Original Article

Factors associated with successful rescue intubation attempts in the emergency department: an analysis of multicenter prospective observational study in Japan

Yukari Goto,[1] Tadahiro Goto,[2] Hiroshi Okamoto,[3] Yusuke Hagiwara,[4] Hiroko Watase,[5] Kohei Hasegawa,[6] on behalf of the Japanese Emergency Medicine Network Investigators†

[1]Department of Emergency and Critical Care, Nagoya University Hospital, Nagoya, Aichi, [2]Graduate School of Medical Sciences, University of Fukui, Fukui, [3]Centre for Clinical Epidemiology, Department of Emergency Medicine, St. Luke's International Hospital, Tokyo, Japan, [4]Department of Pediatric Emergency and Critical Care Medicine, Tokyo Metropolitan Children's Medical Centre, Tokyo, Japan, [5]Department of Surgery, University of Washington, Seattle, Washington, and [6]Department of Emergency Medicine, Harvard Medical School, Massachusetts General Hospital, Boston, Massachusetts

Aim: It remains unclear whether physicians should change intubation approaches after the failed first attempt. We aimed to determine the rescue intervention approaches associated with a higher success rate at the second attempt in the emergency department (ED).

Methods: We analyzed the data from a prospective, multicenter, observational study – the second Japanese Emergency Airway Network Study. The current analysis included all patients who underwent emergency intubation from February 2012 through November 2017. We defined a rescue intubation attempt as a second intubation attempt with any change in intubation approaches (i.e., change in methods, devices, or intubators) from the failed first attempt. The outcome measure was second-attempt success.

Results: Of 2,710 patients with a failed first attempt, 43% underwent a second intubation attempt with changes in intubation approach (i.e., rescue intubation). Rescue intubation attempts were associated with a higher second-attempt success rate compared to non-rescue intubation attempts (adjusted odds ratio [OR], 1.78; 95% confidence interval [CI], 1.50–2.12). The rescue intubation approaches associated with a higher second-attempt success were changes from non-rapid sequence intubation (RSI) to RSI (adjusted OR, 2.04; 95% CI, 1.12–3.75), from non-emergency medicine (EM) residents to EM residents (adjusted OR, 2.02; 95% CI, 1.44–2.82), and from non-EM attending physicians to EM attending physicians (adjusted OR, 2.82; 95% CI, 2.14–3.71).

Conclusions: In this large multicenter study, rescue interventions were associated with a higher second-attempt success rate. The data also support the use of RSI and backup by EM residents or EM attending physicians to improve the airway management performance after a failed attempt in the ED.

Key words: Emergency department, rescue intubation attempt, second intubation attempt, success rate

BACKGROUND

AIRWAY MANAGEMENT IS one of the most critical interventions in the emergency department (ED). Recent evidence has also indicated that repeat intubation attempts are associated with a higher risk of adverse events, higher failure rates at subsequent attempts, lower incidence rate of return of spontaneous circulation during the early resuscitation, and prolonged time to achieve return of spontaneous circulation.[1–5] It is important to successfully intubate patients at the second attempt with an optimized rescue strategy.

†The Japanese Emergency Medicine Network Investigators are listed in Appendix I.

Corresponding: Tadahiro Goto, MD, MPH, Graduate School of Medical Sciences, University of Fukui, 23-3 Matsuoka-shimoaizuki, Eiheiji-cho, Yoshida-gun, Fukui, 910-1193, Japan. E-mail: tadahirogoto@gmail.com.

Received 25 Jul, 2019; accepted 15 Sep, 2019; online publication 14 Oct, 2019

Funding information

St. Luke's Life Science Institute.

Previous studies have described the characteristics of second intubation attempts in the ED[6,7] and reported factors contributing to the second-attempt success rate.[1,8,9] However, these studies were based on the assumption that a repeat attempt alone could lead to intubation success, and did not differentiate these repeat attempts from the attempts with an optimization of intubation approaches. Despite the clinical importance, it remains largely unclear whether and how emergency physicians should change intubation approaches to improve the intubation performance after a failed first attempt.

In this context, using a large, multicenter dataset, we aimed to test the hypothesis that a rescue intubation is associated with a higher second-attempt success compared to a non-rescue intubation attempt.

