Repeated attempts at tracheal intubation by a single intubator associated with decreased success rates in emergency departments: an analysis of a multicentre prospective observational study

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ABSTRACT

Objective To determine whether the success rate of repeated attempts at tracheal intubation by a single intubator was lower than those by alternate intubators in the emergency department (ED).

Methods An analysis of data from a multicentre prospective registry (Japanese Emergency Airway Network Registry) of 13 academic and community EDs in Japan between April 2010 and August 2012. We included all adult and paediatric patients who underwent repeated attempts at tracheal intubation in the ED. We compared the intubation success rates at the second and third attempts between attempts at intubation by a single intubator who performed the previous attempts, and the attempts by alternate intubators.

Results We recorded 4094 patients (capture rate, 96%); 1289 patients with repeated attempts at tracheal intubation were eligible for this study. Among these, 871 patients (68%) had a second attempt at intubation by single intubators. At the second attempt, tracheal intubation by a single intubator was associated with a decreased success rate (adjusted odds ratio or AOR, 0.50; 95% CI 0.36 to 0.71), compared with alternate intubators. At the third attempt, intubation by a single intubator was also associated with a decreased success rate (58% vs 70%; unadjusted OR, 0.58; 95% CI 0.38 to 0.89). However, after adjustment for potential confounders, the association lost statistical significance (AOR, 0.89; 95% CI 0.52 to 1.56).

Conclusions In this large multicentre study of ED patients undergoing tracheal intubation, second attempts at intubation by a single intubator, compared with those by alternate intubators, were independently associated with a decreased success rate.

Key messages

What is already known on this subject

- Although a prior study investigated rescue methods in cases with failed tracheal intubations, there have been no data that a change in intubators contributes to success rates at subsequent tracheal intubation attempts.

What this study adds

- Second tracheal intubation attempts by a single intubator, compared to those by alternate intubators, were independently associated with a decreased success rate.

INTRODUCTION

Background

Tracheal intubation in the emergency department (ED) is a critical and challenging intervention. Indeed, the literature reported that 15%–30% of first attempts at tracheal intubation fail in the ED setting.[1–5] Additionally, the rate of adverse events accelerates with the increased number of attempts at tracheal intubation.[4 6 7] Therefore, after an unsuccessful first attempt, a successful tracheal intubation at the next attempt would become important.

Importance

The international anaesthesia consensus recommends making alternative approaches, such as use of experienced intubators for subsequent tracheal intubations after an unsuccessful attempt.[8] However, there has been little clinical evidence to support or refute this strategy in anaesthesia or ED setting. Although an earlier study investigated rescue methods in cases with failed tracheal intubations,[9] there have been no data that a change in intubators contributes to success rates at subsequent attempts at tracheal intubation.

Goals of this investigation

To address this knowledge gap in the literature, we aimed to determine whether the success rate at repeated attempts at tracheal intubation by a single intubator was lower than that by alternate intubators in the ED, using a large prospective multicentre data set of emergency airway management.

METHODS

Study design and setting

We conducted an analysis of the Japanese Emergency Airway Network (JEAN) Registry, a multicentre prospective observational data registry, designed to characterise current ED airway management across Japan. The study setting, methods of measurement, and measured variables have been reported elsewhere.[3 7 10 11] Briefly, JEAN is a consortium of 13 academic and community medical centres from

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different geographic regions across Japan. The participating institutions were certified as Level I (n=11) or Level II equivalent (n=2) trauma centres; they had a median ED census of 25 000 patient visits per year (range, 4200–67 000). All EDs treated adult and paediatric patients. Additionally, all EDs were staffed by emergency attending physicians, and 12 had affiliations with emergency medicine residency training programmes. An emergency attending physician was defined as postgraduate years 6 or more; an emergency medicine resident physician was defined as postgraduate years 3, 4 and 5. Non-emergency medicine resident physicians also rotated through all of these departments.

Each hospital maintained individual protocols about the policy and procedures for ED airway management. Intubations were performed by attending physicians, or by resident physicians, at the discretion of the supervising ED attending physician. The institutional review board of each participating centre approved the protocol with waiver of informed consent before data collection.

