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Trauma airway management in emergency departments: A multicenter, prospective, observational study in Japan

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Keywords: Airway management, intubation, emergency department, practice variation, rapid sequence intubation

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Abstract

Objectives: Although successful airway management is essential for emergency trauma care, comprehensive studies are limited. We sought to characterize the current trauma care practice of airway management in the emergency departments (EDs) in Japan.

Design: Analysis of data from a prospective, observational, multi-center registry – the Japanese Emergency Airway Network (JEAN) registry.

Setting: 13 academic and community EDs from different geographic regions across Japan.

Participants: 723 trauma patients who underwent emergency intubation from March 2010 through August 2012.

Outcome measures: ED characteristics, patient and operator demographics, methods of airway management, intubation success or failure at each attempt, and adverse events.

Results: A total of 723 trauma patients who underwent emergency intubation were eligible for the analysis. Traumatic cardiac arrest comprised 32.6% (95% CI, 29.3%-36.1%) of patients. Rapid sequence intubation (RSI) was the initial method chosen in 23.9% (95% CI, 21.0%-27.2%) of all trauma patients, and in 35.5% (95% CI, 31.4%-39.9%) of non-cardiac arrest trauma patients. Overall, intubation was successful in ≤3 attempts in 96.0% of patients (95% CI, 94.3%-97.2%). There was a wide variation in the initial methods of intubation; RSI as the initial method was performed in 0% to 50.9% of all trauma patients among the 12 EDs. Similarly, there was a wide variation in success rates and adverse event rates across the EDs. Success rates varied between 35.5% and 90.5% at the first attempt and 85.1% and 100% within 3 attempts across the 12 EDs.

Conclusion: In this multicenter prospective study in Japan, we observed a high overall success rate in airway management during trauma care. However, the methods of intubation and success rates were highly variable among hospitals.

Article summery

Article focus

This paper characterizes the current practice of airway management for trauma patients in the emergency departments (EDs) in Japan by using data from the Japanese Emergency Airway Network (JEAN) Study.

Key messages

The method of intubation, success rates, and adverse event rates were highly variable among EDs. Development and dissemination of nationwide protocols are warranted to achieve safer airway management for trauma victims in Japan.

Strengths and limitations of this study

This is the first to report disparities in trauma airway management based on multicenter, prospective data.

The passive surveillance of the data is subject to self-reporting bias, leading to a possible underestimation of failed intubations and adverse events.

1. Introduction

Successful airway management is a cornerstone in the modern practice of emergency and trauma care. Failure of emergency airway management is often associated with morbidity and mortality in trauma patients. [1-3] Consequently, training in and understanding of airway management is a distinct discipline that is essential for successful trauma resuscitation.

Evidence-based recommendations for airway management during trauma care exist within international and national guidelines of the United States. These guidelines indicate rapid sequence intubation (RSI) as the initial method of emergency airway management in most trauma patients. [1 4 5] Recent studies reported that RSI is the most common airway management method in emergency departments (EDs) in North America and Europe. [6-9] Despite the ubiquitous practice of emergency airway management in trauma patients, little is known about its current practice and performance in other industrialized nations. Therefore, we sought to describe the current practice of airway management for trauma patients in the EDs in Japan.

2. METHODS

Study Design and Setting

We analyzed the data of a prospective, observational, multi-center registry, the Japanese Emergency Airway Network (JEAN) registry. The study design, setting, methods of measurement, and measured variables have been reported elsewhere. [10-13] Briefly, the registry is a consortium of 13 academic and community EDs from different geographic regions across Japan. The participating EDs had a median ED census of 30,000 patient visits per year (range 9,000 to 67,000). All 13 EDs were staffed by attending emergency physicians, and 12 had affiliations with emergency medicine residency training programs. Each hospital maintained individual protocols, policies, and procedures for emergency airway management. Intubations were performed by attending physicians or by resident physicians at the discretion of the ED attending physician. The ethics committee of each participating center approved the protocol, with waiver of informed consent before data collection.

Patients

The registry prospectively collected information on consecutive patients who underwent airway management in the participating EDs during a 30-month period, from March 2010 to August 2012. All adult and pediatric trauma patients who underwent intubation were eligible for this analysis. We excluded an ED in which the number of trauma intubations was less than 10 from the current analysis.

Data Collection

Data collection was passive, relying on self-reports by the intubators on duty. After each intubation, the intubators completed a standardized data sheet, including the patient's age, sex, estimated weight, primary indication for intubation, methods used to facilitate intubation, intubator's level of training and specialty, number of attempts, success or failure, and intubation-related adverse events. Method was defined as the set of medications and devices used, such as RSI with a Macintosh laryngoscope. An intubation attempt was defined as a single insertion of the laryngoscope (or other device) past the teeth [2 10-13]. For nasal intubations, an attempt was defined as a single insertion of a tracheal tube past the turbinates. An attempt was successful if it resulted in the tracheal tube being passed through the vocal cords. One or more methods could be used in each patient, and each method could be attempted several times.

Adverse events were recorded using a pre-specified list, with the option to include additional comments, if necessary. We monitored compliance with data form completion by reviewing professional billing records. Where the data collection form was missing, the intubator was interviewed by one of the investigators within 2 weeks of the patient encounter, to fill out the data form.

The outcomes of interest were the primary indication for intubation, initial method used for intubation, intubation success rates (on the first attempt and within three attempts), and adverse event rates.

Statistical Analysis

We performed all analysis with JMP 10 software (SAS Institute Inc., Cary, NC, USA). At the

patient-level, we described patient demographics, the primary indication for intubation, initial method of intubation, success rates, and adverse event rates as proportions with 95% confidence intervals (CIs) and medians with interquartile ranges (IQR). Then, at the ED-level, we described medians, IQR and ranges for each outcome for all trauma patients. We also repeated the analysis after stratifying the patients as non-cardiac arrest patients and cardiac arrest patients. All *P*-values were two-tailed, with $P<0.05$ considered statistically significant.

3. Results

During the 30-month study period, 4,268 patients required emergency airway management. Of these, the registry recorded 4,094 intubations (capture rate, 95.9%; **Figure 1**), 3370 patients underwent airway management for medical reasons were excluded from the analysis. One of the 13 hospitals, in whom only 1 trauma patient required airway intervention during the study period, was excluded because the number of intubations for trauma care was less than 10 during the study period. Hence, 723 trauma patients were eligible for analysis. Emergency physicians, including emergency medicine residents, performed the first intubation attempts in 60.0% (95% CI, 56.4%-63.5%) of all trauma patients and 66.7% (95% CI, 62.4%-70.8%) of non-cardiac arrest patients. Transitional-year residents (postgraduate years 1 and 2) performed the first intubation attempts in 31.4% (95% CI, 28.1%-34.9%) of all trauma patients and 25.7% (95% CI, 22.0%-29.7%) of non-cardiac arrest patients.

Table 1 shows the baseline characteristics and primary indications in patients who required trauma airway management. Median age was 56 years; two-thirds of the patients were male. Traumatic cardiac arrest was the reason for intubation in 32.6% (95% CI, 29.3%-36.1%) of all trauma patients, while head trauma accounted for 30.4% (95% CI, 27.2%-33.9%). **Table 2** shows the initial method of airway management in the trauma patients. RSI was the initial method chosen in 23.9% (95% CI, 21.0%-27.2%) of all trauma patients and 35.5% (95% CI, 31.4%-39.9%) of non-cardiac arrest patients. Cricothyrotomy was performed as the initial airway management strategy in 2.2% (95% CI, 1.4%-3.6%) of all trauma patients and 0.4% (95% CI, 0.1%-1.5%) of non-cardiac arrest patients.

Table 1. Characteristics of the 723 trauma patients who required intubation

Patient characteristics		
Age (y), median, (IQR)	56	(34 - 73)
Male, % (95% CI)	66.9	(63.4 - 70.3)
Estimated weight (kg), median, (IQR)	60	(50 - 70)
Indication for intubation, % (95% CI)		
Cardiac arrest	32.6	(29.3 - 36.1)
Head trauma	30.4	(27.2 - 33.9)
Shock	16.6	(14.1 - 19.5)
Facial/Neck trauma	8.4	(6.6 - 10.7)
Airway burn	6.8	(5.2 - 8.8)
Others	5.1	(3.3 - 8.0)

Abbreviations: CI, confidence interval; IQR, interquartile range

Table 2. Initial method of intubation

	All trauma patients			Non-cardiac arrest patients		
	n	%	95% CI	n	%	95% CI
Rapid sequence intubation	173	23.9	(21.0 - 27.2)	173	35.5	(31.4 - 39.9)
Sedation without paralysis	153	21.2	(18.3 - 24.3)	153	31.4	(27.5 - 35.7)
Paralytics without sedation	19	2.6	(1.7 - 4.1)	19	3.9	(2.5 - 6.0)
Oral without sedation	349	48.3	(44.6 - 52.0)	127	26.1	(22.4 - 30.2)
Surgical	16	2.2	(1.4 - 3.6)	2	0.4	(0.1 - 1.5)
Nasal intubation	13	1.8	(1.1 - 3.1)	13	2.7	(1.6 - 4.5)
Total	723	100		487	100	

Abbreviations: CI, confidence interval

Table 3 summarizes the intubation success rates and adverse event rates. Overall, intubation was successful in the first attempt in 63.8% (95% CI, 60.2%-67.2%) and within 3 attempts in 96.0% (95% CI, 94.3%-97.2%) of all trauma patients. In non-cardiac arrest patients, intubation was successful in the first attempt in 60.2% (95% CI, 55.8%-64.4%) and within 3 attempts in 94.5% (95% CI, 92.1%-96.2%) of patients. In cardiac arrest patients, intubation was successful in the first attempt in 71.2% (95% CI, 65.1%-76.6%) and in within 3 attempts in 99.2% (95% CI,

97.0%-99.8%) of the patients. Intubation-associated adverse event rates were 10.8% (95% CI, 8.7%-13.3%) in overall trauma patients, 11.5% (95% CI, 9.0%-14.6%) in non-cardiac arrest patients, and 9.3% (95% CI, 6.2%-13.7%) in cardiac arrest patients.

At the ED-level, there was a wide variation in the methods of intubation across the 12 EDs (**Figure 2).** For example, RSI as the initial intubation method was performed in 0% to 50.9% of all trauma patients, and in 0% to 87.5% of non-cardiac arrest patients. Similarly, there was a wide variation in the success rates and adverse event rates across the EDs (**Figure 3**). The range of overall success rates for intubation in the first attempt ranged from 35.5% to 90.5%, and from 85.1% to 100% within 3 attempts. Likewise, overall adverse event rates varied widely (range, 0%-16.7%) across the EDs. These wide variations in intubation success rates and adverse event rates persisted across the non-cardiac arrest and cardiac arrest strata.

Table 3. Success rates and intubation-associated adverse events

	All trauma patients			Non-cardiac arrest patients			Cardiac arrest patients		
	n	%	95% CI	n	%	95% CI	n	%	95% CI
Successful in 1st attempt	461	63.8	(60.2 - 67.2)	293	60.2	(55.8 - 64.4)	168	71.2	(65.1 - 76.6)
Successful in ≤ 3rd attempts	694	96.0	(94.3 - 97.2)	460	94.5	(92.1 - 96.2)	234	99.2	(97.0 - 99.8)
Adverse events	78	10.8	(8.7 - 13.3)	56	11.5	(9.0 - 14.6)	22	9.3	(6.2 - 13.7)
Details of adverse events*									
Esophageal intubation†	25	3.5	(2.2 - 5.1)	15	3.1	(1.7 - 5.0)	10	4.2	(2.0 - 7.7)
Mainstem bronchus intubation	18	2.5	(1.5 - 3.9)	9	1.8	(0.8 - 3.5)	9	3.8	(1.7 - 7.1)
Airway trauma	17	2.4	(1.4 – 3.7)	14	2.9	(1.6 - 4.8)	3	1.3	(0.3 - 3.7)
Hypotension‡	8	1.1	(0.5 - 2.2)	8	1.6	(0.7 - 3.2)			
Vomiting	6	0.8	(0.3 - 1.8)	6	1.2	(0.5 - 2.7)			
Hypoxia	3	0.4	(0.1 - 1.2)	3	0.6	(0.1 - 1.8)			
Cardiac arrest	1	0.1	(0.0 - 0.8)	1	0.2	(0.0 -1.1)			

Abbreviations: CI, confidence interval

*Patients may have more than 1 adverse event.

†Pulse oximetry saturation less than 90% during intubation attempt, not a result of esophageal intubation.

‡Hypotension was defined as systolic blood pressure less than 90 mm Hg.

4. Discussion

In this prospective, multicenter, observational study in Japan, we observed an acceptable success rate of airway management in trauma patients in EDs. However, we also found a wide range of variation in the initial method of intubation, success rates, and adverse event rates during trauma airway management across the EDs. Indeed, the overall success rates in the first intubation attempt ranged from 35.5% to 90.5%.

We were struck by the high degree of variation in the methods of airway management in trauma cases across the 12 EDs. The reasons for the observed practice variations are unclear and are likely multifactorial. It is possible that non-RSI methods were attempted in patients who were predicted to have a difficult intubation. However, the difference in the patient population across the EDs cannot fully explain the observed three-fold difference in the use of RSI. Alternatively, it is also possible that non-RSI methods were more frequently used in certain EDs because of the physicians' preference, procedural experiences, training background, or differences in ED staffing and institutional policies.

Our study also demonstrated a high degree of variations in success and adverse event rates among the EDs. Particularly, the success rate at first attempts was highly variable. To the best of our knowledge, this is the first study to demonstrate such inter-hospital variations in success and adverse event rates in trauma airway management in different EDs. We did not assess the reasons for the variations among the EDs; however, inter-hospital differences in patient population, skills or education backgrounds of intubators, drug or device availability in the ED, or any

combination of these factors may have contributed to these variations. Alternatively, the observed wide variation in the intubation method may have led to these variations in success and adverse event rates.

Although international and Japanese trauma care guidelines recommend the use of RSI as the initial method of emergency airway management in most trauma patients, [1 4 5] the evidence for accurately predicting patients in whom RSI should be avoided remain limited. [14 15] It is, therefore, plausible that the scarcity of evidence may have contributed to the practice variations across the EDs. Our observations should facilitate further investigation of any barriers to the delivery of safer trauma care nationally. Additionally, building more robust evidence on trauma airway management, coupled with improved dissemination of these findings, could decrease the variations in trauma care across the EDs in Japan.

Our study has several potential limitations. First, this passive surveillance of the study data is subject to self-reporting bias, leading to a possible underestimation of failed intubations and adverse events. However, active independent monitoring of ED intubations is difficult to accomplish. We did, however, use a self-reporting system with structured data forms, uniform definitions, and a high capture rate. Second, we did not design this study to measure patient outcomes, such as long-term mortality or morbidity. A more detailed analysis of adverse events and outcomes requires following the patients for a longer period. Third, we did not account for several potential confounders, such as severity of cases and training levels of physicians. Finally, all EDs in this study were designated as tertiary or academic general hospitals, and all but one of the EDs were affiliated with an emergency medicine residency program in Japan. Therefore, our

inferences may not be generalizable to trauma airway management in non-academic EDs or other developed nations. These observations, however, are highly relevant from a policy standpoint. As these EDs provide advanced care for trauma victims and train the majority of emergency physicians, these EDs have a disproportionate impact on current and future trauma care in EDs.

5. Conclusion

In this multicenter prospective study of emergency airway management in Japan, we found an acceptable overall success rate in trauma airway management. However, we also found that the method of intubation, success rates and adverse event rates were highly variable among EDs. Our findings suggest that development and dissemination of nationwide protocols are warranted to achieve safer airway management for trauma victims in Japan.

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Author Contribution

K.H. designed the study, for which S.N. and Y.H. contributed to the data collection and analysis. S.N. wrote the manuscript, which A.K. reviewed.

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Conflict of Interest: None of the authors have any conflict of interest to declare.

Data Sharing Statement

No additional data available

References

1. American College of Surgeons CoT. *Advanced Trauma Life Support for Doctors, Student Course Manual*. 8th ed. Chicago, IL, 2008.
2. Walls RM, Brown CA, 3rd, Bair AE, et al. Emergency airway management: a multi-center report of 8937 emergency department intubations. J Emerg Med 2011;**41**:347-54 doi: 10.1016/j.jemermed.2010.02.024 [published Online First: 9 Nov 2010].
3. Hussain LM, Redmond AD. Are pre-hospital deaths from accidental injury preventable? BMJ 1994;**308**:1077-80 doi: 10.1136/bmj.308.6936.1077.
4. *Japan Advanced Trauma Evaluation and Care (JATEC™) guideline*. 3rd edition ed, 2008.
5. Dunham CM, Barraco RD, Clark DE, et al. Guidelines for emergency tracheal intubation immediately after traumatic injury. J Trauma 2003;**55**:162-79 doi: 10.1097/01.ta.0000083335.93868.2c.
6. Graham CA. Emergency department airway management in the UK. J R Soc Med 2005;**98**:107-10 doi: 10.1258/jrsm.98.3.107.
7. Sakles JC, Laurin EG, Rantapaa AA, et al. Airway management in the emergency department: a one-year study of 610 tracheal intubations. Ann Emerg Med 1998;**31**:325-32 doi: 10.1016/S0196-0644(98)70342-7.
8. Sagarin MJ, Barton ED, Chng YM, et al. 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 doi: 10.1016/j.annemergmed.2005.01.009.
9. Graham CA, Beard D, Henry JM, et al. Rapid sequence intubation of trauma patients in Scotland. J Trauma 2004;**56**:1123-6 doi: 10.1097/01.TA.0000109066.62811.8A.