METHODS

Study design and setting

WE ANALYZED THE data from a prospective, multicenter, observational study of emergency airway management, the second Japanese Emergency Airway Network (JEAN-2) study. This study was designed to characterize current emergency airway management across Japan. A complete description of the study methodology has been described previously.[1,3,10] In summary, JEAN-2 is a consortium of 15 academic and community medical centers from different geographic regions across Japan. The participating institutions included 12 critical medical care centers and had an average ED census of 28,000 patient visits/year (range 1,000–65,000). The institutional review board at each participating institution approved the study with a waiver of informed consent.

Selection of participants

The study prospectively collected the information on all pediatric and adult patients who underwent emergency intubation at one of the participating EDs from February 2012 through November 2017. Among these patients, those who underwent a second intubation attempt after a failed first attempt were eligible for the current analysis. We excluded the patients in whom the first attempt was not undertaken through an oral route, those who died before the second attempt, and those with unknown method, device, or intubator characteristics.

Data collection and processing

After each intubation, the intubator completed a standardized data collection form that included the patient's age, sex, estimated weight and height, primary indication for intubation, markers of difficult airway, methods of intubation, devices and medications used at each attempt, level of training and specialty of the intubator, number of intubation attempts, intubation success or failure, and associated adverse events.[10,3] We used the modified LEMON criteria (score 1 or more) as the marker of difficult intubation.[11] We monitored compliance with data form completion. An intubation attempt was defined as single insertion of the device past the teeth. An attempt was successful if it resulted in an endotracheal tube being placed through the vocal cords. When the data collection item was missing, the involved physicians were interviewed by site investigators to ascertain the airway management details.

Study exposure – rescue intubation attempt

In this study, a "rescue intubation attempt" was defined as a second intubation attempt with any change in intubation approaches, that is, a change in methods, devices, and/or intubators after a failed first attempt.[1,6,12] In contrast, a "non-rescue intubation attempt" was defined as a second attempt using the same methods, devices, and intubators as the first attempt. The methods were categorized into rapid sequence intubation (RSI), surgical intubation (cricothyrotomy/tracheotomy), and other methods. The devices were grouped into direct laryngoscope (DL), video laryngoscope (VL), combination of a gum elastic bougie with DL or VL, and other devices. Intubators' specialties were categorized as transitional-year resident (post-graduated year 1 or 2), emergency medicine (EM) resident, EM attending physician, and other specialties.

Outcome measure

To determine the factors associated with a higher rescue attempt success, we examined the second-attempt success after a failed first attempt.[8]

Data analysis

In the current study, we constructed three logistic regression models. First, to test the hypothesis that a rescue attempt (compared to a non-rescue attempt) is associated with a higher second-attempt success, we modelled any change in intubation approaches as the exposure variable (unadjusted model 1). Second, to determine which rescue approach(es) is associated with successful second attempts, we modelled any change in methods, devices, and specialties of the intubators as the exposure variables (adjusted model 2). Third, to yield more granular information on the approaches associated with successful second attempts, we included the

Table 1. Characteristics of patients with a failed first intubation attempt

Variables	Second intubation attempt (n = 2,710)		P-value
	Rescue attempt (n = 1,167)	Non-rescue attempt (n = 1,543)	
Age, years; median (IQR)	68 (52–79)	71 (55–80)	0.006
Age category, years			
≤18	33 (3)	71 (5)	0.004
19–39	104 (9)	108 (7)	
40–64	356 (31)	405 (26)	
65–84	545 (47)	760 (49)	
≥85	127 (11)	196 (13)	
Sex			
Male	760 (65)	973 (63)	0.270
Female	407 (35)	570 (37)	
Indication			
Cardiac arrest	439 (38)	630 (41)	0.040
Medical indication	589 (50)	770 (50)	
Trauma	139 (12)	143 (9)	
Score of modified LEMON criteria			
0	478 (41)	723 (47)	0.002
≥1	689 (59)	820 (53)	
Method at first attempt			
Rapid sequence intubation	254 (22)	366 (24)	0.052
Oral no medication	663 (57)	909 (59)	
Oral sedation only	198 (17)	218 (14)	
Others	52 (5)	50 (3)	
Device at first attempt[†]			
Direct laryngoscope	921 (79)	1,193 (77)	0.013
Video laryngoscope	234 (20)	346 (22)	
Use of bougie	25 (2)	16 (1)	
Others	12 (1)	4 (<1)	
Intubator's specialty at the first attempt			
Emergency medicine resident	254 (22)	384 (25)	<0.001
Emergency attending physician	97 (8)	200 (13)	
Other specialties	93 (8)	183 (12)	
Transitional-year resident	723 (62)	776 (50)	
Method at second attempt			
Rapid sequence intubation	311 (27)	366 (24)	<0.001
Oral no medication	604 (52)	909 (59)	
Oral sedation only	165 (14)	218 (14)	
Others	87 (2)	50 (3)	
Device at second attempt[†]			
Direct laryngoscope	720 (62)	1193 (77)	<0.001
Video laryngoscope	407 (35)	346 (22)	
Use of bougie	143 (12)	16 (1)	
Others	7 (1)	4 (<1)	
Intubator's specialty at second attempt			
Emergency medicine resident	380 (33)	384 (25)	<0.001
Emergency attending physician	515 (44)	200 (13)	
Other specialties	113 (10)	183 (12)	
Transitional-year resident	159 (14)	776 (50)	