Selection of participants

We included all adult and paediatric patients who underwent a repeated tracheal intubation attempt in the ED during a 24-month period (April 2010 to March 2012). We excluded the patients in whom tracheal intubation was ultimately unsuccessful in the ED and the patients with unknown intubator status.

Data collection and processing

After each intubation encounter in the ED, the intubator completed a standardised data collection form that included the patient's age, sex, primary indication for intubation, methods of intubation, all medications used to facilitate intubation, intubator level of training and specialty, number of attempts, success or failure, and adverse events.[3 7 10 11] We monitored compliance with data form completion by reviewing professional billing records. Where the data collection form was missing, we interviewed the involved physicians to ascertain airway management details. These posthoc interviews occurred within 2 weeks of the patient encounter.

Outcome measures

The outcomes of interest were tracheal intubation success rates at the second and third attempts. An oral 'attempt' was defined as a single insertion of the laryngoscope (or other devices) past the teeth.[3 7 10 11] For nasal tracheal intubations, an attempt was defined as a single insertion of a tracheal tube past the turbinates. An attempt was successful if it resulted in a tracheal tube being placed through the vocal cords. Each encounter could have one or more methods, and each method could have one or more attempts. This allowed us to track different methods in sequence.

Data analysis

To determine whether the success rate at repeated attempts at tracheal intubation by a single intubator was lower than that by alternate intubators in the ED, we excluded the patients with a successful initial attempt at intubation from the analysis. Then, we compared the outcomes between attempts at tracheal intubation by a single intubator who performed the previous attempts and those by alternate intubators. An 'intubator' was defined as a physician who attempted to pass a tracheal tube through the vocal cords of a patient.[1] 'Single intubator' was defined as an intubator who had previously failed to intubate a patient and performed the subsequent attempts. An 'alternate intubator' was defined as an intubator who is a different physician from the one previously attempting an intubation for a patient.

We fit multivariable logistic regression models using each of the two end points as a dependent variable. A set of potential

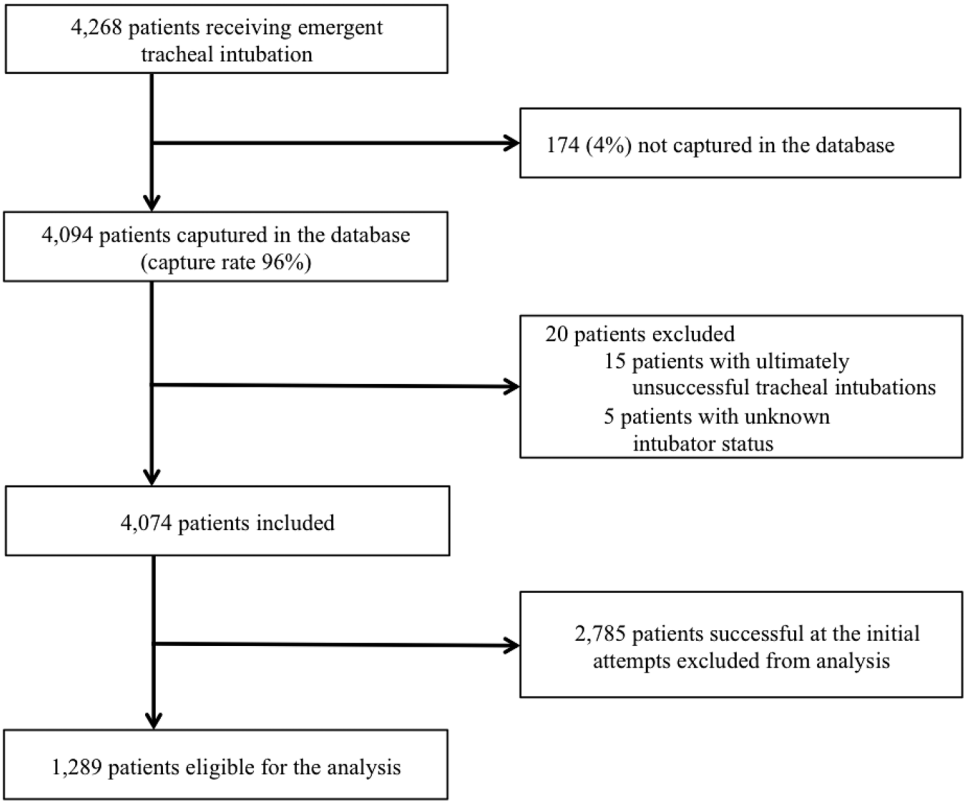

Figure 1 Patients receiving tracheal intubations in emergency departments.