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 doi: 10.1016/j.resuscitation.2011.11.027 [published Online First: 8 Dec 2011].

11. 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 doi: 10.1016/j.annemergmed.2012.04.005 [published Online First: 28 Apr 2012].

12. Imamura T, Brown CA, 3rd, Ofuchi H, et al. Emergency airway management in geriatric and younger patients: analysis of a multicenter prospective observational study. Am J Emerg Med 2013;**31**:190-6 doi: 10.1016/j.ajem.2012.07.008 [published Online First: 18 Oct 2012].

13. Hasegawa K, Hagiwara Y, Imamura T, et al. Increased incidence of hypotension in elderly patients who underwent emergency airway management: an analysis of a multi-centre prospective observational study. Int J Emerg Med 2013;**6**:12 doi: 10.1186/1865-1380-6-12.

14. Reed MJ, Dunn MJ, McKeown DW. Can an airway assessment score predict difficulty at intubation in the emergency department? Emerg Med J 2005;**22**:99-102 doi: 10.1136/emj.2003.008771.

15. Soyuncu S, Eken C, Cete Y, et al. Determination of difficult intubation in the ED. Am J Emerg Med 2009;**27**:905-10 doi: 10.1016/j.ajem.2008.07.003.

Figure Legends

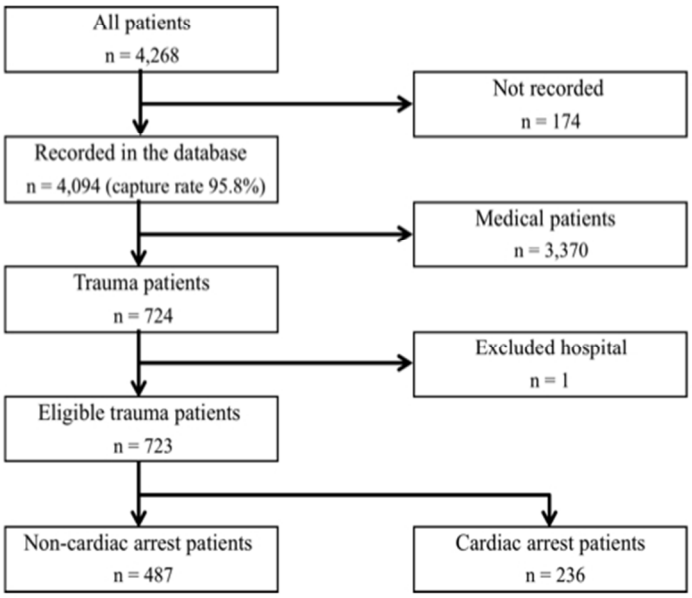
Figure 1. Flow chart showing inclusion of patients in this study

Figure 2. Inter-hospital variations in initial methods of intubation

Boxplots of inter-hospital variations in the initial methods of intubation. The line in the middle of the box represents the median, with the lower and upper limits of the box representing the 25th and 75th percentiles, respectively. The whiskers from the box extend to the minimum and maximum values.

Figure 3. Inter-hospital variations in success rates and adverse event rates

Boxplots of inter-hospital variations in success rates and adverse event rates. The line in the middle of the box represents the median, with the lower and upper limits of the box representing the 25th and 75th percentiles. The whiskers from the box extend to the minimum and maximum values.



Flow chart showing inclusion of patients in this study
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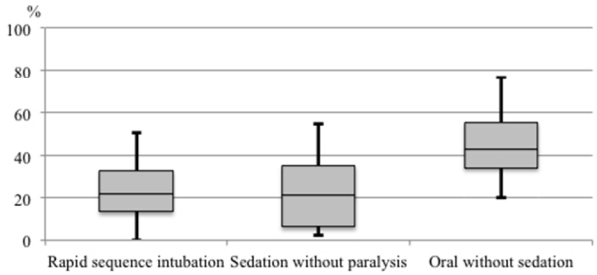
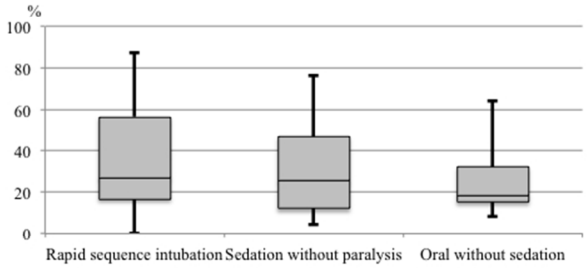
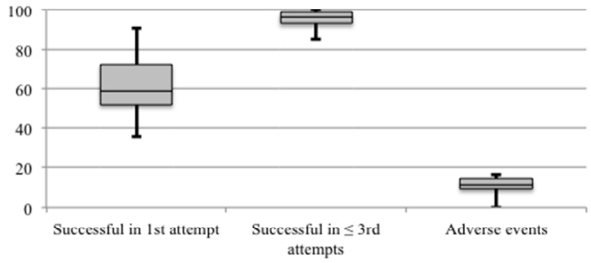


a. Among all trauma patients

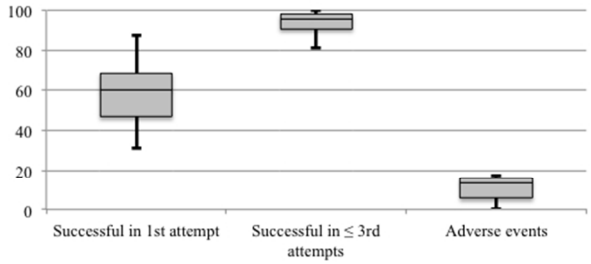


b. Among non-cardiac arrest patients

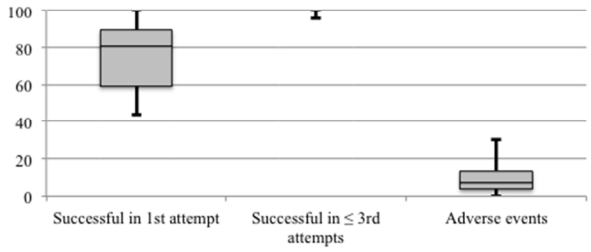
Inter-hospital variations in initial methods of intubation
Boxplots of inter-hospital variations in the initial methods of intubation. The line in the middle of the box represents the median, with the lower and upper limits of the box representing the 25th and 75th percentiles, respectively. The whiskers from the box extend to the minimum and maximum values.
254x338mm (72 x 72 DPI)



a. Among all trauma patients



b. Among non-cardiac arrest patients



c. Among cardiac arrest patients

Inter-hospital variations in success rates and adverse event rates
Boxplots of inter-hospital variations in success rates and adverse event rates. The line in the middle of the box represents the median, with the lower and upper limits of the box representing the 25th and 75th percentiles. The whiskers from the box extend to the minimum and maximum values.
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Keywords: Airway management, intubation, emergency department, practice variation, rapid sequence intubation

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Abstract

Objectives: Although successful airway management is essential for emergency trauma care, comprehensive studies are limited. We sought to characterize the current trauma care practice of airway management in the emergency departments (EDs) in Japan.

Design: Analysis of data from a prospective, observational, multi-center registry – the Japanese Emergency Airway Network (JEAN) registry.

Setting: 13 academic and community EDs from different geographic regions across Japan.

Participants: 723 trauma patients who underwent emergency intubation from March 2010 through August 2012.

Outcome measures: ED characteristics, patient and operator demographics, methods of airway management, intubation success or failure at each attempt, and adverse events.

Results: A total of 723 trauma patients who underwent emergency intubation were eligible for the analysis. Traumatic cardiac arrest comprised 32.6% (95% CI, 29.3%-36.1%) of patients. Rapid sequence intubation (RSI) was the initial method chosen in 23.9% (95% CI, 21.0%-27.2%) of all trauma patients, and in 35.5% (95% CI, 31.4%-39.9%) of non-cardiac arrest trauma patients. Overall, intubation was successful in ≤3 attempts in 96.0% of patients (95% CI, 94.3%-97.2%). There was a wide variation in the initial methods of intubation; RSI as the initial method was performed in 0% to 50.9% of all trauma patients among 12 EDs. Similarly, there was a wide variation in success rates and adverse event rates across the EDs. Success rates varied between 35.5% and 90.5% at the first attempt and 85.1% and 100% within 3 attempts across the 12 EDs.

Conclusion: In this multicenter prospective study in Japan, we observed a high overall success rate in airway management during trauma care. However, the methods of intubation and success rates were highly variable among hospitals.

Article summary

Article focus

This paper characterizes the current practice of airway management for trauma patients in emergency departments (EDs) in Japan by using data from the Japanese Emergency Airway Network (JEAN) Study.

Key messages

The method of intubation, success rates, and adverse event rates are highly variable among EDs. Development and dissemination of nationwide protocols are warranted to achieve safer airway management for trauma victims in Japan.

Strengths and limitations of this study

This is the first study to report disparities in trauma airway management based on multicenter, prospective data.

Passive surveillance of data is subject to self-reporting bias, leading to a possible underestimation of failed intubations and adverse events.

1. INTRODUCTION

Successful airway management is a cornerstone in the modern practice of emergency and trauma care. Failure of emergency airway management is often associated with morbidity and mortality in trauma patients. [1-3] Consequently, training in and understanding of airway management is a distinct discipline that is essential for successful trauma resuscitation.

Evidence-based recommendations for airway management during trauma care exist within international and national guidelines of the United States. These guidelines indicate rapid sequence intubation (RSI) as the initial method of emergency airway management in most trauma patients. [1 4 5] Recent studies reported that RSI is the most common airway management method in emergency departments (EDs) in North America and Europe. [6-9] Despite the ubiquitous practice of emergency airway management in trauma patients, little is known about its current practice and performance in other industrialized nations. Therefore, we sought to describe the current practice of airway management for trauma patients in the EDs in Japan.

2. METHODS

Study Design and Setting

We analyzed the data of a prospective, observational, multi-center registry, the Japanese Emergency Airway Network (JEAN) registry. The study design, setting, methods of measurement, and measured variables have been reported elsewhere. [10-13] Briefly, the registry is a consortium of 13 academic and community EDs from different geographic regions across Japan. These EDs consisted of 10 tertiary medical centers that have a capability to manage the most severe trauma patients and 3 secondary medical centers that are designated to treat moderately severe trauma patients. The participating EDs had a median ED census of 30,000 patient visits per year (range 9,000 to 67,000). All 13 EDs were staffed by attending emergency physicians, and 12 had affiliations with emergency medicine residency training programs. Each hospital maintained individual protocols, policies, and procedures for emergency airway management. Intubations were performed by attending physicians or by resident physicians at the discretion of the ED attending physician. The ethics committee of each participating center approved the protocol, with waiver of informed consent before data collection.

Patients

The registry prospectively collected information on consecutive patients who underwent airway management in the participating EDs during a 30-month period, from March 2010 to August 2012. All adult and pediatric trauma patients who underwent intubation were eligible for this analysis. We excluded an ED in which the number of trauma intubations was less than 10 from the current analysis.

Data Collection

Data collection was passive, relying on self-reports by the intubators on duty. After each intubation, the intubators completed a standardized data sheet, including the patient's age, sex, estimated weight, primary indication for intubation, methods used to facilitate intubation, intubator's level of training (emergency physicians, resident physicians, and transitional year residents) and specialty (emergency physician or not), number of attempts, success or failure, and intubation-related adverse events. Method was defined as the set of medications and devices used, such as RSI with a Macintosh laryngoscope. Transitional-years residents were post-graduate year 1-2 physicians who rotate through the ED. An intubation attempt was defined as a single insertion of the laryngoscope (or other device) past the teeth [2 10-13]. For nasal intubations, an attempt was defined as a single insertion of a tracheal tube past the turbinates. An attempt was successful if it resulted in the tracheal tube being passed through the vocal cords. One or more methods could be used in each patient, and each method could be attempted several times.

Adverse events were recorded using a pre-specified list, with the option to include additional comments, if necessary. We monitored compliance with data form completion by reviewing professional billing records. Where the data collection form was missing, the intubator was interviewed by one of the investigators within 2 weeks of the patient encounter, to fill out the data form.

The outcomes of interest were the primary indication for intubation, initial method used for

intubation, intubation success rates (on the first attempt and within three attempts), and adverse event rates.

Statistical Analysis

We performed all analysis with JMP 10 software (SAS Institute Inc., Cary, NC, USA). At the patient-level, we described patient demographics, the primary indication for intubation, initial method of intubation, success rates, and adverse event rates as proportions with 95% confidence intervals (CIs) and medians with interquartile ranges (IQR). Then, at the ED-level, we described medians, IQR and ranges for each outcome for all trauma patients. We also repeated the analysis after stratifying by indication (non-cardiac arrest vs. cardiac arrest) and specialty (emergency physicians vs. non-emergency physicians). All *P*-values were two-tailed, with $P<0.05$ considered statistically significant.

3. RESULTS

During the 30-month study period, 4,268 patients required emergency airway management. Of these, the registry recorded 4,094 intubations (capture rate, 95.9%; **Figure 1**), of which 3370 patients who underwent airway management for medical reasons were excluded from the analysis. One of the 13 hospitals, in whom only 1 trauma patient required airway intervention during the study period, was excluded because the number of intubations for trauma care was less than 10 during the study period. Hence, 723 trauma patients were eligible for analysis. Emergency physicians, including emergency medicine residents, performed the first intubation attempts in 60.0% (95% CI, 56.4%-63.5%) of all trauma patients and 66.7% (95% CI, 62.4%-70.8%) of non-cardiac arrest patients. Transitional-year residents (postgraduate years 1 and 2) performed the first intubation attempts in 31.4% (95% CI, 28.1%-34.9%) of all trauma patients and 25.7% (95% CI, 22.0%-29.7%) of non-cardiac arrest patients.

Table 1 shows the baseline characteristics and primary indications in patients who required trauma airway management. Median age was 56 years; two-thirds of the patients were male. Traumatic cardiac arrest was the reason for intubation in 32.6% (95% CI, 29.3%-36.1%) of all trauma patients, while head trauma accounted for 30.4% (95% CI, 27.2%-33.9%). **Table 2** shows the initial method of airway management in the trauma patients. RSI was the initial method chosen in 23.9% (95% CI, 21.0%-27.2%) of all trauma patients and 35.5% (95% CI, 31.4%-39.9%) of non-cardiac arrest patients. Cricothyrotomy was performed as the initial airway management strategy in 2.2% (95% CI, 1.4%-3.6%) of all trauma patients and 0.4% (95% CI, 0.1%-1.5%) of non-cardiac arrest patients.

Table 1. Characteristics of the 723 trauma patients who required intubation

Patient characteristics		
Age (y), median, (IQR)	56	(34 - 73)
Male, % (95% CI)	66.9	(63.4 - 70.3)
Estimated weight (kg), median, (IQR)	60	(50 - 70)
Indication for intubation, % (95% CI)		
Cardiac arrest	32.6	(29.3 - 36.1)
Head trauma	30.4	(27.2 - 33.9)
Shock	16.6	(14.1 - 19.5)
Facial/Neck trauma	8.4	(6.6 - 10.7)
Airway burn	6.8	(5.2 - 8.8)
Others	5.1	(3.3 - 8.0)

Abbreviations: CI, confidence interval; IQR, interquartile range

Table 2. Initial method of intubation

	All trauma patients			Non-cardiac arrest patients		
	n	%	95% CI	n	%	95% CI
Rapid sequence intubation	173	23.9	(21.0 - 27.2)	173	35.5	(31.4 - 39.9)
Sedation without paralysis	153	21.2	(18.3 - 24.3)	153	31.4	(27.5 - 35.7)
Paralytics without sedation	19	2.6	(1.7 - 4.1)	19	3.9	(2.5 - 6.0)
Oral without sedation	349	48.3	(44.6 - 52.0)	127	26.1	(22.4 - 30.2)
Surgical	16	2.2	(1.4 - 3.6)	2	0.4	(0.1 - 1.5)
Nasal intubation	13	1.8	(1.1 - 3.1)	13	2.7	(1.6 - 4.5)
Total	723	100		487	100	

Abbreviations: CI, confidence interval

Table 3 summarizes the intubation success rates and adverse event rates. Overall, intubation was successful in the first attempt in 63.8% (95% CI, 60.2%-67.2%) and within 3 attempts in 96.0% (95% CI, 94.3%-97.2%) of all trauma patients. In non-cardiac arrest patients, intubation was successful in the first attempt in 60.2% (95% CI, 55.8%-64.4%) and within 3 attempts in 94.5% (95% CI, 92.1%-96.2%) of patients. In cardiac arrest patients, intubation was successful in the first attempt in 71.2% (95% CI, 65.1%-76.6%) and within 3 attempts in 99.2% (95% CI,

97.0%-99.8%) of the patients. In the stratified analysis by the specialty (i.e., emergency physicians [n=434] vs. non-emergency physicians [n=289]), emergency physicians had a higher success at the first attempt (72.8 % vs. 50.2 %, p<0.001) compared to non-emergency physicians. Intubation-associated adverse event rates were 10.8% (95% CI, 8.7%-13.3%) in overall trauma patients, 11.5% (95% CI, 9.0%-14.6%) in non-cardiac arrest patients, and 9.3% (95% CI, 6.2%-13.7%) in cardiac arrest patients.

