–54.
11. Kim JH, Kim Y-M, Choi HJ, Je SM, Kim E, On behalf of the Korean Emergency Airway Management Registry (KEAMR) Investigators. Factors associated with successful second and third intubation attempts in the ED. Am J Emerg Med 2013;31:1376–81.
12. Hasegawa K, Hagiwara Y, Chiba T, et al. Emergency airway management in Japan: interim analysis of a multi-center prospective observational study. Resuscitation 2012;83:428–33.
13. Tam AYB, Lau FL. A prospective study of tracheal intubation in an emergency department in Hong Kong. Eur J Emerg Med 2001;8:305–10.
14. Wong E, Wong YT, Ho KK. Emergency airway management – experience of a tertiary hospital in south-east Asia. Resuscitation 2004;61:349–55.
15. Fathil SM, Mohd Mahdi SN, Che'Man Z, Ahmad Z, Ismail AK. A prospective study of tracheal intubation in an academic emergency department in Malaysia. Int J Emerg Med 2010;3:233–7.
16. Sagarin MJ, Barton ED, Chng YM, Walls RM. Airway management by US and Canadian emergency medicine residents: a multicenter analysis of more than 6,000 endotracheal intubation attempts. Ann Emerg Med 2005;46:328–36.
17. Tayal VS, Riggs RW, Marx JA, Tomaszewski CA, Schneider RE. Rapid-sequence intubation at an emergency medicine residency: success rate and adverse events during a two-year period. Acad Emerg Med 1999;6:31–7.
18. Cormack RS, Lehane J. Difficult tracheal intubation in obstetrics. Anaesthesia 1984;39:1105–11.
19. 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.
20. Mort TC. Emergency tracheal intubation: complications associated with repeated laryngoscopic attempts. Anesth Analg 2004;99:607–13.
21. 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.
22. Schmidt UH, Kumwilaisak K, Bittner E, George E, Hess D. Effects of supervision by attending anesthesiologists on complications of emergency tracheal intubation. Anesthesiology 2008;109:973–7.
23. 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.
24. Boylan JF, Kavanagh BP. Emergency airway management. Competence versus expertise? Anesthesiology 2008;109:945–7.

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