confounders was chosen based on biological plausibility and a priori knowledge. These selected variables included age, sex, principal indication, change in methods of intubation, use of alternate devices for intubation (video laryngoscope and others), additional dosage of medications, and the intubator's specialty and level of training. Clinically meaningful interactions were also included in the model. Their significance was tested as a group to avoid inflating type I error. Specifically, we tested for (changes in intubator −×− a change in methods of intubation, use of alternate devices of intubation, and use of additional medications) interactions using likelihood ratio test; however, preliminary results did not indicate the presence of any effect modifications (data not shown). Therefore, we did not include these interaction terms in the final model.

In sensitivity analysis, we repeated the multivariable analysis with stratification by initial intubator specialty because transitional year residents might have been undertrained in airway management and, therefore, any subsequent intubators would have a better chance of intubation success. We stratified the specialty of the initial intubator as follows: transitional year residents and physicians other than transitional year residents. Additionally, we used Cochran–Armitage testing to assess whether the success rates improved or declined with the increased number of attempts at tracheal intubation for each intubator group. Data analyses were conducted with JMP statistical software (V.10.0.2; SAS Institute, Cary, North Carolina, USA). All statistical tests were two-tailed; the chosen type 1 error rate was $p<0.05$.

RESULTS

During the 24-month period, there were 4268 encounters requiring emergency airway management (figure 1). Among these, the database recorded 4094 encounters (capture rate, 96%). We excluded 15 patients with unsuccessful tracheal intubations, and five patients with unknown intubator status (postgraduate year and specialty). Overall statistics are shown in table 1. For the purpose of this study, we excluded 2785 patients with a successful tracheal intubation at the first attempt, leaving 1289 patients with repeated attempts at tracheal intubation eligible for this study.

At the second attempt, the mean age of all patients receiving repeated attempts at tracheal intubation was 61 years; the majority was male (table 1). Approximately half the intubations involved medical emergencies (52%); 33% of the patients were in cardiac arrest. More than half the second attempts were performed with oral tracheal intubation without any drugs. Induction agents or sedatives without neuromuscular blockade were used in one-fourth of patients; and rapid sequence intubation was used in an additional one-fifth of patients. Emergency physicians (including emergency medicine residents) performed 55% of attempts at tracheal intubation, while transitional year residents performed 34% of the attempts.

At the second attempts, 871 patients (68%) received tracheal intubations by single intubators (table 2). Of 428 patients who underwent the third attempts at tracheal intubation, 122 patients (29%) received tracheal intubation by single intubators. Patient and airway management characteristics were generally similar between the intubator groups (tables 2 and 3). Overall, the transitional year residents accounted for 49% of the single intubator group. By contrast, emergency medicine residents and emergency physicians accounted for 88% of the alternate intubator group.

The overall numbers of successful intubation at the second and third attempts were 861 (67%; 95% CI 62% to 71%) and 285 (67%; 95% CI 62% to 71%), respectively (table 1). The success rates by a single intubator significantly declined as the number of attempts increased (p_{trend} <0.001, figure 2). By contrast, in the alternate intubator group, the success rate increased at the second attempt, then, decreased thereafter (p_{trend}=0.002).

At the second attempt, tracheal intubation by a single intubator was associated with a decreased success rate (59% vs 83%; unadjusted OR, 0.30; 95% CI 0.23% to 0.40%; table 4), compared to that by alternate intubators. After the adjustment for potential confounders, the association between attempts at tracheal intubation by a single intubator and decreased success rate attenuated (adjusted OR or AOR, 0.50; 95% CI 0.36% to 0.71%). Additionally, a change in methods, use of alternate devices, and additional medications were not significantly associated with an increased success rate. At the third attempt, tracheal intubation by a single intubator was also associated with a decreased success rate (58% vs 70%; unadjusted OR, 0.58; 95% CI 0.38% to 0.89%). By contrast, after adjustment for confounders, tracheal intubation by a single intubator had a non-significant decreased odds rate of success (AOR, 0.89; 95% CI 0.52% to 1.56%).