At the ED-level, there was a wide variation in the methods of intubation across the 12 EDs (**Figure 2).** For example, RSI as the initial intubation method was performed in 0% to 50.9% of all trauma patients, and in 0% to 87.5% of non-cardiac arrest patients. Similarly, there was a wide variation in the success rates and adverse event rates across the EDs (**Figure 3**). The range of overall success rates for intubation in the first attempt ranged from 35.5% to 90.5%, and from 85.1% to 100% within 3 attempts. Likewise, overall adverse event rates varied widely (range, 0%-16.7%) across the EDs. These wide variations in intubation success rates and adverse event rates persisted across the non-cardiac arrest and cardiac arrest strata.

Table 3. Success rates and intubation-associated adverse events

	All trauma patients			Non-cardiac arrest patients			Cardiac arrest patients		
	n	%	95% CI	n	%	95% CI	n	%	95% CI
Successful in 1st attempt	461	63.8	(60.2 - 67.2)	293	60.2	(55.8 - 64.4)	168	71.2	(65.1 - 76.6)
Successful in ≤ 3rd attempts	694	96.0	(94.3 - 97.2)	460	94.5	(92.1 - 96.2)	234	99.2	(97.0 - 99.8)
Adverse events	78	10.8	(8.7 - 13.3)	56	11.5	(9.0 - 14.6)	22	9.3	(6.2 - 13.7)
Details of adverse events*									
Esophageal intubation	25	3.5	(2.2 - 5.1)	15	3.1	(1.7 - 5.0)	10	4.2	(2.0 - 7.7)
Mainstem bronchus intubation	18	2.5	(1.5 - 3.9)	9	1.8	(0.8 - 3.5)	9	3.8	(1.7 - 7.1)
Airway trauma	17	2.4	(1.4 – 3.7)	14	2.9	(1.6 - 4.8)	3	1.3	(0.3 - 3.7)
Hypotension†	8	1.1	(0.5 - 2.2)	8	1.6	(0.7 - 3.2)			
Vomiting	6	0.8	(0.3 - 1.8)	6	1.2	(0.5 - 2.7)			
Hypoxia‡	3	0.4	(0.1 - 1.2)	3	0.6	(0.1 - 1.8)			
Cardiac arrest	1	0.1	(0.0 - 0.8)	1	0.2	(0.0 -1.1)			

Abbreviations: CI, confidence interval

*Patients may have more than 1 adverse event.

†Hypotension was defined as systolic blood pressure less than 90 mm Hg.

‡Hypoxia was defined as pulse oximetric oxygen saturation of less than 90% during intubation attempts, not as a result of esophageal intubation.

4. DISCUSSION

In this prospective, multicenter, observational study in Japan, we observed an acceptable success rate of airway management in trauma patients in EDs. However, we also found a wide range of variation in the initial method of intubation, success rates, and adverse event rates during trauma airway management across the EDs. Indeed, the overall success rates in the first intubation attempt ranged from 35.5% to 90.5%.

We were struck by the high degree of variation in the methods of airway management in trauma cases across the 12 EDs. The reasons for the observed practice variations are unclear and are likely multifactorial. It is possible that non-RSI methods were attempted in patients who were predicted to have a difficult intubation. However, the difference in the patient population across the EDs cannot fully explain the observed three-fold difference in the use of RSI. Alternatively, it is also possible that non-RSI methods were more frequently used in certain EDs because of the physicians' preference, procedural experiences, training background, or differences in ED staffing and institutional policies.

Our study also demonstrated a high degree of variations in success and adverse event rates among the EDs. Particularly, the success rate at first attempts was highly variable. To the best of our knowledge, this is the first study to demonstrate such inter-hospital variations in success and adverse event rates in trauma airway management in different EDs. The reasons for the variations among the EDs are likely multifactorial; the potential explanations include inter-hospital differences in patient population, skills or education backgrounds of intubators,[14]

drug and device availability in the ED, or any combination of these factors. Alternatively, the observed wide variation in the intubation method may have led to these variations in success and adverse event rates. Furthermore, there are no requirements for procedural credentials to perform ED intubations both in individuals and institutions in Japan. [10] This lack of procedural requirements would have contributed, at least partially, to the observed inter-hospital variations in the success rates.

Although international and Japanese trauma care guidelines recommend the use of RSI as the initial method of emergency airway management in most trauma patients, [1 4 5] the evidence for accurately predicting patients in whom RSI should be avoided remain limited. [15 16] It is, therefore, plausible that the scarcity of evidence may have contributed to the practice variations across the EDs. Our observations should facilitate further investigation of any barriers to the delivery of safer trauma care nationally. Additionally, building more robust evidence on trauma airway management, coupled with improved dissemination of these findings, could decrease the variations in trauma care across the EDs in Japan.

Our study has several potential limitations. First, this passive surveillance of the study data is subject to self-reporting bias, leading to a possible underestimation of failed intubations and adverse events. However, active independent monitoring of ED intubations is difficult to accomplish. We did, however, use a self-reporting system with structured data forms, uniform definitions, and a high capture rate. Second, we did not design this study to measure patient outcomes, such as long-term mortality or morbidity. A more detailed analysis of adverse events and outcomes requires following the patients for a longer period. Third, we did not account for

several potential confounders, such as severities (the Injury Severity Score, the Revised Trauma Score, etc.) of cases and training levels of physicians. However, this prospective multicenter data reflect the current airway management in the natural setting of a "real" population and current clinical practice, therefore enhancing the potential generalizability of the findings. Finally, all EDs in this study were designated as tertiary or academic general hospitals, and all but one of the EDs were affiliated with an emergency medicine residency program in Japan. Therefore, our inferences may not be generalizable to trauma airway management in non-academic EDs or other developed nations. These observations, however, are highly relevant from a policy standpoint. As these EDs provide advanced care for trauma victims and train the majority of emergency physicians, these EDs have a disproportionate impact on current and future trauma care in EDs.

5. CONCLUSION

In this multicenter prospective study of emergency airway management in Japan, we found an acceptable overall success rate in trauma airway management. However, we also found that the method of intubation, success rates and adverse event rates were highly variable among EDs. For researchers, our observations should facilitate further investigations to identify the reasons of the inter-hospital variations. Additionally, for policy makers and professional organizations, our findings suggest that development and dissemination of nationwide protocols are warranted to achieve safer airway management for trauma victims in Japan.

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Author Contribution

K.H. designed the study, for which S.N. and Y.H. contributed to the data collection and analysis. S.N. wrote the manuscript, which A.K. reviewed.

Conflict of Interest: None of the authors have any conflict of interest to declare.

Data Sharing Statement

No additional data available

Figure Legends

Figure 1. Flow chart showing inclusion of patients in this study

Figure 2. Inter-hospital variations in initial methods of intubation

Boxplots of inter-hospital variations in the initial methods of intubation. The line in the middle of the box represents the median, with the lower and upper limits of the box representing the 25th and 75th percentiles, respectively. The whiskers from the box extend to the minimum and maximum values.

Figure 3. Inter-hospital variations in success rates and adverse event rates

Boxplots of inter-hospital variations in success rates and adverse event rates. The line in the middle of the box represents the median, with the lower and upper limits of the box representing the 25th and 75th percentiles. The whiskers from the box extend to the minimum and maximum values.

References

1. American College of Surgeons CoT. *Advanced Trauma Life Support for Doctors, Student Course Manual*. 8th ed. Chicago, IL, 2008.
2. Walls RM, Brown CA, 3rd, Bair AE, et al. Emergency airway management: a multi-center report of 8937 emergency department intubations. The Journal of emergency medicine 2011;41:347-54 doi: 10.1016/j.jemermed.2010.02.024.
3. Hussain LM, Redmond AD. Are pre-hospital deaths from accidental injury preventable? Bmj 1994;308:1077-80 doi: 10.1136/bmj.308.6936.1077.
4. *Japan Advanced Trauma Evaluation and Care (JATEC™) guideline*. 3rd edition ed, 2008.
5. Dunham CM, Barraco RD, Clark DE, et al. Guidelines for emergency tracheal intubation immediately after traumatic injury. The Journal of trauma 2003;55:162-79 doi: 10.1097/01.ta.0000083335.93868.2c.
6. Graham CA. Emergency department airway management in the UK. Journal of the Royal Society of Medicine 2005;98:107-10 doi: 10.1258/jrsm.98.3.107.
7. Sakles JC, Laurin EG, Rantapaa AA, et al. Airway management in the emergency department: a one-year study of 610 tracheal intubations. Annals of emergency medicine 1998;31:325-32 doi: 10.1016/S0196-0644(98)70342-7.
8. Sagarin MJ, Barton ED, Chng YM, et al. Airway management by US and Canadian emergency medicine residents: a multicenter analysis of more than 6,000 endotracheal intubation attempts. Annals of emergency medicine 2005;46:328-36 doi: 10.1016/j.annemergmed.2005.01.009.
9. Graham CA, Beard D, Henry JM, et al. Rapid sequence intubation of trauma patients in Scotland. The Journal of trauma 2004;56:1123-6 doi:

10.1097/01.TA.0000109066.62811.8A.

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 doi: 10.1016/j.resuscitation.2011.11.027.

11. 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. Annals of emergency medicine 2012;60:749-54 e2 doi: 10.1016/j.annemergmed.2012.04.005.

12. Imamura T, Brown CA, 3rd, Ofuchi H, et al. Emergency airway management in geriatric and younger patients: analysis of a multicenter prospective observational study. The American journal of emergency medicine 2013;31:190-6 doi: 10.1016/j.ajem.2012.07.008.

13. Hasegawa K, Hagiwara Y, Imamura T, et al. Increased incidence of hypotension in elderly patients who underwent emergency airway management: an analysis of a multi-centre prospective observational study. International journal of emergency medicine 2013;6:12 doi: 10.1186/1865-1380-6-12.

14. Graham CA, Beard D, Oglesby AJ, et al. Rapid sequence intubation in Scottish urban emergency departments. Emergency medicine journal : EMJ 2003;20:3-5

15. Reed MJ, Dunn MJ, McKeown DW. Can an airway assessment score predict difficulty at intubation in the emergency department? Emergency medicine journal : EMJ 2005;22:99-102 doi: 10.1136/emj.2003.008771.

16. Soyuncu S, Eken C, Cete Y, et al. Determination of difficult intubation in the ED. The American journal of emergency medicine 2009;27:905-10 doi:

10.1016/j.ajem.2008.07.003.

Trauma airway management in emergency departments: A multicenter, prospective, observational study in Japan

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This paper characterizes the current practice of airway management for trauma patients in emergency departments (EDs) in Japan by using data from the Japanese Emergency Airway Network (JEAN) Study.

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Strengths and limitations of this study

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Passive surveillance of data is subject to self-reporting bias, leading to a possible underestimation of failed intubations and adverse events.

1. INTRODUCTION

Successful airway management is a cornerstone in the modern practice of emergency and trauma care. Failure of emergency airway management is often associated with morbidity and mortality in trauma patients. [1-3] Consequently, training in and understanding of airway management is a distinct discipline that is essential for successful trauma resuscitation.

Evidence-based recommendations for airway management during trauma care exist within international and national guidelines of the United States. These guidelines indicate rapid sequence intubation (RSI) as the initial method of emergency airway management in most trauma patients. [1 4 5] Recent studies reported that RSI is the most common airway management method in emergency departments (EDs) in North America and Europe. [6-9] Despite the ubiquitous practice of emergency airway management in trauma patients, little is known about its current practice and performance in other industrialized nations. Therefore, we sought to describe the current practice of airway management for trauma patients in the EDs in Japan.

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the current analysis.

Data Collection

Data collection was passive, relying on self-reports by the intubators on duty. After each intubation, the intubators completed a standardized data sheet, including the patient's age, sex, estimated weight, primary indication for intubation, methods used to facilitate intubation, intubator's level of training **(emergency physicians, resident physicians, and transitional year residents)** and specialty **(emergency physician or not)**, number of attempts, success or failure, and intubation-related adverse events. Method was defined as the set of medications and devices used, such as RSI with a Macintosh laryngoscope. **Transitional-years residents were post-graduate year 1-2 physicians who rotate through the ED.** An intubation attempt was defined as a single insertion of the laryngoscope (or other device) past the teeth [2 10-13]. For nasal intubations, an attempt was defined as a single insertion of a tracheal tube past the turbinates. An attempt was successful if it resulted in the tracheal tube being passed through the vocal cords. One or more methods could be used in each patient, and each method could be attempted several times.

Adverse events were recorded using a pre-specified list, with the option to include additional comments, if necessary. We monitored compliance with data form completion by reviewing professional billing records. Where the data collection form was missing, the intubator was interviewed by one of the investigators within 2 weeks of the patient encounter, to fill out the data form.

The outcomes of interest were the primary indication for intubation, initial method used for intubation, intubation success rates (on the first attempt and within three attempts), and adverse event rates.

Statistical Analysis

We performed all analysis with JMP 10 software (SAS Institute Inc., Cary, NC, USA). At the patient-level, we described patient demographics, the primary indication for intubation, initial method of intubation, success rates, and adverse event rates as proportions with 95% confidence intervals (CIs) and medians with interquartile ranges (IQR). Then, at the ED-level, we described medians, IQR and ranges for each outcome for all trauma patients. We also repeated the analysis after stratifying **by indication (non-cardiac arrest vs. cardiac arrest) and specialty (emergency physicians vs. non-emergency physicians).** All *P*-values were two-tailed, with $P<0.05$ considered statistically significant.

3. RESULTS

During the 30-month study period, 4,268 patients required emergency airway management. Of these, the registry recorded 4,094 intubations (capture rate, 95.9%; **Figure 1**), of which 3370 patients who underwent airway management for medical reasons were excluded from the analysis. One of the 13 hospitals, in whom only 1 trauma patient required airway intervention during the study period, was excluded because the number of intubations for trauma care was less than 10 during the study period. Hence, 723 trauma patients were eligible for analysis. Emergency physicians, including emergency medicine residents, performed the first intubation attempts in 60.0% (95% CI, 56.4%-63.5%) of all trauma patients and 66.7% (95% CI, 62.4%-70.8%) of non-cardiac arrest patients. Transitional-year residents (postgraduate years 1 and 2) performed the first intubation attempts in 31.4% (95% CI, 28.1%-34.9%) of all trauma patients and 25.7% (95% CI, 22.0%-29.7%) of non-cardiac arrest patients.

Table 1 shows the baseline characteristics and primary indications in patients who required trauma airway management. Median age was 56 years; two-thirds of the patients were male. Traumatic cardiac arrest was the reason for intubation in 32.6% (95% CI, 29.3%-36.1%) of all trauma patients, while head trauma accounted for 30.4% (95% CI, 27.2%-33.9%). **Table 2** shows the initial method of airway management in the trauma patients. RSI was the initial method chosen in 23.9% (95% CI, 21.0%-27.2%) of all trauma patients and 35.5% (95% CI, 31.4%-39.9%) of non-cardiac arrest patients. Cricothyrotomy was performed as the initial airway management strategy in 2.2% (95% CI, 1.4%-3.6%) of all trauma patients and 0.4% (95% CI, 0.1%-1.5%) of non-cardiac arrest patients.