[†]Sum does not equal the number of rescue attempts because some patients were intubated with multiple rescue devices.
IQR, interquartile range.

following variables in the model (adjusted model 3): change from non-RSI to RSI, change from non-surgical to surgical method, other method changes, change from non-DL to DL, change from non-VL to VL, use of bougie, other device changes, change from non-EM resident to EM resident, change from non-EM attending physician to EM attending physician, and other specialty changes. In the adjusted models, we controlled for patient's age, sex, body mass index, primary indication for intubation, marker for difficult intubation (modified LEMON criteria of ≥1), intubation methods at the first attempt, device at the first attempt, and specialties of the intubators at the first attempt. Given the study objective, product terms were not tested in the adjusted models. The models also accounted for patient clustering within the EDs using generalized estimating equation.[1,3,6,8,13,14] In the sensitivity analysis, we repeated the analysis with stratification by cardiac arrest as the primary indication because of the potential heterogeneity in the factors associated with successful second intubation attempts between patients with cardiac arrest and those without. In addition, we also undertook a sensitivity analysis stratified by marker for difficult intubation (modified LEMON criteria of ≥1). The analysis was carried out with JMP version 9.0.2 (SAS Institute, Cary, NC, USA) and STATA 14.1 (StataCorp, College Station, TX, USA). We considered a two-sided $P < 0.05$ to be statistically significant.

RESULTS

DURING THE STUDY period, 9,694 patients underwent emergency airway management in the ED. Among these, the database recorded 9,408 patients (capture rate, 97%). We excluded 6,698 patients (Fig. S1), and the remaining 2,710 patients were eligible for the current analysis.

Overall, the median age was 65 (interquartile range, 54–80) years, 96% were adults (aged ≥18 years), and 36% were female. The primary indication for intubation was medical in 50%, and cardiac arrest in 40%. The majority (56%) were considered a difficult airway. Of the 2,710 patients with a failed first attempt, 43% (n = 1,167) subsequently underwent a second intubation attempt with a change in methods, devices, and/or intubators (i.e., rescue intubation attempt). Table 1 summarizes the characteristics of patients who underwent a rescue attempt and non-rescue attempt. Patients who underwent a rescue attempt were younger and more likely to have trauma indication compared to those without a rescue attempt (both, $P < 0.05$).

Table 2 shows the details of rescue attempts used after failed first attempts. Among these, 9% were undertaken with a change in methods, 38% with a change in devices, and 62% with a change in intubators; 10% were carried out with changes in multiple approaches. More specifically, the most frequent changes in each approach were changes from non-RSI to RSI (5%), changes from non-VL to VL (22%), and changes from non-EM attending physician to EM attending physician (36%).