Although statistical power was limited, we performed sensitivity analyses with stratification by initial intubator specialty (table 5). At the second attempt, tracheal intubation by a single intubator was significantly associated with a decreased success rate in both

Table 1 Characteristics and outcomes in overall patients receiving tracheal intubation in emergency department, according to number of attempts at intubation

Patient characteristics	Initial attempt (n=4074)	Second attempt (n=1289)	Third attempt (n=428)
Age (years), mean (SD)*	63 (21)	61 (21)	60 (22)
Adults (≥18 years)	3947 (97)	1233 (96)	406 (95)
Children (<18 years)	127 (3)	56 (4)	22 (5)
Female sex	1599 (39)	482 (37)	153 (36)
Primary indication			
Cardiac arrest	1543 (38)	421 (33)	113 (26)
Medical encounters	2045 (50)	675 (52)	249 (58)
Trauma encounters	486 (12)	193 (15)	66 (15)
Methods			
Oral without medications	2247 (55)	654 (51)	183 (43)
Sedation without paralytics	880 (22)	323 (25)	126 (29)
Rapid sequence intubation	763 (19)	236 (18)	83 (19)
Surgical cricothyrotomy	22 (1)	13 (1)	8 (2)
Others*	162 (4)	63 (5)	28 (6)
Devices			
Direct laryngoscope	3909 (96)	1179 (91)	362 (85)
Video laryngoscope	83 (2)	42 (3)	20 (5)
Others	82 (2)	68 (5)	46 (11)
Specialty			
Transitional year resident	1615 (40)	434 (34)	59 (14)
Emergency medicine resident	1174 (29)	363 (28)	135 (32)
Emergency physician	793 (19)	351 (27)	169 (39)
Other specialty	492 (12)	141 (11)	65 (15)
Successful intubation at each attempt			
Overall	2785 (68)	861 (67)	285 (67)
Adults (≥18 years)	2718 (69)	827 (67)	275 (68)
Children (<18 years)	71 (56)	34 (61)	10 (45)

Data were expressed as % unless otherwise indicated.
*Including children.

Table 2 Characteristics of patients receiving tracheal intubations in emergency department, according to number of attempts at intubation and intubator

	Second attempt		Third attempt	
Patient characteristics	Single intubator (n=871)	Alternate intubator (n=418)	Single intubator (n=122)	Alternate intubator (n=306)
Age (year), mean (SD)	61 (22)	62 (20)	54 (25)	62 (20)
Adults (≥18 years)	826 (95)	407 (97)	109 (89)	297 (97)
Children (<18 years)	45 (5)	11 (3)	13 (11)	9 (3)
Female sex	331 (38)	151 (36)	40 (33)	113 (37)
Primary indication				
Medical encounters	703 (81)	325 (78)	101 (82)	247 (81)
Cardiac arrest	218 (25)	135 (32)	21 (18)	78 (25)
Altered mental status	240 (28)	101 (24)	45 (36)	77 (25)
Respiratory failure	145 (17)	52 (12)	24 (19)	59 (19)
Shock	65 (7)	22 (5)	6 (5)	19 (6)
Airway obstruction	25 (3)	13 (3)	5 (4)	13 (4)
Asthma	4 (1)	1 (1)	0	0
Other medical	6 (1)	1 (1)	0	1 (1)
Trauma encounters	168 (19)	93 (22)	21 (18)	59 (19)
Traumatic arrest	34 (4)	34 (8)	4 (3)	10 (3)
Head trauma	57 (7)	32 (7)	11 (10)	21 (7)
Shock	34 (4)	6 (1)	1 (1)	10 (3)
Facial/neck trauma	23 (3)	9 (2)	2 (1)	10 (3)
Burn/inhalation	15 (2)	3 (1)	3 (2)	4 (1)
Other trauma	4 (1)	4 (1)	0	4 (1)