Table 1. Characteristics of the 723 trauma patients who required intubation

Patient characteristics		
Age (y), median, (IQR)	56	(34 - 73)
Male, % (95% CI)	66.9	(63.4 - 70.3)
Estimated weight (kg), median, (IQR)	60	(50 - 70)
Indication for intubation, % (95% CI)		
Cardiac arrest	32.6	(29.3 - 36.1)
Head trauma	30.4	(27.2 - 33.9)
Shock	16.6	(14.1 - 19.5)
Facial/Neck trauma	8.4	(6.6 - 10.7)
Airway burn	6.8	(5.2 - 8.8)
Others	5.1	(3.3 - 8.0)

Abbreviations: CI, confidence interval; IQR, interquartile range

Table 2. Initial method of intubation

	All trauma patients			Non-cardiac arrest patients		
	n	%	95% CI	n	%	95% CI
Rapid sequence intubation	173	23.9	(21.0 - 27.2)	173	35.5	(31.4 - 39.9)
Sedation without paralysis	153	21.2	(18.3 - 24.3)	153	31.4	(27.5 - 35.7)
Paralytics without sedation	19	2.6	(1.7 - 4.1)	19	3.9	(2.5 - 6.0)
Oral without sedation	349	48.3	(44.6 - 52.0)	127	26.1	(22.4 - 30.2)
Surgical	16	2.2	(1.4 - 3.6)	2	0.4	(0.1 - 1.5)
Nasal intubation	13	1.8	(1.1 - 3.1)	13	2.7	(1.6 - 4.5)
Total	723	100		487	100	

Abbreviations: CI, confidence interval

Table 3 summarizes the intubation success rates and adverse event rates. Overall, intubation was successful in the first attempt in 63.8% (95% CI, 60.2%-67.2%) and within 3 attempts in 96.0% (95% CI, 94.3%-97.2%) of all trauma patients. In non-cardiac arrest patients, intubation was successful in the first attempt in 60.2% (95% CI, 55.8%-64.4%) and within 3 attempts in 94.5% (95% CI, 92.1%-96.2%) of patients. In cardiac arrest patients, intubation was successful in the first attempt in 71.2% (95% CI, 65.1%-76.6%) and within 3 attempts in 99.2% (95% CI,

97.0%-99.8%) of the patients. **In the stratified analysis by the specialty (i.e., emergency physicians [n=434] vs. non-emergency physicians [n=289]), emergency physicians had a higher success at the first attempt (72.8 % vs. 50.2 %, p<0.001) compared to non-emergency physicians.** Intubation-associated adverse event rates were 10.8% (95% CI, 8.7%-13.3%) in overall trauma patients, 11.5% (95% CI, 9.0%-14.6%) in non-cardiac arrest patients, and 9.3% (95% CI, 6.2%-13.7%) in cardiac arrest patients.

At the ED-level, there was a wide variation in the methods of intubation across the 12 EDs (**Figure 2).** For example, RSI as the initial intubation method was performed in 0% to 50.9% of all trauma patients, and in 0% to 87.5% of non-cardiac arrest patients. Similarly, there was a wide variation in the success rates and adverse event rates across the EDs (**Figure 3**). The range of overall success rates for intubation in the first attempt ranged from 35.5% to 90.5%, and from 85.1% to 100% within 3 attempts. Likewise, overall adverse event rates varied widely (range, 0%-16.7%) across the EDs. These wide variations in intubation success rates and adverse event rates persisted across the non-cardiac arrest and cardiac arrest strata.

Table 3. Success rates and intubation-associated adverse events

	All trauma patients			Non-cardiac arrest patients			Cardiac arrest patients		
	n	%	95% CI	n	%	95% CI	n	%	95% CI
Successful in 1st attempt	461	63.8	(60.2 - 67.2)	293	60.2	(55.8 - 64.4)	168	71.2	(65.1 - 76.6)
Successful in ≤ 3rd attempts	694	96.0	(94.3 - 97.2)	460	94.5	(92.1 - 96.2)	234	99.2	(97.0 - 99.8)
Adverse events	78	10.8	(8.7 - 13.3)	56	11.5	(9.0 - 14.6)	22	9.3	(6.2 - 13.7)
Details of adverse events*									
Esophageal intubation	25	3.5	(2.2 - 5.1)	15	3.1	(1.7 - 5.0)	10	4.2	(2.0 - 7.7)
Mainstem bronchus intubation	18	2.5	(1.5 - 3.9)	9	1.8	(0.8 - 3.5)	9	3.8	(1.7 - 7.1)
Airway trauma	17	2.4	(1.4 – 3.7)	14	2.9	(1.6 - 4.8)	3	1.3	(0.3 - 3.7)
Hypotension†	8	1.1	(0.5 - 2.2)	8	1.6	(0.7 - 3.2)			
Vomiting	6	0.8	(0.3 - 1.8)	6	1.2	(0.5 - 2.7)			
Hypoxia‡	3	0.4	(0.1 - 1.2)	3	0.6	(0.1 - 1.8)			
Cardiac arrest	1	0.1	(0.0 - 0.8)	1	0.2	(0.0 -1.1)			

Abbreviations: CI, confidence interval

*Patients may have more than 1 adverse event.

†Hypotension was defined as systolic blood pressure less than 90 mm Hg.

‡Hypoxia was defined as pulse oximetric oxygen saturation of less than 90% during intubation attempts, not as a result of esophageal intubation.

4. DISCUSSION

In this prospective, multicenter, observational study in Japan, we observed an acceptable success rate of airway management in trauma patients in EDs. However, we also found a wide range of variation in the initial method of intubation, success rates, and adverse event rates during trauma airway management across the EDs. Indeed, the overall success rates in the first intubation attempt ranged from 35.5% to 90.5%.

We were struck by the high degree of variation in the methods of airway management in trauma cases across the 12 EDs. The reasons for the observed practice variations are unclear and are likely multifactorial. It is possible that non-RSI methods were attempted in patients who were predicted to have a difficult intubation. However, the difference in the patient population across the EDs cannot fully explain the observed three-fold difference in the use of RSI. Alternatively, it is also possible that non-RSI methods were more frequently used in certain EDs because of the physicians' preference, procedural experiences, training background, or differences in ED staffing and institutional policies.

Our study also demonstrated a high degree of variations in success and adverse event rates among the EDs. Particularly, the success rate at first attempts was highly variable. To the best of our knowledge, this is the first study to demonstrate such inter-hospital variations in success and adverse event rates in trauma airway management in different EDs. **The reasons for the variations among the EDs are likely multifactorial; the potential explanations include** inter-hospital differences in patient population, skills or education backgrounds of intubators,**[14]**

drug and device availability in the ED, or any combination of these factors. Alternatively, the observed wide variation in the intubation method may have led to these variations in success and adverse event rates. **Furthermore, there are no requirements for procedural credentials to perform ED intubations both in individuals and institutions in Japan. [10] This lack of procedural requirements would have contributed, at least partially, to the observed inter-hospital variations in the success rates.**

Although international and Japanese trauma care guidelines recommend the use of RSI as the initial method of emergency airway management in most trauma patients, [1 4 5] the evidence for accurately predicting patients in whom RSI should be avoided remain limited. [15 16] It is, therefore, plausible that the scarcity of evidence may have contributed to the practice variations across the EDs. Our observations should facilitate further investigation of any barriers to the delivery of safer trauma care nationally. Additionally, building more robust evidence on trauma airway management, coupled with improved dissemination of these findings, could decrease the variations in trauma care across the EDs in Japan.

Our study has several potential limitations. First, this passive surveillance of the study data is subject to self-reporting bias, leading to a possible underestimation of failed intubations and adverse events. However, active independent monitoring of ED intubations is difficult to accomplish. We did, however, use a self-reporting system with structured data forms, uniform definitions, and a high capture rate. Second, we did not design this study to measure patient outcomes, such as long-term mortality or morbidity. A more detailed analysis of adverse events and outcomes requires following the patients for a longer period. Third, we did not account for

several potential confounders, such as severities **(the Injury Severity Score, the Revised Trauma Score, etc.)** of cases and training levels of physicians. **However, this prospective multicenter data reflect the current airway management in the natural setting of a "real" population and current clinical practice, therefore enhancing the potential generalizability of the findings.** Finally, all EDs in this study were designated as tertiary or academic general hospitals, and all but one of the EDs were affiliated with an emergency medicine residency program in Japan. Therefore, our inferences may not be generalizable to trauma airway management in non-academic EDs or other developed nations. These observations, however, are highly relevant from a policy standpoint. As these EDs provide advanced care for trauma victims and train the majority of emergency physicians, these EDs have a disproportionate impact on current and future trauma care in EDs.

5. CONCLUSION

In this multicenter prospective study of emergency airway management in Japan, we found an acceptable overall success rate in trauma airway management. However, we also found that the method of intubation, success rates and adverse event rates were highly variable among EDs. **For researchers, our observations should facilitate further investigations to identify the reasons of the inter-hospital variations. Additionally, for policy makers and professional organizations,** our findings suggest that development and dissemination of nationwide protocols are warranted to achieve safer airway management for trauma victims in Japan.

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Finally, we are grateful to our many emergency physicians and residents for their perseverance in pursuing new knowledge about this vital resuscitative procedure.

Author Contribution

K.H. designed the study, for which S.N. and Y.H. contributed to the data collection and analysis. S.N. wrote the manuscript, which A.K. reviewed.

Data Sharing Statement

No additional data available

References

1. American College of Surgeons CoT. *Advanced Trauma Life Support for Doctors, Student Course Manual*. 8th ed. Chicago, IL, 2008.
2. Walls RM, Brown CA, 3rd, Bair AE, et al. Emergency airway management: a multi-center report of 8937 emergency department intubations. The Journal of emergency medicine 2011;41:347-54 doi: 10.1016/j.jemermed.2010.02.024.
3. Hussain LM, Redmond AD. Are pre-hospital deaths from accidental injury preventable? Bmj 1994;308:1077-80 doi: 10.1136/bmj.308.6936.1077.
4. *Japan Advanced Trauma Evaluation and Care (JATEC™) guideline*. 3rd edition ed, 2008.
5. Dunham CM, Barraco RD, Clark DE, et al. Guidelines for emergency tracheal intubation immediately after traumatic injury. The Journal of trauma 2003;55:162-79 doi: 10.1097/01.ta.0000083335.93868.2c.
6. Graham CA. Emergency department airway management in the UK. Journal of the Royal Society of Medicine 2005;98:107-10 doi: 10.1258/jrsm.98.3.107.
7. Sakles JC, Laurin EG, Rantapaa AA, et al. Airway management in the emergency department: a one-year study of 610 tracheal intubations. Annals of emergency medicine 1998;31:325-32 doi: 10.1016/S0196-0644(98)70342-7.
8. Sagarin MJ, Barton ED, Chng YM, et al. Airway management by US and Canadian emergency medicine residents: a multicenter analysis of more than 6,000 endotracheal intubation attempts. Annals of emergency medicine 2005;46:328-36 doi: 10.1016/j.annemergmed.2005.01.009.
9. Graham CA, Beard D, Henry JM, et al. Rapid sequence intubation of trauma patients in Scotland. The Journal of trauma 2004;56:1123-6 doi:

10.1097/01.TA.0000109066.62811.8A.

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 doi: 10.1016/j.resuscitation.2011.11.027.

11. 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. Annals of emergency medicine 2012;60:749-54 e2 doi: 10.1016/j.annemergmed.2012.04.005.

12. Imamura T, Brown CA, 3rd, Ofuchi H, et al. Emergency airway management in geriatric and younger patients: analysis of a multicenter prospective observational study. The American journal of emergency medicine 2013;31:190-6 doi: 10.1016/j.ajem.2012.07.008.

13. Hasegawa K, Hagiwara Y, Imamura T, et al. Increased incidence of hypotension in elderly patients who underwent emergency airway management: an analysis of a multi-centre prospective observational study. International journal of emergency medicine 2013;6:12 doi: 10.1186/1865-1380-6-12.

14. **Graham CA, Beard D, Oglesby AJ, et al. Rapid sequence intubation in Scottish urban emergency departments. Emergency medicine journal : EMJ 2003;20:3-5**

15. Reed MJ, Dunn MJ, McKeown DW. Can an airway assessment score predict difficulty at intubation in the emergency department? Emergency medicine journal : EMJ 2005;22:99-102 doi: 10.1136/emj.2003.008771.

16. Soyuncu S, Eken C, Cete Y, et al. Determination of difficult intubation in the ED. The American journal of emergency medicine 2009;27:905-10 doi:

10.1016/j.ajem.2008.07.003.

Figure Legends

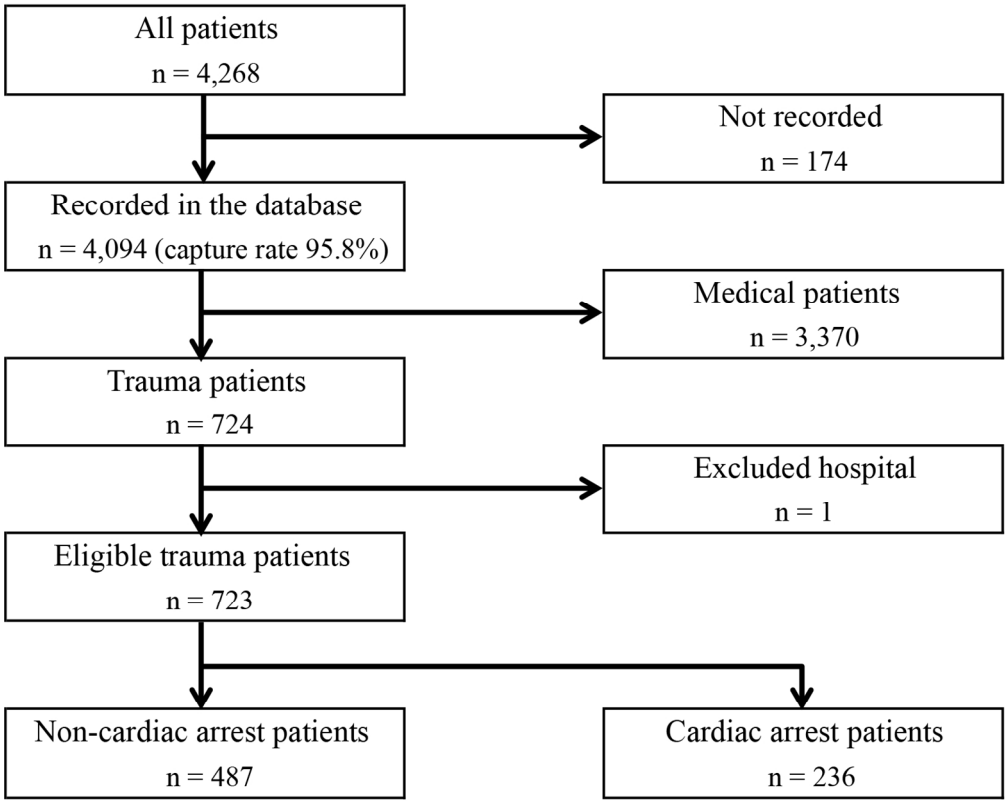
Figure 1. Flow chart showing inclusion of patients in this study

Figure 2. Inter-hospital variations in initial methods of intubation

Boxplots of inter-hospital variations in the initial methods of intubation. The line in the middle of the box represents the median, with the lower and upper limits of the box representing the 25th and 75th percentiles, respectively. The whiskers from the box extend to the minimum and maximum values.

Figure 3. Inter-hospital variations in success rates and adverse event rates

Boxplots of inter-hospital variations in success rates and adverse event rates. The line in the middle of the box represents the median, with the lower and upper limits of the box representing the 25th and 75th percentiles. The whiskers from the box extend to the minimum and maximum values.