Overall, the success rate at the second intubation attempts was 72% with rescue attempts and 62% with non-rescue intubation attempts. Rescue intubation attempts were associated with a significantly higher successful second-attempt rate, compared to non-rescue attempts (unadjusted odds ratio [OR], 1.64; 95% confidence interval [CI], 1.39–1.94; $P < 0.001$; model 1, Table S1). The magnitude of this association was amplified after adjusting for potential confounders (adjusted OR, 1.78; 95% CI, 1.50–2.12; $P < 0.001$; Fig. 1, Table S1). Among three rescue interventions (i.e., changes in methods, devices, and intubators; model 2), the change in methods (adjusted OR, 1.59; 95% CI, 1.01–2.49; $P = 0.04$) and intubators (adjusted OR, 2.25; 95% CI, 1.82–2.76; $P < 0.001$) were associated with a higher second-attempt success rate. More specifically (model 3), the change from non-RSI to RSI (adjusted OR, 2.04; 95% CI, 1.12–3.75; $P = 0.02$), from non-EM residents to EM residents (adjusted OR, 2.02; 95% CI, 1.44–2.82; $P < 0.001$), and from non-EM attending physicians to EM attending physicians (adjusted OR, 2.82; 95% CI, 2.14–3.71; $P < 0.001$) were associated with a higher likelihood of second-attempt success. In the sensitivity analysis with stratification by cardiac arrest (Fig. S2, Table S2) and by marker for difficult intubation (Fig. S3, Table S3), although the statistical power was limited, similar associations were found across strata.

Table 2. Details of rescue intubation approaches used after failed first attempts

Rescue attempt approach	*n* (%)
Overall[†]	
Change in methods	106 (9)
Change in devices	448 (38)
Change in intubators	726 (62)
Change in methods	
Change from non-RSI to RSI	59 (5)
Change from non-surgical to surgical methods[‡]	26 (2)
Other method changes	21 (2)
Change in devices	
Change from non-DL to DL	82 (7)
Change from non-VL to VL	251 (22)
Use of bougie	143 (12)
Other device changes	14 (1)
Change in specialties of intubators	
Change from non-EM resident to EM resident	221 (19)
Change from non-EM attending physicianto emergency attending physician	425 (36)
Other specialty changes	80 (7)

[†]Sum is not equal to the number of rescued patients because 113 patients were intubated with changes in multiple approaches.
[‡]Surgical methods include cricothyrotomy and tracheotomy.
DL, direct laryngoscope; EM, emergency medicine; RSI, rapid sequence intubation; VL, video laryngoscope.

DISCUSSION

BY USING THE large prospective multicenter data of 2,710 ED patients with a failed first intubation attempt, we found that 43% underwent their second attempt with a change in methods, devices, and/or intubators – a rescue intubation. We found that rescue intubations are associated with a higher likelihood of success at the second attempt compared to non-rescue intubation attempts. In particular, the change in methods (non-RSI to RSI) and in intubators (non-EM residents to EM residents, non-EM attending physicians to EM attending physicians) were associated with a higher second-attempt success rate.

Although the proportion of patients with a failed first attempt is not small (17–32%),[1,2,6,8,10,13,15,16] only a few studies have investigated rescue intubations in the ED. In 2002, an analysis of 207 intubations recorded in the second National