Data were expressed as % unless otherwise indicated.
*Percentages may not equal 100 due to rounding.

transitional year residents (AOR, 0.21; 95% CI 0.14% to 0.30%) and physicians other than transitional year residents (AOR, 0.51; 95% CI 0.29% to 0.86%). At the third attempt, the significant association remained significant among transitional year residents (AOR, 0.48; 95% CI 0.25% to 0.93%). Among the physicians other than transitional year residents, tracheal intubation by a single intubator had a non-significant decreased odds rate of success (AOR, 0.90; 95% CI 0.42% to 1.96%).

DISCUSSION

In this large prospective multicentre cohort of patients undergoing emergency tracheal intubation, we observed that the success rate by a single intubator significantly declined as the number of attempts increased. Furthermore, we found that second attempts at tracheal intubation by a single intubator, compared to those by alternate intubators, were associated with a decreased intubation success rate in EDs. By contrast, there was no significant difference in the success rate at the third attempts between the intubator groups.

To the best of our knowledge, this is the first study reporting the independent association between a change in intubators and tracheal intubation success rates. The causal link of the observed associations is unclear and likely multifactorial; however, it may be explained, at least in part, by subsequent attempts at tracheal intubation with alternative intubation methods, devices and medications. Interestingly, even after adjusting for these variables at the second attempts at tracheal intubation, the observed associations between a change in intubators and an increased intubation success rate remained significant. Thus, the observed association might result from unmeasured factors other than these rescue methods, such as mental and strategic preparations for attempts at tracheal intubation, to use optimal rescue approaches (eg, the patient positioning and airway management adjuncts).[12–14] Additionally, subsequent attempts by more advanced intubators might contribute to an increased success rate, compared with consecutive attempts by a single intubator. By contrast, our data did not show a significant difference in success rates at the third tracheal attempt at intubation between the single intubator group and alternate intubators group. This finding may suggest that the effectiveness of alternate intubators attenuates in more selected

Table 3 Airway management in patients receiving tracheal intubation in emergency department, according to number of attempts at intubation

	Second attempt		Third attempt	
Management	Single intubator (n=871)	Alternate intubator (n=418)	Single intubator (n=122)	Alternate intubator (n=306)
Methods				
Oral without medications	418 (48)	236 (57)	50 (41)	133 (44)
Sedation without paralytics	241 (28)	82 (19)	39 (32)	87 (28)
Rapid sequence intubation	163 (19)	73 (18)	23 (19)	60 (20)
Surgical cricothyrotomy	6 (1)	7 (2)	2 (2)	6 (2)
Others*	43 (5)	20 (5)	8 (6)	20 (6)
Devices				
Direct laryngoscope	796 (91)	383 (92)	97 (81)	265 (87)
Video laryngoscope	34 (4)	8 (2)	8 (6)	12 (4)
Other†	41 (5)	27 (6)	17 (13)	29 (9)
Specialty of intubator				
Transitional year resident‡	423 (49)	11 (2)	49 (40)	10 (3)
Emergency medicine resident	226 (26)	137 (33)	25 (21)	110 (36)
Emergency physician§	122 (14)	229 (55)	22 (18)	147 (48)
Other specialty	100 (12)	41 (10)	26 (22)	39 (13)

Data were expressed as % unless otherwise indicated. AOR, adjusted odds ratio.
*Defined as oral intubation using topical anaesthesia, lidocaine, atropine, or paralytics without sedatives.
†Defined as nasotracheal intubation, video laryngoscope, bronchoscope, light stylet or combination with direct laryngoscope and gum elastic bougie or video laryngoscope.
‡Defined as postgraduate years 1 or 2.
§Defined as postgraduate years >6.