Flow chart showing inclusion of patients in this study

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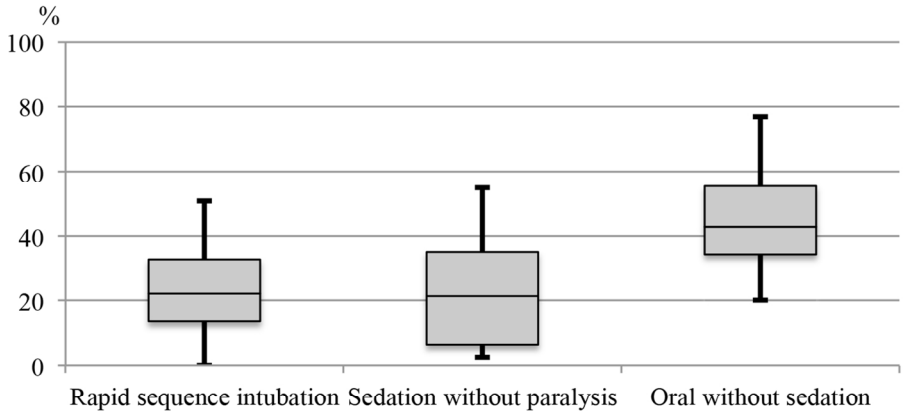
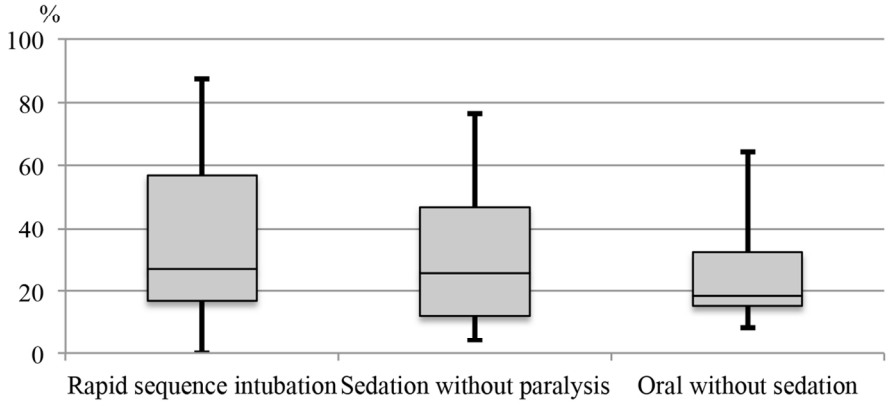
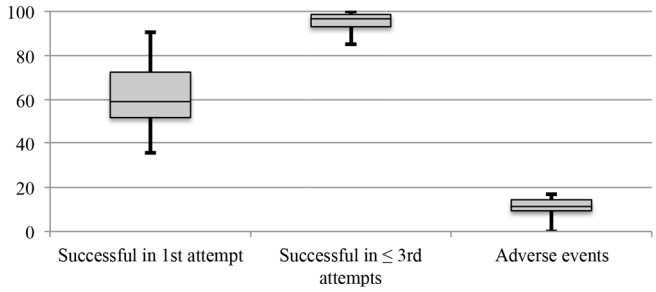


a. Among all trauma patients

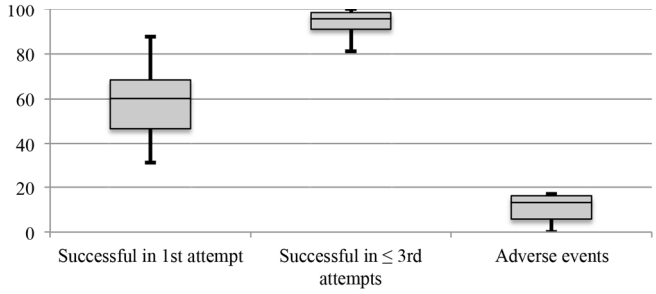


b. Among non-cardiac arrest patients

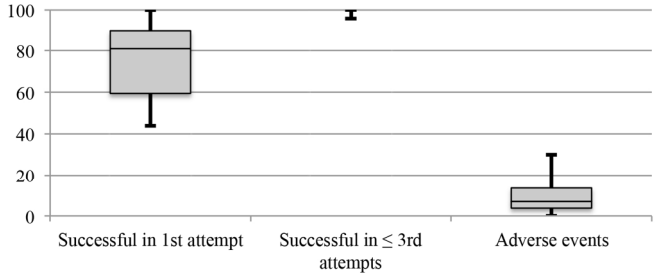
Inter-hospital variations in initial methods of intubation
Boxplots of inter-hospital variations in the initial methods of intubation. The line in the middle of the box represents the median, with the lower and upper limits of the box representing the 25th and 75th percentiles, respectively. The whiskers from the box extend to the minimum and maximum values.
140x165mm (300 x 300 DPI)



a. Among all trauma patients



b. Among non-cardiac arrest patients



c. Among cardiac arrest patients

Inter-hospital variations in success rates and adverse event rates
Boxplots of inter-hospital variations in success rates and adverse event rates. The line in the middle of the box represents the median, with the lower and upper limits of the box representing the 25th and 75th percentiles. The whiskers from the box extend to the minimum and maximum values.
137x233mm (300 x 300 DPI)

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Trauma airway management in emergency departments: A multicenter, prospective, observational study in Japan

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Trauma airway management in emergency departments: A multicenter, prospective, observational study in Japan

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Conflict of Interest: None of the authors have any conflict of interest to declare.

Keywords: Airway management, intubation, emergency department, practice variation, rapid sequence intubation

Abstract

Objectives: Although successful airway management is essential for emergency trauma care, comprehensive studies are limited. We sought to characterize the current trauma care practice of airway management in the emergency departments (EDs) in Japan.

Design: Analysis of data from a prospective, observational, multi-center registry – the Japanese Emergency Airway Network (JEAN) registry.

Setting: 13 academic and community EDs from different geographic regions across Japan.

Participants: 723 trauma patients who underwent emergency intubation from March 2010 through August 2012.

Outcome measures: ED characteristics, patient and operator demographics, methods of airway management, intubation success or failure at each attempt, and adverse events.

Results: A total of 723 trauma patients who underwent emergency intubation were eligible for the analysis. Traumatic cardiac arrest comprised 32.6% (95% CI, 29.3%-36.1%) of patients. Rapid sequence intubation (RSI) was the initial method chosen in 23.9% (95% CI, 21.0%-27.2%) of all trauma patients, and in 35.5% (95% CI, 31.4%-39.9%) of non-cardiac arrest trauma patients. Overall, intubation was successful in ≤3 attempts in 96.0% of patients (95% CI, 94.3%-97.2%). There was a wide variation in the initial methods of intubation; RSI as the initial method was performed in 0% to 50.9% of all trauma patients among 12 EDs. Similarly, there was a wide variation in success rates and adverse event rates across the EDs. Success rates varied between 35.5% and 90.5% at the first attempt and 85.1% and 100% within 3 attempts across the 12 EDs.

Conclusion: In this multicenter prospective study in Japan, we observed a high overall success rate in airway management during trauma care. However, the methods of intubation and success rates were highly variable among hospitals.

Article summary

Article focus

This paper characterizes the current practice of airway management for trauma patients in emergency departments (EDs) in Japan by using data from the Japanese Emergency Airway Network (JEAN) Study.

Key messages

The method of intubation, success rates, and adverse event rates are highly variable among EDs. Development and dissemination of nationwide protocols are warranted to achieve safer airway management for trauma victims in Japan.

Strengths and limitations of this study

This is the first study to report disparities in trauma airway management based on multicenter, prospective data.

Passive surveillance of data is subject to self-reporting bias, leading to a possible underestimation of failed intubations and adverse events.

1. INTRODUCTION

Successful airway management is a cornerstone in the modern practice of emergency and trauma care. Failure of emergency airway management is often associated with morbidity and mortality in trauma patients.[1-3] Consequently, training in and understanding of airway management is a distinct discipline that is essential for successful trauma resuscitation.

Evidence-based recommendations for airway management during trauma care exist within international and national guidelines of the United States. These guidelines indicate rapid sequence intubation (RSI) as the initial method of emergency airway management in most trauma patients.[1 4 5] Recent studies reported that RSI is the most common airway management method in emergency departments (EDs) in North America and Europe.[6-9] Despite the ubiquitous practice of emergency airway management in trauma patients, little is known about its current practice and performance in other industrialized nations. Therefore, we sought to describe the current practice of airway management for trauma patients in the EDs in Japan.

2. METHODS

Study Design and Setting

We analyzed the data of a prospective, observational, multi-center registry, the Japanese Emergency Airway Network (JEAN) registry. The study design, setting, methods of measurement, and measured variables have been reported elsewhere.[10-13] Briefly, the registry is a consortium of 13 academic and community EDs from different geographic regions across Japan. These EDs consisted of 10 tertiary medical centers that have a capability to manage the most severe trauma patients and 3 secondary medical centers that are designated to treat moderately severe trauma patients. The participating EDs had a median ED census of 30,000 patient visits per year (range 9,000 to 67,000). All 13 EDs were staffed by attending emergency physicians, and 12 had affiliations with emergency medicine residency training programs. Each hospital maintained individual protocols, policies, and procedures for emergency airway management. Intubations were performed by attending physicians or by resident physicians at the discretion of the ED attending physician. The ethics committee of each participating center approved the protocol, with waiver of informed consent before data collection.

Patients

The registry prospectively collected information on consecutive patients who underwent airway management in the participating EDs during a 30-month period, from March 2010 to August 2012. All adult and pediatric trauma patients who underwent intubation were eligible for this analysis. We excluded an ED in which the number of trauma intubations was less than 10 from the current analysis.

Data Collection

Data collection was passive, relying on self-reports by the intubators on duty. After each intubation, the intubators completed a standardized data sheet, including the patient's age, sex, estimated weight, primary indication for intubation, methods used to facilitate intubation, intubator's level of training (emergency physicians, resident physicians, and transitional year residents) and specialty (emergency physician or not), number of attempts, success or failure, and intubation-related adverse events. Method was defined as the set of medications and devices used, such as RSI with a Macintosh laryngoscope. Transitional-years residents were post-graduate year 1-2 physicians who rotate through the ED. An intubation attempt was defined as a single insertion of the laryngoscope (or other device) past the teeth.[2 10-13] For nasal intubations, an attempt was defined as a single insertion of a tracheal tube past the turbinates. An attempt was successful if it resulted in the tracheal tube being passed through the vocal cords. One or more methods could be used in each patient, and each method could be attempted several times.

Adverse events were recorded using a pre-specified list, with the option to include additional comments, if necessary. Adverse events were defined as cardiac arrest, hypotension, hypoxemia, dysrhythmia, vomiting, esophageal intubation, mainstem bronchial intubation, and airway trauma that are considered to be intubation-related.[11] Cardiac arrest included asystole, bradycardia, or dysrhythmia with nonmeasurable blood pressure and cardiopulmonary resuscitation during or after intubation. Hypotension was defined as systolic blood pressure less than 90 mm Hg. Hypoxemia was defined as pulse oximetric saturation less than 90% during an

intubation attempt, not a result of esophageal intubation. Preexisting hypotension or hypoxemia before an intubation attempt were not counted as an adverse event. Esophageal intubation was defined as misplacement of the endotracheal tube in the upper esophagus or hypopharynx, with a lapse of time and desaturation (pulse oximetric saturation <90%) before the removal of the misplaced tube. We monitored compliance with data form completion by reviewing professional billing records. Where the data collection form was missing, the intubator was interviewed by one of the investigators within 2 weeks of the patient encounter, to fill out the data form.

The outcomes of interest were the primary indication for intubation, initial method used for intubation, intubation success rates (on the first attempt and within three attempts), and intubation-related adverse event rates.

Statistical Analysis

We performed all analysis with JMP 10 software (SAS Institute Inc., Cary, NC, USA). At the patient-level, we described patient demographics, the primary indication for intubation, initial method of intubation, success rates, and adverse event rates as proportions with 95% confidence intervals (CIs) and medians with interquartile ranges (IQR). Then, at the ED-level, we described medians, IQR and ranges for each outcome for all trauma patients. We also repeated the analysis after stratifying by indication (non-cardiac arrest vs. cardiac arrest) and specialty (emergency physicians vs. non-emergency physicians). All *P*-values were two-tailed, with $P<0.05$ considered statistically significant.

3. RESULTS

During the 30-month study period, 4,268 patients required emergency airway management. Of these, the registry recorded 4,094 intubations (capture rate, 95.9%; **Figure 1**), of which 3370 patients who underwent airway management for medical reasons were excluded from the analysis. One of the 13 hospitals, in whom only 1 trauma patient required airway intervention during the study period, was excluded because the number of intubations for trauma care was less than 10 during the study period. Hence, 723 trauma patients were eligible for analysis. Emergency physicians, including emergency medicine residents, performed the first intubation attempts in 60.0% (95% CI, 56.4%-63.5%) of all trauma patients and 66.7% (95% CI, 62.4%-70.8%) of non-cardiac arrest patients. Transitional-year residents (postgraduate years 1 and 2) performed the first intubation attempts in 31.4% (95% CI, 28.1%-34.9%) of all trauma patients and 25.7% (95% CI, 22.0%-29.7%) of non-cardiac arrest patients.

Table 1 shows the baseline characteristics and primary indications in patients who required trauma airway management. Median age was 56 years; two-thirds of the patients were male. Traumatic cardiac arrest was the reason for intubation in 32.6% (95% CI, 29.3%-36.1%) of all trauma patients, while head trauma accounted for 30.4% (95% CI, 27.2%-33.9%). **Table 2** shows the initial method of airway management in the trauma patients. RSI was the initial method chosen in 23.9% (95% CI, 21.0%-27.2%) of all trauma patients and 35.5% (95% CI, 31.4%-39.9%) of non-cardiac arrest patients. Cricothyrotomy was performed as the initial airway management strategy in 2.2% (95% CI, 1.4%-3.6%) of all trauma patients and 0.4% (95% CI, 0.1%-1.5%) of non-cardiac arrest patients. The direct laryngoscope was used in most of intubations (n=654, 90.5%), and the remaining were intubated using a video laryngoscope (n=30,

4.1%), a bronchoscope (n=17, 2.4%), a lighted stylet (n=1, 0.1%) on the first attempt.

Table 1. Characteristics of the 723 trauma patients who required intubation

Patient characteristics		
Age (y), median, (IQR)	56	(34 - 73)
Male, % (95% CI)	66.9	(63.4 - 70.3)
Estimated weight (kg), median, (IQR)	60	(50 - 70)
Indication for intubation, % (95% CI)		
Cardiac arrest	32.6	(29.3 - 36.1)
Head trauma	30.4	(27.2 - 33.9)
Shock	16.6	(14.1 - 19.5)
Facial/Neck trauma	8.4	(6.6 - 10.7)
Airway burn	6.8	(5.2 - 8.8)
Others	5.1	(3.3 - 8.0)

Abbreviations: CI, confidence interval; IQR, interquartile range

Table 2. Initial method of intubation

	All trauma patients			Non-cardiac arrest patients		
	n	%	95% CI	n	%	95% CI
Rapid sequence intubation	173	23.9	(21.0 - 27.2)	173	35.5	(31.4 - 39.9)
Sedation without paralysis	153	21.2	(18.3 - 24.3)	153	31.4	(27.5 - 35.7)
Paralytics without sedation	19	2.6	(1.7 - 4.1)	19	3.9	(2.5 - 6.0)
Oral without sedation	349	48.3	(44.6 - 52.0)	127	26.1	(22.4 - 30.2)
Surgical	16	2.2	(1.4 - 3.6)	2	0.4	(0.1 - 1.5)
Nasal intubation	13	1.8	(1.1 - 3.1)	13	2.7	(1.6 - 4.5)
Total	723	100		487	100	

Abbreviations: CI, confidence interval

Table 3 summarizes the intubation success rates and adverse event rates. Overall, intubation was successful in the first attempt in 63.8% (95% CI, 60.2%-67.2%) and within 3 attempts in 96.0% (95% CI, 94.3%-97.2%) of all trauma patients. In non-cardiac arrest patients, intubation was successful in the first attempt in 60.2% (95% CI, 55.8%-64.4%) and within 3 attempts in 94.5%

(95% CI, 92.1%-96.2%) of patients. In cardiac arrest patients, intubation was successful in the first attempt in 71.2% (95% CI, 65.1%-76.6%) and within 3 attempts in 99.2% (95% CI, 97.0%-99.8%) of the patients. In the stratified analysis by the specialty (i.e., emergency physicians [n=434] vs. non-emergency physicians [n=289]), emergency physicians had a higher success at the first attempt (72.8 % vs. 50.2 %, p<0.001) compared to non-emergency physicians (including all transitional-year residents [n=237]). Intubation-associated adverse event rates were 10.8% (95% CI, 8.7%-13.3%) in overall trauma patients, 11.5% (95% CI, 9.0%-14.6%) in non-cardiac arrest patients, and 9.3% (95% CI, 6.2%-13.7%) in cardiac arrest patients.

At the ED-level, there was a wide variation in the methods of intubation across the 12 EDs (**Figure 2).** For example, RSI as the initial intubation method was performed in 0% to 50.9% of all trauma patients, and in 0% to 87.5% of non-cardiac arrest patients. Similarly, there was a wide variation in the success rates and adverse event rates across the EDs (**Figure 3**). The range of overall success rates for intubation in the first attempt ranged from 35.5% to 90.5%, and from 85.1% to 100% within 3 attempts. Likewise, overall adverse event rates varied widely (range, 0%-16.7%) across the EDs. These wide variations in intubation success rates and adverse event rates persisted across the non-cardiac arrest and cardiac arrest strata.

Table 3. Success rates and intubation-associated adverse events

	All trauma patients			Non-cardiac arrest patients			Cardiac arrest patients		
	n	%	95% CI	n	%	95% CI	n	%	95% CI
Successful in 1st attempt	461	63.8	(60.2 - 67.2)	293	60.2	(55.8 - 64.4)	168	71.2	(65.1 - 76.6)
Successful in ≤ 3rd attempts	694	96.0	(94.3 - 97.2)	460	94.5	(92.1 - 96.2)	234	99.2	(97.0 - 99.8)
Adverse events	78	10.8	(8.7 - 13.3)	56	11.5	(9.0 - 14.6)	22	9.3	(6.2 - 13.7)
Details of adverse events*									
Esophageal intubation	25	3.5	(2.2 - 5.1)	15	3.1	(1.7 - 5.0)	10	4.2	(2.0 - 7.7)
Mainstem bronchus intubation	18	2.5	(1.5 - 3.9)	9	1.8	(0.8 - 3.5)	9	3.8	(1.7 - 7.1)
Airway trauma	17	2.4	(1.4 – 3.7)	14	2.9	(1.6 - 4.8)	3	1.3	(0.3 - 3.7)
Hypotension†	8	1.1	(0.5 - 2.2)	8	1.6	(0.7 - 3.2)			
Vomiting	6	0.8	(0.3 - 1.8)	6	1.2	(0.5 - 2.7)			
Hypoxia‡	3	0.4	(0.1 - 1.2)	3	0.6	(0.1 - 1.8)			
Cardiac arrest	1	0.1	(0.0 - 0.8)	1	0.2	(0.0 -1.1)			

Abbreviations: CI, confidence interval

*Patients may have more than 1 adverse event.