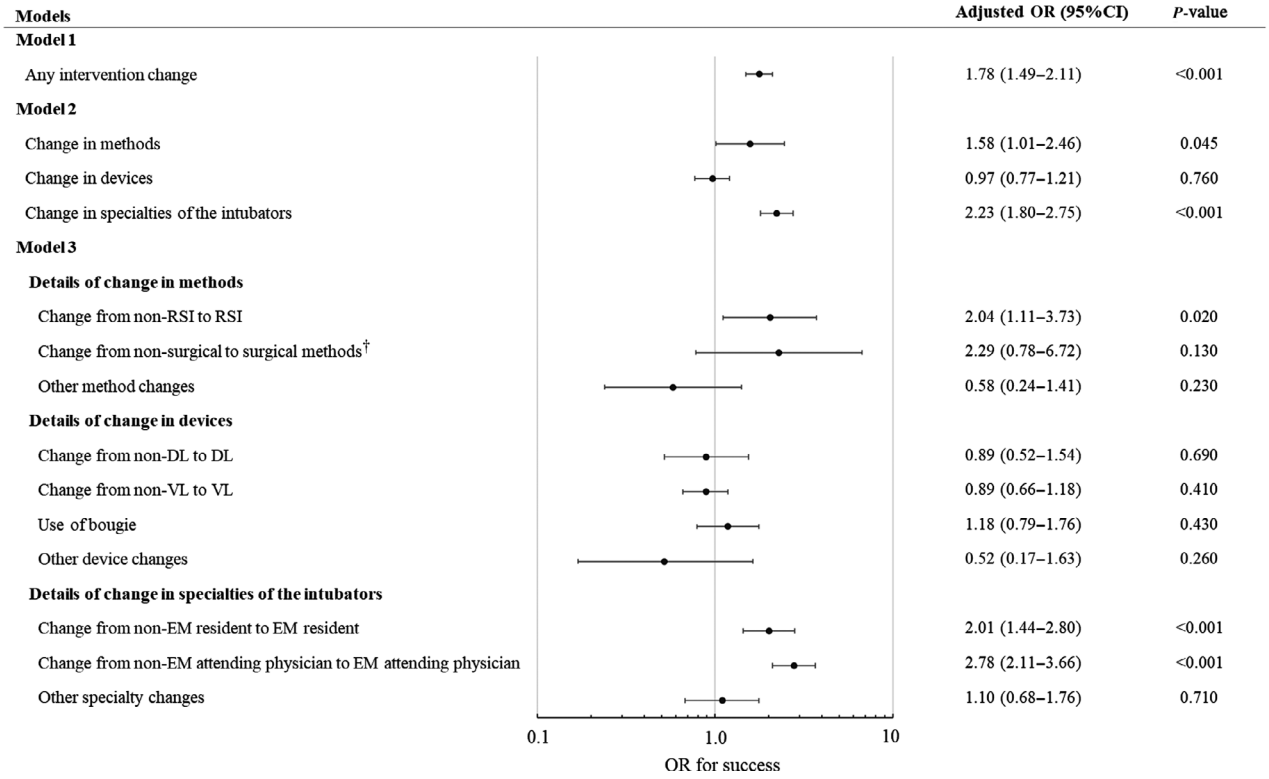

Fig. 1. Adjusted association with second-attempt success rate among patients who underwent intubations in emergency departments. †Surgical methods include cricothyrotomy and tracheotomy. CI, confidence interval; DL, direct laryngoscope; EM, emergency medicine; OR, odds ratio; RSI, rapid sequence intubation; VL, video laryngoscope.

Emergency Airway Registry (NEAR-II) database described the techniques and devices being used for rescue airway management after failed attempts.[7] A more recent analysis of 1,122 intubations from Korea reported the factors associated with success at the second attempt, such as the use of RSI, intubation by emergency physicians or senior physicians, and non-difficult airway.[8] However, this study did not differentiate a rescue attempt from a non-rescue attempt, that is, a repeat attempt with the use of same methods, devices, and intubator following a failed attempt was also considered as a rescue attempt. The current multicenter study with the largest sample size in this topic builds on these earlier studies, and extends them by demonstrating the superiority of rescue intubation attempts (compared to non-rescue attempts).

The observed relationship between the change from non-RSI to RSI with second-attempt success is consistent with previous studies that reported the superiority of RSI in ED intubations, including first intubation attempts.[2,6,8,13,17] Studies have shown that the advantages of RSI use (e.g., better intubating conditions, including the lack of vocal cord movement)[18,19] In addition, the observed associations between the change in intubators and higher likelihoods of second-attempt success is in agreement with previous studies.[8,9] There are plausible mechanisms underlying this finding, for example, strategic and mental preparations for intubation attempts by an alternate intubator, and potentially higher competence. In contrast, we observed no significant association between changes in devices and likelihoods of second-attempt success. Studies reported that, although VLs have been increasingly considered the intubation device of choice in the ED,[2,15,16] the superiority of VL intubations remains controversial – the success rate using VL is higher than[15,20,21] and no different from that using DL.[22–25] Notwithstanding the complexity of rescue intubation attempts in the ED, our data not only refute the approach that assumes repeat attempts alone would lead to an intubation success, but also lend an additional support to the intubation strategy that systematically optimizes intubation approaches (e.g., the use of RSI and alternative intubators) immediately after a failed attempt.

Potential limitations

The current study has several potential limitations. First, passive surveillance introduces the potential of self-reporting

bias. For example, underestimation of failed intubations is possible. Nevertheless, we used previously applied standardized data forms and uniform definitions,[6,10,13] and achieved a high capture rate. Therefore, we believe that these data represent the best available data. Second, as with any observational study, the causal inference might be confounded by unmeasured factors (e.g., patient's severity of illness, individual intubator competence). Third, although we defined rescue intubation attempts as those with a change in major components (i.e., methods, devices, and/or intubators), we did not capture information on other potentially important interventions, such as position change and pre-oxygenation techniques. Nevertheless, as these factors were likely related to intubation success, the lack of information would have biased our inference toward the null. Finally, the study sample consisted predominantly of academic EDs in Japan. Although formal validation of the results in other settings is needed, the observed relationships were large and plausible, and were likely present in different practice settings.