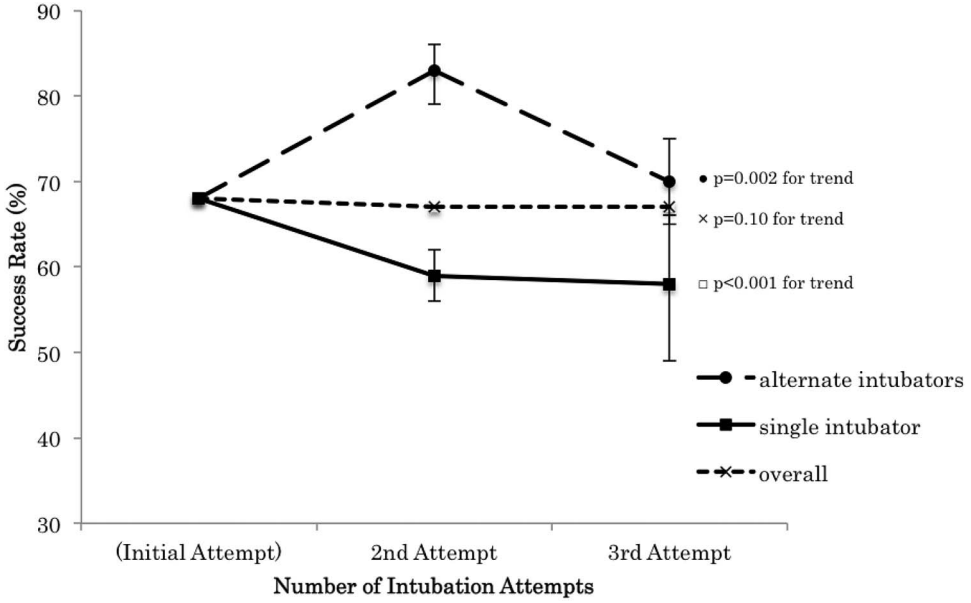

Figure 2 Tracheal intubation success rates, according to number of attempts at intubation. The success rates by a single intubator significantly declined as the number of attempts increased (p_{trend} <0.001). By contrast, in the alternate intubator group, the success rate increased at second attempt, then decreased thereafter (p_{trend}=0.002). I bars represent 95% CIs.

patient population (ie, more difficult airway patients resulting in repeated failed attempts). Alternatively, as the point estimates demonstrated a favourable success rate in the alternate intubators group, these non-significant associations may be attributable to the small number of tracheal intubation failures at the third attempt in our study data set.

Although our observational study cannot establish causal relationships, the data have several important implications for the practice of ED airway management. For clinicians, our findings support strategies that use alternate intubators when the initial attempt is unsuccessful. This approach is also consistent with a principle of using early and systematic rescue airway techniques.[1 4 7] For emergency care researchers, our observation should facilitate studies that evaluate the determinants of success rates in emergency airway management, and call for continued efforts to seek optimal rescue approaches, coupled with the dissemination of these findings.

Potential limitations

Our study has several potential limitations. First, as with any passive surveillance systems, our registry data were subject to self-reporting bias. However, the real-time independent monitoring of ED airway management is difficult to accomplish. To address this concern, we used a previously applied self-reporting system with structured data forms, uniform definitions, and a high capture rate.[2] We believe that these data represent the best available data.

Second, as with any observational study, the association between attempts at tracheal intubation by a single intubator and a decreased success rate does not necessarily prove causality, and might be confounded by unmeasured factors. For example, residual confounding variables include the patient's severity of illness, mental status (eg, Glasgow Coma Scale) and individual intubator skill levels and experience. To help account for the intubator skill levels, we did adjust for the level of training and specialty of intubators. Another potential confounding variable was difficulty in the airway management of individual patients (eg, Intubation Difficulty Scale).[15] However, it is possible that advanced-level intubators selectively attempted subsequent tracheal intubations on more difficult patients. Therefore, the success rate of the alternate intubator group would have become lower; this would have biased our conclusions toward the null.