†Hypotension was defined as systolic blood pressure less than 90 mm Hg.

‡Hypoxia was defined as pulse oximetric oxygen saturation of less than 90% during intubation attempts, not as a result of esophageal intubation.

4. DISCUSSION

In this prospective, multicenter, observational study in Japan, we observed an acceptable success rate of airway management in trauma patients in EDs. However, we also found a wide range of variation in the initial method of intubation, success rates, and adverse event rates during trauma airway management across the EDs. Indeed, the overall success rates in the first intubation attempt ranged from 35.5% to 90.5%.

We were struck by the high degree of variation in the methods of airway management in trauma cases across the 12 EDs. The reasons for the observed practice variations are unclear and are likely multifactorial. It is possible that non-RSI methods were attempted in patients who were predicted to have a difficult intubation. However, the difference in the patient population across the EDs cannot fully explain the observed three-fold difference in the use of RSI. Therefore, some of the patients might have been inappropriately considered as "difficult intubation," and intubated with non-RSI methods. Alternatively, it is also plausible that non-RSI methods were more frequently used in certain EDs because of the physicians' preference, procedural experiences, training background, or differences in ED staffing and institutional policies.

Our study also demonstrated a high degree of variations in success and adverse event rates among the EDs. Particularly, the success rate at first attempts was highly variable. To the best of our knowledge, this is the first study to demonstrate such inter-hospital variations in success and adverse event rates in trauma airway management in different EDs. The reasons for the variations among the EDs are likely multifactorial; the potential explanations include

inter-hospital differences in patient population, skills or education backgrounds of intubators,[14] drug and device availability in the ED, or any combination of these factors. Alternatively, the observed wide variation in the intubation method may have led to these variations in success and adverse event rates. Furthermore, there are no requirements for procedural credentials to perform ED intubations both in individuals and institutions in Japan.[10] This lack of procedural requirements would have contributed, at least partially, to the observed inter-hospital variations in the success rates. Indeed, we observed that intubation success rates performed by non-emergency physicians were significantly lower; this was, at least in part, explained by the intubation attempts by transitional-year residents. However, it is well documented in the literature that first-pass success is important in critically-ill patients[11]; therefore, the observed lower success rate by these non-skilled physicians cannot be justified. Our data underscore the reinforcement of Japanese methodology of training for non-skilled physicians (e.g., the use of simulators and training in a more controlled setting[15-17] to improve their intubation skill set, which will, in turn, improve patients' outcomes.

Although international and Japanese trauma care guidelines recommend the use of RSI as the initial method of emergency airway management in most trauma patients,[1 4 5] the evidence for accurately predicting patients in whom RSI should be avoided remain limited.[18 19] It is, therefore, plausible that the scarcity of evidence may have contributed to the practice variations across the EDs. Our observations should facilitate further investigation of any barriers to the delivery of safer trauma care nationally. Additionally, building more robust evidence on trauma airway management, coupled with improved dissemination of these findings, could decrease the variations in trauma care across the EDs in Japan.

Our study has several potential limitations. First, this passive surveillance of the study data is subject to self-reporting bias, leading to a possible underestimation of failed intubations and adverse events. However, active independent monitoring of ED intubations is difficult to accomplish. We did, however, use a self-reporting system with structured data forms, uniform definitions, and a high capture rate. Second, we did not design this study to measure patient outcomes, such as long-term mortality or morbidity. A more detailed analysis of adverse events and outcomes requires following the patients for a longer period. Third, we did not account for several potential confounders, such as severities (the Injury Severity Score, the Revised Trauma Score, etc.) of cases and training levels of physicians. However, this prospective multicenter data reflect the current airway management in the natural setting of a "real" population and current clinical practice, therefore enhancing the potential generalizability of the findings. Finally, all EDs in this study were designated as tertiary or academic general hospitals, and all but one of the EDs were affiliated with an emergency medicine residency program in Japan. Therefore, our inferences may not be generalizable to trauma airway management in non-academic EDs or other developed nations. These observations, however, are highly relevant from a policy standpoint. As these EDs provide advanced care for trauma victims and train the majority of emergency physicians, these EDs have a disproportionate impact on current and future trauma care in EDs.

5. CONCLUSION

In this multicenter prospective study of emergency airway management in Japan, we found an acceptable overall success rate in trauma airway management. However, we also found that the method of intubation, success rates and adverse event rates were highly variable among EDs. For

researchers, our observations should facilitate further investigations to identify the reasons of the inter-hospital variations. Additionally, for policy makers and professional organizations, our findings suggest that development and dissemination of nationwide protocols are warranted to achieve safer airway management for trauma victims in Japan.

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Finally, we are grateful to our many emergency physicians and residents for their perseverance in pursuing new knowledge about this vital resuscitative procedure.

Author Contribution

K.H. designed the study, for which S.N. and Y.H. contributed to the data collection and analysis. S.N. wrote the manuscript, which A.K. reviewed.

Data Sharing Statement

No additional data available

References

1. American College of Surgeons CoT. *Advanced Trauma Life Support for Doctors, Student Course Manual*. 8th ed. Chicago, IL, 2008.
2. Walls RM, Brown CA, 3rd, Bair AE, et al. Emergency airway management: a multi-center report of 8937 emergency department intubations. The Journal of emergency medicine 2011;41:347-54 doi: 10.1016/j.jemermed.2010.02.024.
3. Hussain LM, Redmond AD. Are pre-hospital deaths from accidental injury preventable? Bmj 1994;308:1077-80 doi: 10.1136/bmj.308.6936.1077.
4. *Japan Advanced Trauma Evaluation and Care (JATEC™) guideline*. 3rd edition ed, 2008.
5. Dunham CM, Barraco RD, Clark DE, et al. Guidelines for emergency tracheal intubation immediately after traumatic injury. The Journal of trauma 2003;55:162-79 doi: 10.1097/01.ta.0000083335.93868.2c.
6. Graham CA. Emergency department airway management in the UK. Journal of the Royal Society of Medicine 2005;98:107-10 doi: 10.1258/jrsm.98.3.107.
7. Sakles JC, Laurin EG, Rantapaa AA, et al. Airway management in the emergency department: a one-year study of 610 tracheal intubations. Annals of emergency medicine 1998;31:325-32 doi: 10.1016/S0196-064470342-7.
8. Sagarin MJ, Barton ED, Chng YM, et al. Airway management by US and Canadian emergency medicine residents: a multicenter analysis of more than 6,000 endotracheal intubation attempts. Annals of emergency medicine 2005;46:328-36 doi: 10.1016/j.annemergmed.2005.01.009.
9. Graham CA, Beard D, Henry JM, et al. Rapid sequence intubation of trauma patients in Scotland. The Journal of trauma 2004;56:1123-6 doi:

10.1097/01.TA.0000109066.62811.8A.

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 doi: 10.1016/j.resuscitation.2011.11.027.

11. 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. Annals of emergency medicine 2012;60:749-54 e2 doi: 10.1016/j.annemergmed.2012.04.005.

12. Imamura T, Brown CA, 3rd, Ofuchi H, et al. Emergency airway management in geriatric and younger patients: analysis of a multicenter prospective observational study. The American journal of emergency medicine 2013;31:190-6 doi: 10.1016/j.ajem.2012.07.008.

13. Hasegawa K, Hagiwara Y, Imamura T, et al. Increased incidence of hypotension in elderly patients who underwent emergency airway management: an analysis of a multi-centre prospective observational study. International journal of emergency medicine 2013;6:12 doi: 10.1186/1865-1380-6-12.

14. Graham CA, Beard D, Oglesby AJ, et al. Rapid sequence intubation in Scottish urban emergency departments. Emergency medicine journal : EMJ 2003;20:3-5

15. Mayo PH, Hackney JE, Mueck JT, et al. Achieving house staff competence in emergency airway management: results of a teaching program using a computerized patient simulator. Critical care medicine 2004;32:2422-7

16. Cook DA, Hatala R, Brydges R, et al. Technology-enhanced simulation for health professions education: a systematic review and meta-analysis. JAMA : the journal of the

American Medical Association 2011;306:978-88 doi: 10.1001/jama.2011.1234.

17. Bernhard M, Mohr S, Weigand MA, et al. Developing the skill of endotracheal intubation: implication for emergency medicine. Acta anaesthesiologica Scandinavica 2012;56:164-71 doi: 10.1111/j.1399-6576.2011.02547.x.

18. Reed MJ, Dunn MJ, McKeown DW. Can an airway assessment score predict difficulty at intubation in the emergency department? Emergency medicine journal : EMJ 2005;22:99-102 doi: 10.1136/emj.2003.008771.

19. Soyuncu S, Eken C, Cete Y, et al. Determination of difficult intubation in the ED. The American journal of emergency medicine 2009;27:905-10 doi: 10.1016/j.ajem.2008.07.003.

Figure Legends

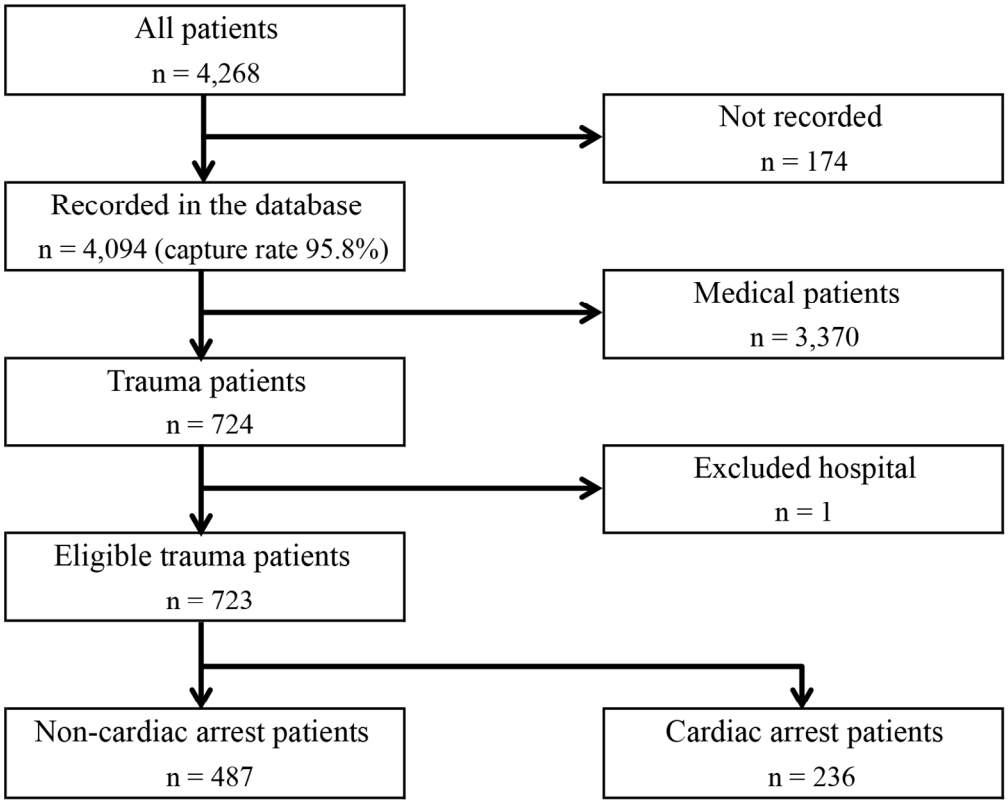
Figure 1. Flow chart showing inclusion of patients in this study

Figure 2. Inter-hospital variations in initial methods of intubation

Boxplots of inter-hospital variations in the initial methods of intubation. The line in the middle of the box represents the median, with the lower and upper limits of the box representing the 25th and 75th percentiles, respectively. The whiskers from the box extend to the minimum and maximum values.

Figure 3. Inter-hospital variations in success rates and adverse event rates

Boxplots of inter-hospital variations in success rates and adverse event rates. The line in the middle of the box represents the median, with the lower and upper limits of the box representing the 25th and 75th percentiles. The whiskers from the box extend to the minimum and maximum values.



Flow chart showing inclusion of patients in this study

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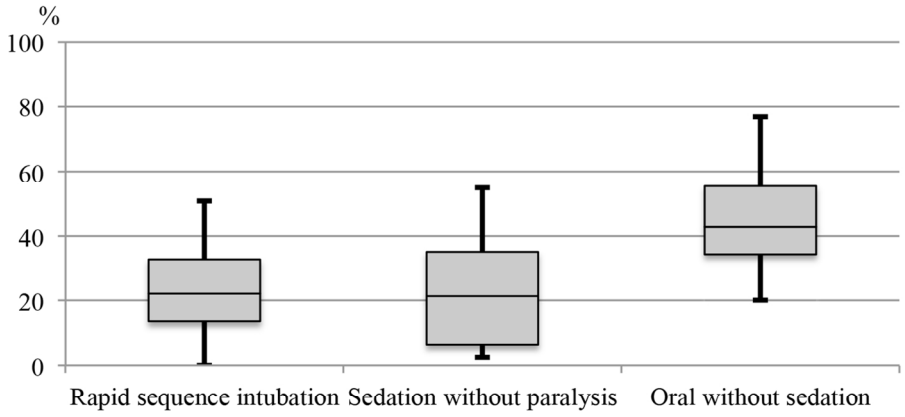
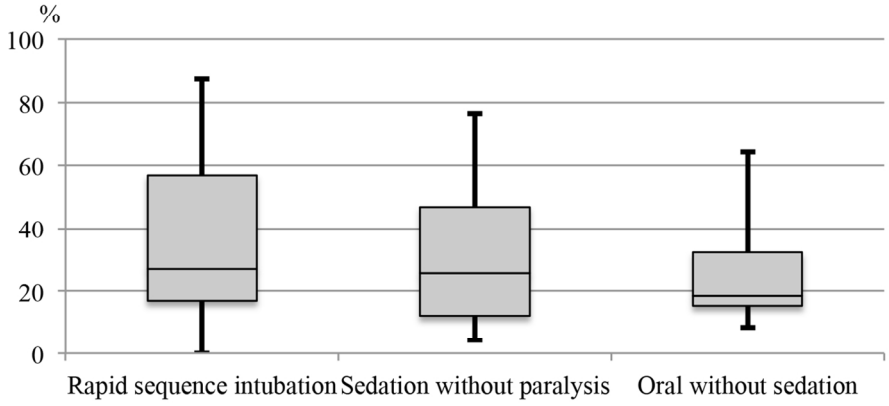
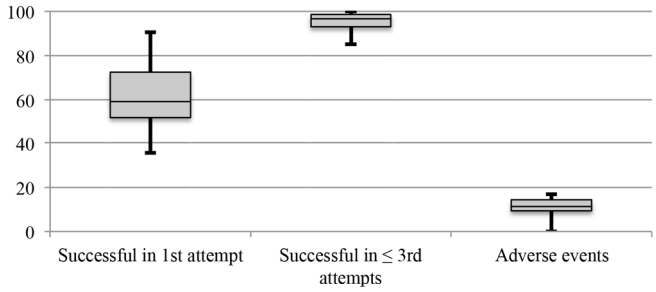


a. Among all trauma patients

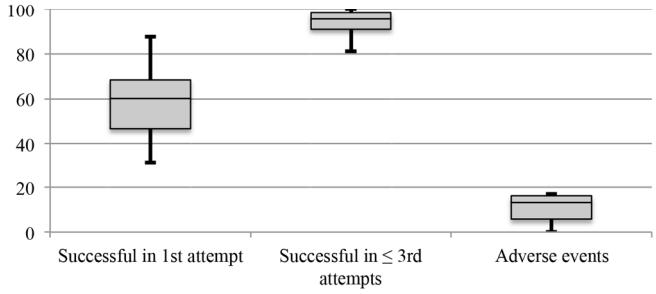


b. Among non-cardiac arrest patients

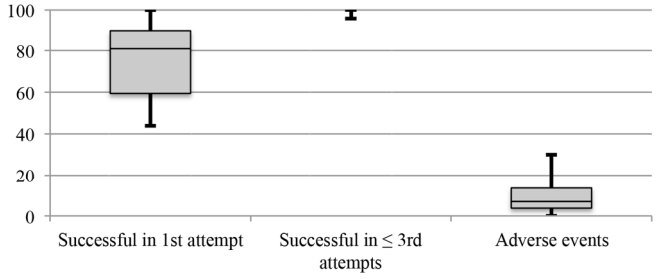
Inter-hospital variations in initial methods of intubation
Boxplots of inter-hospital variations in the initial methods of intubation. The line in the middle of the box represents the median, with the lower and upper limits of the box representing the 25th and 75th percentiles, respectively. The whiskers from the box extend to the minimum and maximum values.
140x165mm (300 x 300 DPI)



a. Among all trauma patients



b. Among non-cardiac arrest patients



c. Among cardiac arrest patients

Inter-hospital variations in success rates and adverse event rates
Boxplots of inter-hospital variations in success rates and adverse event rates. The line in the middle of the box represents the median, with the lower and upper limits of the box representing the 25th and 75th percentiles. The whiskers from the box extend to the minimum and maximum values.
137x233mm (300 x 300 DPI)

Trauma airway management in emergency departments: A multicenter, prospective, observational study in Japan

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Conflict of Interest: None of the authors have any conflict of interest to declare.