CONCLUSIONS

BASED ON DATA from a 15-center prospective study, approximately 40% of patients underwent the second intubation attempt with a change in methods, device, and/or intubator – a rescue intubation – after the failed first attempt in an ED. Our data also indicated that rescue intubations were associated with a higher likelihood of success at the second attempt. Furthermore, for clinicians, our observations lend additional support to the use of RSI and backup by EM residents or EM attending physicians to improve the airway management performance immediately after a failed attempt.

ACKNOWLEDGEMENT

THIS STUDY WAS supported by grants from St. Luke's Life Science Institute (Tokyo, Japan).

DISCLOSURE

Ethics approval and consent to participate: The institutional review board at each participating institution approved the study with a waiver of informed consent.
Consent for publication: N/A.
Availability of data and materials: The study data cannot be made publicly available because it contains protected health information of the participants and violates the ethical agreement with the institutional review boards that approved the study.
Animal studies: N/A.
Conflict of interest: None declared.

REFERENCES

1 Goto T, Gibo K, Hagiwara Y *et al*. Multiple failed intubation attempts are associated with decreased success rates on the first rescue intubation in the emergency department: a retrospective analysis of multicentre observational data. Scand. J. Trauma Resusc. Emerg. Med. 2015; 23: 5.
2 Goto T, Goto Y, Hagiwara Y, Okamoto H, Watase H, Hasegawa K. Advancing emergency airway management practice and research. Acute Med. Surg. 2019; 6: 336–51.
3 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 e2.
4 Kim J, Kim K, Kim T *et al*. The clinical significance of a failed initial intubation attempt during emergency department resuscitation of out-of-hospital cardiac arrest patients. Resuscitation 2014; 85: 623–7.
5 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.
6 Sagarin MJ, Barton ED, Chng YM, Walls RM. National Emergency Airway Registry I. 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.
7 Bair AE, Filbin MR, Kulkarni RG, Walls RM. The failed intubation attempt in the emergency department: analysis of prevalence, rescue techniques, and personnel. J. Emerg. Med. 2002; 23: 131–40.
8 Kim JH, Kim YM, Choi HJ, Je SM, Kim E. Korean Emergency Airway Management Registry I. Factors associated with successful second and third intubation attempts in the ED. Am. J. Emerg. Med. 2013; 31: 1376–81.
9 Goto T, Watase H, Morita H *et al*. 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. Emerg. Med. J. 2015; 32: 781–6.
10 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.
11 Hagiwara Y, Watase H, Okamoto H, Goto T, Hasegawa K. Japanese Emergency Medicine Network I. Prospective validation of the modified LEMON criteria to predict difficult intubation in the ED. Am. J. Emerg. Med. 2015; 33: 1492–6.
12 Aziz MF, Brambrink AM, Healy DW *et al*. Success of intubation rescue techniques after failed direct laryngoscopy in adults: a retrospective comparative analysis from the multicenter perioperative outcomes group. Anesthesiology 2016; 125: 656–66.