Table 4 Bivariate and multivariable analysis for tracheal intubation success comparing single intubator versus alternate intubator, according to number of attempts at intubation

Models	AOR at second attempt (95% CI)	AOR at third attempt (95% CI)
Bivariate associations		
Intubation by single intubator	0.30 (0.23 to 0.40)	0.58 (0.38 to 0.89)
Multivariable associations		
Intubation by single intubator	0.50 (0.36 to 0.71)	0.89 (0.52 to 1.56)
Covariates		
Age	0.99 (0.98 to 1.00)	0.99 (0.98 to 1.00)
Female	1.20 (0.93 to 1.55)	0.77 (0.50 to 1.20)
Change in methods	1.69 (0.86 to 3.42)	1.32 (0.50 to 3.86)
Change in devices		
No change	1 (reference)	1 (reference)
Change to video laryngoscope	0.85 (0.38–1.99)	0.15 (0.04 to 0.48)
Change to non-video laryngoscope*	1.06 (0.58 to 2.00)	1.41 (0.67 to 3.20)
Additional medications	0.75 (0.47 to 1.19)	0.78 (0.41 to 1.48)
Indication		
Cardiac arrest	1 (reference)	1 (reference)
Medical non-arrest	0.67 (0.50 to 0.89)	0.81 (0.48 to 1.34)
Traumatic non-arrest	0.66 (0.44 to 0.99)	0.56 (0.28 to 1.14)
Specialty of intubator		
Transitional year resident†	1 (reference)	1 (reference)
Emergency medicine resident	2.61 (1.88 to 3.65)	1.71 (0.82 to 3.57)
Emergency physician‡	2.80 (1.90 to 4.16)	3.79 (1.76 to 8.31)
Others	1.58 (1.05 to 2.39)	2.01 (0.92 to 4.46)

*Defined as nasotracheal intubation, bronchoscope, light stylet or combination with direct laryngoscope and gum elastic bougie.
†Defined as postgraduate years 1 or 2.
‡Defined as postgraduate years >6.

Table 5 Bivariate and multivariable analysis for tracheal intubation success comparing single intubator versus alternate intubator, stratified by initial intubator specialty

Models, stratified by initial intubator specialty	AOR at second attempt (95% CI)	AOR at third attempt (95% CI)
Bivariate associations		
Intubation by a single intubator		
Transitional year resident*	0.22 (0.15 to 0.31)	0.48 (0.26 to 0.91)
Physicians other than transitional year resident	0.42 (0.26 to 0.70)	0.71 (0.37 to 1.34)
Multivariable associations		
Intubation by single intubator		
Transitional year resident	0.21 (0.14 to 0.30)	0.48 (0.25 to 0.93)
Physicians other than transitional year resident	0.51 (0.29 to 0.86)	0.90 (0.42 to 1.96)

*Defined as postgraduate years 1 or 2. AOR, adjusted odds ratio.

Third, a large number of intubations were attempted by transitional year residents in the present study, thereby potentially limiting the generalisability to those attempted by attending physicians. However, the adjusted association of tracheal intubation by a single intubator with a decreased success rate persisted in the sensitivity analysis after excluding those by transitional year residents.

Last, our sample consisted predominantly of academic EDs in Japan. Because of the absence of bodies responsible for the accreditation of graduate medical training programmes, emergency medicine residency trainings in Japan vary in scope and clinical exposure.[3] This threatens the generalizability of our findings; therefore, it may be tempting to dismiss the broader applicability of our findings. However, the observed association between attempts at intubation by a single intubator and a decreased success rate was large and persisted in the sensitivity analysis. Although the validations of our results in systems with established emergency medicine training and practice are warranted, our inferences are clinically plausible and are likely applicable to different practice settings.

CONCLUSIONS

In this large multicentre cohort of patients undergoing tracheal intubation in Japanese EDs, second attempts at tracheal intubation by a single intubator, compared with those by alternate intubators, were independently associated with a decreased success rate. Our results support the use of strategies that use alternate intubators early in conjunction with systematic rescue airway techniques when the initial attempt is unsuccessful.

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Contributors TG: study concept and design, analysis and interpretation of the data, drafting of the manuscript. HW: analysis and interpretation of the data, statistical expertise. HM and HN: acquisition of the data, analysis and interpretation of the data. CAB and DFMB: analysis and interpretation of the data, critical revision of the manuscript for important intellectual content. KH: Study concept and design, statistical expertise, obtained funding, critical revision of the manuscript for important intellectual content, study supervision.

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Competing interests None.

Ethics approval The institutional review board of each participating centre approved the protocol with waiver of informed consent before data collection.

Provenance and peer review Not commissioned; externally peer reviewed.

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