Keywords: Airway management, intubation, emergency department, practice variation, rapid sequence intubation

Abstract

Objectives: Although successful airway management is essential for emergency trauma care, comprehensive studies are limited. We sought to characterize the current trauma care practice of airway management in the emergency departments (EDs) in Japan.

Design: Analysis of data from a prospective, observational, multi-center registry – the Japanese Emergency Airway Network (JEAN) registry.

Setting: 13 academic and community EDs from different geographic regions across Japan.

Participants: 723 trauma patients who underwent emergency intubation from March 2010 through August 2012.

Outcome measures: ED characteristics, patient and operator demographics, methods of airway management, intubation success or failure at each attempt, and adverse events.

Results: A total of 723 trauma patients who underwent emergency intubation were eligible for the analysis. Traumatic cardiac arrest comprised 32.6% (95% CI, 29.3%-36.1%) of patients. Rapid sequence intubation (RSI) was the initial method chosen in 23.9% (95% CI, 21.0%-27.2%) of all trauma patients, and in 35.5% (95% CI, 31.4%-39.9%) of non-cardiac arrest trauma patients. Overall, intubation was successful in ≤3 attempts in 96.0% of patients (95% CI, 94.3%-97.2%). There was a wide variation in the initial methods of intubation; RSI as the initial method was performed in 0% to 50.9% of all trauma patients among 12 EDs. Similarly, there was a wide variation in success rates and adverse event rates across the EDs. Success rates varied between 35.5% and 90.5% at the first attempt and 85.1% and 100% within 3 attempts across the 12 EDs.

Conclusion: In this multicenter prospective study in Japan, we observed a high overall success rate in airway management during trauma care. However, the methods of intubation and success rates were highly variable among hospitals.

Article summary

Article focus

This paper characterizes the current practice of airway management for trauma patients in emergency departments (EDs) in Japan by using data from the Japanese Emergency Airway Network (JEAN) Study.

Key messages

The method of intubation, success rates, and adverse event rates are highly variable among EDs.

Development and dissemination of nationwide protocols are warranted to achieve safer airway management for trauma victims in Japan.

Strengths and limitations of this study

This is the first study to report disparities in trauma airway management based on multicenter, prospective data.

Passive surveillance of data is subject to self-reporting bias, leading to a possible underestimation of failed intubations and adverse events.

1. INTRODUCTION

Successful airway management is a cornerstone in the modern practice of emergency and trauma care. Failure of emergency airway management is often associated with morbidity and mortality in trauma patients.[1-3] Consequently, training in and understanding of airway management is a distinct discipline that is essential for successful trauma resuscitation.

Evidence-based recommendations for airway management during trauma care exist within international and national guidelines of the United States. These guidelines indicate rapid sequence intubation (RSI) as the initial method of emergency airway management in most trauma patients.[1 4 5] Recent studies reported that RSI is the most common airway management method in emergency departments (EDs) in North America and Europe.[6-9] Despite the ubiquitous practice of emergency airway management in trauma patients, little is known about its current practice and performance in other industrialized nations. Therefore, we sought to describe the current practice of airway management for trauma patients in the EDs in Japan.

2. METHODS

Study Design and Setting

We analyzed the data of a prospective, observational, multi-center registry, the Japanese Emergency Airway Network (JEAN) registry. The study design, setting, methods of measurement, and measured variables have been reported elsewhere.[10-13] Briefly, the registry is a consortium of 13 academic and community EDs from different geographic regions across Japan. These EDs consisted of 10 tertiary medical centers that have a capability to manage the most severe trauma patients and 3 secondary medical centers that are designated to treat moderately severe trauma patients. The participating EDs had a median ED census of 30,000 patient visits per year (range 9,000 to 67,000). All 13 EDs were staffed by attending emergency physicians, and 12 had affiliations with emergency medicine residency training programs. Each hospital maintained individual protocols, policies, and procedures for emergency airway management. Intubations were performed by attending physicians or by resident physicians at the discretion of the ED attending physician. The ethics committee of each participating center approved the protocol, with waiver of informed consent before data collection.

Patients

The registry prospectively collected information on consecutive patients who underwent airway management in the participating EDs during a 30-month period, from March 2010 to August 2012. All adult and pediatric trauma patients who underwent intubation were eligible for this analysis. We excluded an ED in which the number of trauma intubations was less than 10 from the current analysis.

Data Collection

Data collection was passive, relying on self-reports by the intubators on duty. After each intubation, the intubators completed a standardized data sheet, including the patient's age, sex, estimated weight, primary indication for intubation, methods used to facilitate intubation, intubator's level of training (emergency physicians, resident physicians, and transitional year residents) and specialty (emergency physician or not), number of attempts, success or failure, and intubation-related adverse events. Method was defined as the set of medications and devices used, such as RSI with a Macintosh laryngoscope. Transitional-years residents were post-graduate year 1-2 physicians who rotate through the ED. An intubation attempt was defined as a single insertion of the laryngoscope (or other device) past the teeth.[2 10-13] For nasal intubations, an attempt was defined as a single insertion of a tracheal tube past the turbinates. An attempt was successful if it resulted in the tracheal tube being passed through the vocal cords. One or more methods could be used in each patient, and each method could be attempted several times.

Adverse events were recorded using a pre-specified list, with the option to include additional comments, if necessary. **Adverse events were defined as cardiac arrest, hypotension, hypoxemia, dysrhythmia, vomiting, esophageal intubation, mainstem bronchial intubation, and airway trauma that are considered to be intubation-related.[11] Cardiac arrest included asystole, bradycardia, or dysrhythmia with nonmeasurable blood pressure and cardiopulmonary resuscitation during or after intubation. Hypotension was defined as systolic blood pressure less than 90 mm Hg. Hypoxemia was defined as pulse oximetric**

saturation less than 90% during an intubation attempt, not a result of esophageal intubation. Preexisting hypotension or hypoxemia before an intubation attempt were not counted as an adverse event. Esophageal intubation was defined as misplacement of the endotracheal tube in the upper esophagus or hypopharynx, with a lapse of time and desaturation (pulse oximetric saturation <90%) before the removal of the misplaced tube.

We monitored compliance with data form completion by reviewing professional billing records. Where the data collection form was missing, the intubator was interviewed by one of the investigators within 2 weeks of the patient encounter, to fill out the data form.

The outcomes of interest were the primary indication for intubation, initial method used for intubation, intubation success rates (on the first attempt and within three attempts), and **intubation-related** adverse event rates.

Statistical Analysis

We performed all analysis with JMP 10 software (SAS Institute Inc., Cary, NC, USA). At the patient-level, we described patient demographics, the primary indication for intubation, initial method of intubation, success rates, and adverse event rates as proportions with 95% confidence intervals (CIs) and medians with interquartile ranges (IQR). Then, at the ED-level, we described medians, IQR and ranges for each outcome for all trauma patients. We also repeated the analysis after stratifying by indication (non-cardiac arrest vs. cardiac arrest) and specialty (emergency physicians vs. non-emergency physicians). All *P*-values were two-tailed, with $P<0.05$ considered statistically significant.

3. RESULTS

During the 30-month study period, 4,268 patients required emergency airway management. Of these, the registry recorded 4,094 intubations (capture rate, 95.9%; **Figure 1**), of which 3370 patients who underwent airway management for medical reasons were excluded from the analysis. One of the 13 hospitals, in whom only 1 trauma patient required airway intervention during the study period, was excluded because the number of intubations for trauma care was less than 10 during the study period. Hence, 723 trauma patients were eligible for analysis. Emergency physicians, including emergency medicine residents, performed the first intubation attempts in 60.0% (95% CI, 56.4%-63.5%) of all trauma patients and 66.7% (95% CI, 62.4%-70.8%) of non-cardiac arrest patients. Transitional-year residents (postgraduate years 1 and 2) performed the first intubation attempts in 31.4% (95% CI, 28.1%-34.9%) of all trauma patients and 25.7% (95% CI, 22.0%-29.7%) of non-cardiac arrest patients.

Table 1 shows the baseline characteristics and primary indications in patients who required trauma airway management. Median age was 56 years; two-thirds of the patients were male. Traumatic cardiac arrest was the reason for intubation in 32.6% (95% CI, 29.3%-36.1%) of all trauma patients, while head trauma accounted for 30.4% (95% CI, 27.2%-33.9%). **Table 2** shows the initial method of airway management in the trauma patients. RSI was the initial method chosen in 23.9% (95% CI, 21.0%-27.2%) of all trauma patients and 35.5% (95% CI, 31.4%-39.9%) of non-cardiac arrest patients. Cricothyrotomy was performed as the initial airway management strategy in 2.2% (95% CI, 1.4%-3.6%) of all trauma patients and 0.4% (95% CI, 0.1%-1.5%) of non-cardiac arrest patients. The direct laryngoscope was used in most of intubations (n=654, 90.5%), and the remaining were intubated using a video laryngoscope (n=30,

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4.1%), a bronchoscope (n=17, 2.4%), a lighted stylet (n=1, 0.1%) on the first attempt.

Table 1. Characteristics of the 723 trauma patients who required intubation

Patient characteristics		
Age (y), median, (IQR)	56	(34 - 73)
Male, % (95% CI)	66.9	(63.4 - 70.3)
Estimated weight (kg), median, (IQR)	60	(50 - 70)
Indication for intubation, % (95% CI)		
Cardiac arrest	32.6	(29.3 - 36.1)
Head trauma	30.4	(27.2 - 33.9)
Shock	16.6	(14.1 - 19.5)
Facial/Neck trauma	8.4	(6.6 - 10.7)
Airway burn	6.8	(5.2 - 8.8)
Others	5.1	(3.3 - 8.0)

Abbreviations: CI, confidence interval; IQR, interquartile range

Table 2. Initial method of intubation

	All trauma patients			Non-cardiac arrest patients		
	n	%	95% CI	n	%	95% CI
Rapid sequence intubation	173	23.9	(21.0 - 27.2)	173	35.5	(31.4 - 39.9)
Sedation without paralysis	153	21.2	(18.3 - 24.3)	153	31.4	(27.5 - 35.7)
Paralytics without sedation	19	2.6	(1.7 - 4.1)	19	3.9	(2.5 - 6.0)
Oral without sedation	349	48.3	(44.6 - 52.0)	127	26.1	(22.4 - 30.2)
Surgical	16	2.2	(1.4 - 3.6)	2	0.4	(0.1 - 1.5)
Nasal intubation	13	1.8	(1.1 - 3.1)	13	2.7	(1.6 - 4.5)
Total	723	100		487	100	

Abbreviations: CI, confidence interval

Table 3 summarizes the intubation success rates and adverse event rates. Overall, intubation was successful in the first attempt in 63.8% (95% CI, 60.2%-67.2%) and within 3 attempts in 96.0% (95% CI, 94.3%-97.2%) of all trauma patients. In non-cardiac arrest patients, intubation was successful in the first attempt in 60.2% (95% CI, 55.8%-64.4%) and within 3 attempts in 94.5%

(95% CI, 92.1%-96.2%) of patients. In cardiac arrest patients, intubation was successful in the first attempt in 71.2% (95% CI, 65.1%-76.6%) and within 3 attempts in 99.2% (95% CI, 97.0%-99.8%) of the patients. In the stratified analysis by the specialty (i.e., emergency physicians [n=434] vs. non-emergency physicians [n=289]), emergency physicians had a higher success at the first attempt (72.8 % vs. 50.2 %, p<0.001) compared to non-emergency physicians **(including all transitional-year residents [n=237])**. Intubation-associated adverse event rates were 10.8% (95% CI, 8.7%-13.3%) in overall trauma patients, 11.5% (95% CI, 9.0%-14.6%) in non-cardiac arrest patients, and 9.3% (95% CI, 6.2%-13.7%) in cardiac arrest patients.

At the ED-level, there was a wide variation in the methods of intubation across the 12 EDs (**Figure 2).** For example, RSI as the initial intubation method was performed in 0% to 50.9% of all trauma patients, and in 0% to 87.5% of non-cardiac arrest patients. Similarly, there was a wide variation in the success rates and adverse event rates across the EDs (**Figure 3**). The range of overall success rates for intubation in the first attempt ranged from 35.5% to 90.5%, and from 85.1% to 100% within 3 attempts. Likewise, overall adverse event rates varied widely (range, 0%-16.7%) across the EDs. These wide variations in intubation success rates and adverse event rates persisted across the non-cardiac arrest and cardiac arrest strata.

Table 3. Success rates and intubation-associated adverse events

	All trauma patients			Non-cardiac arrest patients			Cardiac arrest patients		
	n	%	95% CI	n	%	95% CI	n	%	95% CI
Successful in 1st attempt	461	63.8	(60.2 - 67.2)	293	60.2	(55.8 - 64.4)	168	71.2	(65.1 - 76.6)
Successful in ≤ 3rd attempts	694	96.0	(94.3 - 97.2)	460	94.5	(92.1 - 96.2)	234	99.2	(97.0 - 99.8)
Adverse events	78	10.8	(8.7 - 13.3)	56	11.5	(9.0 - 14.6)	22	9.3	(6.2 - 13.7)
Details of adverse events*									
Esophageal intubation	25	3.5	(2.2 - 5.1)	15	3.1	(1.7 - 5.0)	10	4.2	(2.0 - 7.7)
Mainstem bronchus intubation	18	2.5	(1.5 - 3.9)	9	1.8	(0.8 - 3.5)	9	3.8	(1.7 - 7.1)
Airway trauma	17	2.4	(1.4 – 3.7)	14	2.9	(1.6 - 4.8)	3	1.3	(0.3 - 3.7)
Hypotension†	8	1.1	(0.5 - 2.2)	8	1.6	(0.7 - 3.2)			
Vomiting	6	0.8	(0.3 - 1.8)	6	1.2	(0.5 - 2.7)			
Hypoxia‡	3	0.4	(0.1 - 1.2)	3	0.6	(0.1 - 1.8)			
Cardiac arrest	1	0.1	(0.0 - 0.8)	1	0.2	(0.0 -1.1)			

Abbreviations: CI, confidence interval

*Patients may have more than 1 adverse event.

†Hypotension was defined as systolic blood pressure less than 90 mm Hg.

‡Hypoxia was defined as pulse oximetric oxygen saturation of less than 90% during intubation attempts, not as a result of esophageal intubation.

4. DISCUSSION

In this prospective, multicenter, observational study in Japan, we observed an acceptable success rate of airway management in trauma patients in EDs. However, we also found a wide range of variation in the initial method of intubation, success rates, and adverse event rates during trauma airway management across the EDs. Indeed, the overall success rates in the first intubation attempt ranged from 35.5% to 90.5%.

We were struck by the high degree of variation in the methods of airway management in trauma cases across the 12 EDs. The reasons for the observed practice variations are unclear and are likely multifactorial. It is possible that non-RSI methods were attempted in patients who were predicted to have a difficult intubation. However, the difference in the patient population across the EDs cannot fully explain the observed three-fold difference in the use of RSI. Therefore, some of the patients might have been inappropriately considered as "difficult intubation," and intubated with non-RSI methods. Alternatively, it is also plausible that non-RSI methods were more frequently used in certain EDs because of the physicians' preference, procedural experiences, training background, or differences in ED staffing and institutional policies.

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Our study also demonstrated a high degree of variations in success and adverse event rates among the EDs. Particularly, the success rate at first attempts was highly variable. To the best of our knowledge, this is the first study to demonstrate such inter-hospital variations in success and adverse event rates in trauma airway management in different EDs. The reasons for the variations among the EDs are likely multifactorial; the potential explanations include

inter-hospital differences in patient population, skills or education backgrounds of intubators,[14] drug and device availability in the ED, or any combination of these factors. Alternatively, the observed wide variation in the intubation method may have led to these variations in success and adverse event rates. Furthermore, there are no requirements for procedural credentials to perform ED intubations both in individuals and institutions in Japan.[10] This lack of procedural requirements would have contributed, at least partially, to the observed inter-hospital variations in the success rates. Indeed, we observed that intubation success rates performed by non-emergency physicians were significantly lower; this was, at least in part, explained by the intubation attempts by transitional-year residents. However, it is well documented in the literature that first-pass success is important in critically-ill patients[11]; therefore, the observed lower success rate by these non-skilled physicians cannot be justified. Our data underscore the reinforcement of Japanese methodology of training for non-skilled physicians (e.g., the use of simulators and training in a more controlled setting[15-17] to improve their intubation skill set, which will, in turn, improve patients' outcomes.