13 Walls RM, Brown CA 3rd, Bair AE, Pallin DJ, Investigators NI. Emergency airway management: a multi-center report of 8937 emergency department intubations. J. Emerg. Med. 2011; 41: 347–54.
14 Yakushiji H, Goto T, Shirasaka W *et al*. Associations of obesity with tracheal intubation success on first attempt and adverse events in the emergency department: an analysis of the multicenter prospective observational study in Japan. PLoS ONE 2018; 13: e0195938.
15 Brown CA 3rd, Bair AE, Pallin DJ, Walls RM, Investigators NI. Techniques, success, and adverse events of emergency department adult intubations. Ann. Emerg. Med. 2015; 65: 363–70.
16 Goto Y, Goto T, Hagiwara Y *et al*. Techniques and outcomes of emergency airway management in Japan: an analysis of two multicentre prospective observational studies, 2010-2016. Resuscitation 2017; 114: 14–20.
17 Okubo M, Gibo K, Hagiwara Y, Nakayama Y, Hasegawa K. The effectiveness of rapid sequence intubation (RSI) versus non-RSI in emergency department: an analysis of multicenter prospective observational study. Int. J. Emerg. Med. 2017; 10: 1.
18 Kirkegaard-Nielsen H, Caldwell JE, Berry PD. Rapid tracheal intubation with rocuronium: a probability approach to determining dose. Anesthesiology 1999; 91: 131–6.
19 Naguib M, Samarkandi A, Riad W, Alharby SW. Optimal dose of succinylcholine revisited. Anesthesiology 2003; 99: 1045–9.
20 Mosier JM, Stolz U, Chiu S, Sakles JC. Difficult airway management in the emergency department: GlideScope videolaryngoscopy compared to direct laryngoscopy. J. Emerg. Med. 2012; 42: 629–34.
21 Sakles JC, Mosier J, Chiu S, Cosentino M, Kalin L. A comparison of the C-MAC video laryngoscope to the Macintosh direct laryngoscope for intubation in the emergency department. Ann. Emerg. Med. 2012; 60: 739–48.
22 Goksu E, Kilic T, Yildiz G, Unal A, Kartal M. Comparison of the C-MAC video laryngoscope to the Macintosh laryngoscope for intubation of blunt trauma patients in the ED. Turk. J. Emerg. Med. 2016; 16: 53–6.
23 Kim JW, Park SO, Lee KR *et al*. Video laryngoscopy vs. direct laryngoscopy: which should be chosen for endotracheal intubation during cardiopulmonary resuscitation? A prospective randomized controlled study of experienced intubators. Resuscitation 2016; 105: 196–202.
24 Lascarrou JB, Boisrame-Helms J, Bailly A *et al*. Video laryngoscopy vs direct laryngoscopy on successful first-pass orotracheal intubation among ICU patients: a randomized clinical trial. JAMA 2017; 317: 483–93.
25 Sulser S, Ubmann D, Schlaepfer M *et al*. C-MAC videolaryngoscope compared with direct laryngoscopy for rapid sequence intubation in an emergency department: a randomised clinical trial. Eur. J. Anaesthesiol. 2016; 33: 943–8.

APPENDIX I

THE JAPANESE EMERGENCY MEDICINE NETWORK INVESTIGATORS

HIROSHI MORITA, TAKAHISA Kawano, and Yohei Kamikawa (Fukui University Hospital); Hideya Nagai, Takashi Matsumoto, Suguru Nonami, and Yusuke Miyoshi (Fukui Prefectural Hospital); Sho Segawa, Yuya Kitai, Kenzo Tanaka, and Saburo Minami (Kameda Medical Center); Hiromasa Yakushiji (Kishiwada Tokushukai Hospital); Naoto Miyauchi and Yudai Yano (Kurashiki Central Hospital); Nobuhiro Sato (Nigata City General Hospital); Koichiro Gibo, Masashi Okubo, Shojiro Oka, and Yukiko Nakayama (Okinawa Chubu Prefectural Hospital); Nobuhiro Miyamae (Otowa Hospital); Kaoru Hirose, Taichi Imamura, and Azusa Uendan (Shonan Kamakura General Hospital); Yasuaki Koyama (St. Marianna University School of Medicine Hospital); Hiroshi Kamura, Yoshiyuki Nakashima, and Jin Takahashi (Tokyo Bay Urayasu Ichikawa Medical Center); Jin Irie and Nobunaga Okada (University Hospital, Kyoto Prefectural University of Medicine); Seiro Oya (Yokohama Rosai Hospital); and Akihiko Inoue (Hyogo Emergency Medical Center).

SUPPORTING INFORMATION

Additional Supporting Information may be found in the online version of this article at the publisher's web-site:

Fig. S1. Patients who underwent intubations in emergency departments.
Fig. S2. Adjusted association with second-attempt success rate of intubation in the sensitivity analysis with stratification by cardiac arrest.
Fig. S3. Adjusted association with second-attempt success rate of intubation in the sensitivity analysis with stratification by marker for difficult intubation (modified LEMON criteria of ≥1).
Table S1. Unadjusted and adjusted association with second-attempt success rate among patients who underwent intubations in emergency departments
Table S2. Adjusted association with second-attempt success of intubation, according to cardiac arrest
Table S3. Adjusted association with second-attempt success of intubation, according to difficult intubation