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Although international and Japanese trauma care guidelines recommend the use of RSI as the initial method of emergency airway management in most trauma patients,[1 4 5] the evidence for accurately predicting patients in whom RSI should be avoided remain limited.[18 19] It is, therefore, plausible that the scarcity of evidence may have contributed to the practice variations across the EDs. Our observations should facilitate further investigation of any barriers to the delivery of safer trauma care nationally. Additionally, building more robust evidence on trauma airway management, coupled with improved dissemination of these findings, could decrease the variations in trauma care across the EDs in Japan.

Our study has several potential limitations. First, this passive surveillance of the study data is subject to self-reporting bias, leading to a possible underestimation of failed intubations and adverse events. However, active independent monitoring of ED intubations is difficult to accomplish. We did, however, use a self-reporting system with structured data forms, uniform definitions, and a high capture rate. Second, we did not design this study to measure patient outcomes, such as long-term mortality or morbidity. A more detailed analysis of adverse events and outcomes requires following the patients for a longer period. Third, we did not account for several potential confounders, such as severities (the Injury Severity Score, the Revised Trauma Score, etc.) of cases and training levels of physicians. However, this prospective multicenter data reflect the current airway management in the natural setting of a "real" population and current clinical practice, therefore enhancing the potential generalizability of the findings. Finally, all EDs in this study were designated as tertiary or academic general hospitals, and all but one of the EDs were affiliated with an emergency medicine residency program in Japan. Therefore, our inferences may not be generalizable to trauma airway management in non-academic EDs or other developed nations. These observations, however, are highly relevant from a policy standpoint. As these EDs provide advanced care for trauma victims and train the majority of emergency physicians, these EDs have a disproportionate impact on current and future trauma care in EDs.

5. CONCLUSION

In this multicenter prospective study of emergency airway management in Japan, we found an acceptable overall success rate in trauma airway management. However, we also found that the method of intubation, success rates and adverse event rates were highly variable among EDs. For

researchers, our observations should facilitate further investigations to identify the reasons of the inter-hospital variations. Additionally, for policy makers and professional organizations, our findings suggest that development and dissemination of nationwide protocols are warranted to achieve safer airway management for trauma victims in Japan.

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Author Contribution

K.H. designed the study, for which S.N. and Y.H. contributed to the data collection and analysis. S.N. wrote the manuscript, which A.K. reviewed.

Data Sharing Statement

No additional data available

References

1. American College of Surgeons CoT. *Advanced Trauma Life Support for Doctors, Student Course Manual*. 8th ed. Chicago, IL, 2008.
2. Walls RM, Brown CA, 3rd, Bair AE, et al. Emergency airway management: a multi-center report of 8937 emergency department intubations. The Journal of emergency medicine 2011;41:347-54 doi: 10.1016/j.jemermed.2010.02.024.
3. Hussain LM, Redmond AD. Are pre-hospital deaths from accidental injury preventable? Bmj 1994;308:1077-80 doi: 10.1136/bmj.308.6936.1077.
4. *Japan Advanced Trauma Evaluation and Care (JATEC™) guideline*. 3rd edition ed, 2008.
5. Dunham CM, Barraco RD, Clark DE, et al. Guidelines for emergency tracheal intubation immediately after traumatic injury. The Journal of trauma 2003;55:162-79 doi: 10.1097/01.ta.0000083335.93868.2c.
6. Graham CA. Emergency department airway management in the UK. Journal of the Royal Society of Medicine 2005;98:107-10 doi: 10.1258/jrsm.98.3.107.
7. Sakles JC, Laurin EG, Rantapaa AA, et al. Airway management in the emergency department: a one-year study of 610 tracheal intubations. Annals of emergency medicine 1998;31:325-32 doi: 10.1016/S0196-064470342-7.
8. Sagarin MJ, Barton ED, Chng YM, et al. Airway management by US and Canadian emergency medicine residents: a multicenter analysis of more than 6,000 endotracheal intubation attempts. Annals of emergency medicine 2005;46:328-36 doi: 10.1016/j.annemergmed.2005.01.009.
9. Graham CA, Beard D, Henry JM, et al. Rapid sequence intubation of trauma patients in Scotland. The Journal of trauma 2004;56:1123-6 doi:

10.1097/01.TA.0000109066.62811.8A.

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 doi: 10.1016/j.resuscitation.2011.11.027.

11. 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. Annals of emergency medicine 2012;60:749-54 e2 doi: 10.1016/j.annemergmed.2012.04.005.

12. Imamura T, Brown CA, 3rd, Ofuchi H, et al. Emergency airway management in geriatric and younger patients: analysis of a multicenter prospective observational study. The American journal of emergency medicine 2013;31:190-6 doi: 10.1016/j.ajem.2012.07.008.

13. Hasegawa K, Hagiwara Y, Imamura T, et al. Increased incidence of hypotension in elderly patients who underwent emergency airway management: an analysis of a multi-centre prospective observational study. International journal of emergency medicine 2013;6:12 doi: 10.1186/1865-1380-6-12.

14. Graham CA, Beard D, Oglesby AJ, et al. Rapid sequence intubation in Scottish urban emergency departments. Emergency medicine journal : EMJ 2003;20:3-5

15. Mayo PH, Hackney JE, Mueck JT, et al. Achieving house staff competence in emergency airway management: results of a teaching program using a computerized patient simulator. Critical care medicine 2004;32:2422-7

16. Cook DA, Hatala R, Brydges R, et al. Technology-enhanced simulation for health professions education: a systematic review and meta-analysis. JAMA : the journal of the

American Medical Association 2011;306:978-88 doi: 10.1001/jama.2011.1234.

17. Bernhard M, Mohr S, Weigand MA, et al. Developing the skill of endotracheal intubation: implication for emergency medicine. Acta anaesthesiologica Scandinavica 2012;56:164-71 doi: 10.1111/j.1399-6576.2011.02547.x.

18. Reed MJ, Dunn MJ, McKeown DW. Can an airway assessment score predict difficulty at intubation in the emergency department? Emergency medicine journal : EMJ 2005;22:99-102 doi: 10.1136/emj.2003.008771.

19. Soyuncu S, Eken C, Cete Y, et al. Determination of difficult intubation in the ED. The American journal of emergency medicine 2009;27:905-10 doi: 10.1016/j.ajem.2008.07.003.

Figure Legends

Figure 1. Flow chart showing inclusion of patients in this study

Figure 2. Inter-hospital variations in initial methods of intubation

Boxplots of inter-hospital variations in the initial methods of intubation. The line in the middle of the box represents the median, with the lower and upper limits of the box representing the 25th and 75th percentiles, respectively. The whiskers from the box extend to the minimum and maximum values.

Figure 3. Inter-hospital variations in success rates and adverse event rates

Boxplots of inter-hospital variations in success rates and adverse event rates. The line in the middle of the box represents the median, with the lower and upper limits of the box representing the 25th and 75th percentiles. The whiskers from the box extend to the minimum and maximum values.

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Trauma airway management in emergency departments: A multicenter, prospective, observational study in Japan

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Trauma airway management in emergency departments: A multicenter, prospective, observational study in Japan

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Conflict of Interest: None of the authors have any conflict of interest to declare.

Keywords: Airway management, intubation, emergency department, practice variation, rapid sequence intubation

Abstract

Objectives: Although successful airway management is essential for emergency trauma care, comprehensive studies are limited. We sought to characterize the current trauma care practice of airway management in the emergency departments (EDs) in Japan.

Design: Analysis of data from a prospective, observational, multi-center registry – the Japanese Emergency Airway Network (JEAN) registry.

Setting: 13 academic and community EDs from different geographic regions across Japan.

Participants: 723 trauma patients who underwent emergency intubation from March 2010 through August 2012.

Outcome measures: ED characteristics, patient and operator demographics, methods of airway management, intubation success or failure at each attempt, and adverse events.

Results: A total of 723 trauma patients who underwent emergency intubation were eligible for the analysis. Traumatic cardiac arrest comprised 32.6% (95% CI, 29.3%-36.1%) of patients. Rapid sequence intubation (RSI) was the initial method chosen in 23.9% (95% CI, 21.0%-27.2%) of all trauma patients, and in 35.5% (95% CI, 31.4%-39.9%) of non-cardiac arrest trauma patients. Overall, intubation was successful in ≤3 attempts in 96.0% of patients (95% CI, 94.3%-97.2%). There was a wide variation in the initial methods of intubation; RSI as the initial method was performed in 0% to 50.9% of all trauma patients among 12 EDs. Similarly, there was a wide variation in success rates and adverse event rates across the EDs. Success rates varied between 35.5% and 90.5% at the first attempt and 85.1% and 100% within 3 attempts across the 12 EDs.

Conclusion: In this multicenter prospective study in Japan, we observed a high overall success rate in airway management during trauma care. However, the methods of intubation and success rates were highly variable among hospitals.

Article summary

Article focus

This paper characterizes the current practice of airway management for trauma patients in emergency departments (EDs) in Japan by using data from the Japanese Emergency Airway Network (JEAN) Study.

Key messages

The method of intubation, success rates, and adverse event rates are highly variable among EDs. Development and dissemination of nationwide protocols are warranted to achieve safer airway management for trauma victims in Japan.

Strengths and limitations of this study

This is the first study to report disparities in trauma airway management based on multicenter, prospective data.

Passive surveillance of data is subject to self-reporting bias, leading to a possible underestimation of failed intubations and adverse events.

1. INTRODUCTION

Successful airway management is a cornerstone in the modern practice of emergency and trauma care. Failure of emergency airway management is often associated with morbidity and mortality in trauma patients.[1-3] Consequently, training in and understanding of airway management is a distinct discipline that is essential for successful trauma resuscitation.

Evidence-based recommendations for airway management during trauma care exist within international and national guidelines of the United States. These guidelines indicate rapid sequence intubation (RSI) as the initial method of emergency airway management in most trauma patients.[1 4 5] Recent studies reported that RSI is the most common airway management method in emergency departments (EDs) in North America and Europe.[6-9] Despite the ubiquitous practice of emergency airway management in trauma patients, little is known about its current practice and performance in other industrialized nations. Therefore, we sought to describe the current practice of airway management for trauma patients in the EDs in Japan.

2. METHODS

Study Design and Setting

We analyzed the data of a prospective, observational, multi-center registry, the Japanese Emergency Airway Network (JEAN) registry. The study design, setting, methods of measurement, and measured variables have been reported elsewhere.[10-13] Briefly, the registry is a consortium of 13 academic and community EDs from different geographic regions across Japan. These EDs consisted of 10 tertiary medical centers that have a capability to manage the most severe trauma patients and 3 secondary medical centers that are designated to treat moderately severe trauma patients. The participating EDs had a median ED census of 30,000 patient visits per year (range 9,000 to 67,000). The participating hospitals had a median trauma admission of 1,000 per year (range, 300 to 1,500).[14] All 13 EDs were staffed by attending emergency physicians, and 12 had affiliations with emergency medicine residency training programs. Each hospital maintained individual protocols, policies, and procedures for emergency airway management. Intubations were performed by attending physicians or by resident physicians at the discretion of the ED attending physician. The ethics committee of each participating center approved the protocol, with waiver of informed consent before data collection.

Patients

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analysis. We excluded an ED in which the number of trauma intubations was less than 10 from the current analysis.

Data Collection

Data collection was passive, relying on self-reports by the intubators on duty. After each intubation, the intubators completed a standardized data sheet, including the patient's age, sex, estimated weight, primary indication for intubation, methods used to facilitate intubation, intubator's level of training (emergency physicians, resident physicians, and transitional year residents) and specialty (emergency physician or not), number of attempts, success or failure, and intubation-related adverse events. Method was defined as the set of medications and devices used, such as RSI with a Macintosh laryngoscope. Transitional-years residents were post-graduate year 1-2 physicians who rotate through the ED. An intubation attempt was defined as a single insertion of the laryngoscope (or other device) past the teeth.[2 10-13] For nasal intubations, an attempt was defined as a single insertion of a tracheal tube past the turbinates. An attempt was successful if it resulted in the tracheal tube being passed through the vocal cords. One or more methods could be used in each patient, and each method could be attempted several times.

Adverse events were recorded using a pre-specified list, with the option to include additional comments, if necessary. Adverse events were defined as cardiac arrest, hypotension, hypoxemia, dysrhythmia, vomiting, esophageal intubation, mainstem bronchial intubation, and airway trauma that are considered to be intubation-related.[11] Cardiac arrest included asystole, bradycardia, or dysrhythmia with nonmeasurable blood pressure and cardiopulmonary

resuscitation during or after intubation. Hypotension was defined as systolic blood pressure less than 90 mm Hg. Hypoxemia was defined as pulse oximetric saturation less than 90% during an intubation attempt, not a result of esophageal intubation. Preexisting hypotension or hypoxemia before an intubation attempt were not counted as an adverse event. Esophageal intubation was defined as misplacement of the endotracheal tube in the upper esophagus or hypopharynx, with a lapse of time and desaturation (pulse oximetric saturation <90%) before the removal of the misplaced tube. We monitored compliance with data form completion by reviewing professional billing records. Where the data collection form was missing, the intubator was interviewed by one of the investigators within 2 weeks of the patient encounter, to fill out the data form.

The outcomes of interest were the primary indication for intubation, initial method used for intubation, intubation success rates (on the first attempt and within three attempts), and intubation-related adverse event rates.

Statistical Analysis

We performed all analysis with JMP 10 software (SAS Institute Inc., Cary, NC, USA). At the patient-level, we described patient demographics, the primary indication for intubation, initial method of intubation, success rates, and adverse event rates as proportions with 95% confidence intervals (CIs) and medians with interquartile ranges (IQR). Then, at the ED-level, we described medians, IQR and ranges for each outcome for all trauma patients. We also repeated the analysis after stratifying by indication (non-cardiac arrest vs. cardiac arrest) and specialty (emergency physicians vs. non-emergency physicians). All *P*-values were two-tailed, with $P<0.05$ considered statistically significant.

3. RESULTS

During the 30-month study period, 4,268 patients required emergency airway management. Of these, the registry recorded 4,094 intubations (capture rate, 95.9%; **Figure 1**), of which 3370 patients who underwent airway management for medical reasons were excluded from the analysis. One of the 13 hospitals, in whom only 1 trauma patient required airway intervention during the study period, was excluded because the number of intubations for trauma care was less than 10 during the study period. Hence, 723 trauma patients were eligible for analysis. Emergency physicians, including emergency medicine residents, performed the first intubation attempts in 60.0% (95% CI, 56.4%-63.5%) of all trauma patients and 66.7% (95% CI, 62.4%-70.8%) of non-cardiac arrest patients. Transitional-year residents (postgraduate years 1 and 2) performed the first intubation attempts in 31.4% (95% CI, 28.1%-34.9%) of all trauma patients and 25.7% (95% CI, 22.0%-29.7%) of non-cardiac arrest patients.

Table 1 shows the baseline characteristics and primary indications in patients who required trauma airway management. Median age was 56 years; two-thirds of the patients were male. Traumatic cardiac arrest was the reason for intubation in 32.6% (95% CI, 29.3%-36.1%) of all trauma patients, while head trauma accounted for 30.4% (95% CI, 27.2%-33.9%). **Table 2** shows the initial method of airway management in the trauma patients. RSI was the initial method chosen in 23.9% (95% CI, 21.0%-27.2%) of all trauma patients and 35.5% (95% CI, 31.4%-39.9%) of non-cardiac arrest patients. Cricothyrotomy was performed as the initial airway management strategy in 2.2% (95% CI, 1.4%-3.6%) of all trauma patients and 0.4% (95% CI, 0.1%-1.5%) of non-cardiac arrest patients. The direct laryngoscope was used in most of intubations (n=654, 90.5%), and the remaining were intubated using a video laryngoscope (n=30,

4.1%), a bronchoscope (n=17, 2.4%), a lighted stylet (n=1, 0.1%) on the first attempt.

Table 1. Characteristics of the 723 trauma patients who required intubation

Patient characteristics		
Age (y), median, (IQR)	56	(34 - 73)
Male, % (95% CI)	66.9	(63.4 - 70.3)
Estimated weight (kg), median, (IQR)	60	(50 - 70)
Indication for intubation, % (95% CI)		
Cardiac arrest	32.6	(29.3 - 36.1)
Head trauma	30.4	(27.2 - 33.9)
Shock	16.6	(14.1 - 19.5)
Facial/Neck trauma	8.4	(6.6 - 10.7)
Airway burn	6.8	(5.2 - 8.8)
Others	5.1	(3.3 - 8.0)

Abbreviations: CI, confidence interval; IQR, interquartile range

Table 2. Initial method of intubation

	All trauma patients			Non-cardiac arrest patients		
	n	%	95% CI	n	%	95% CI
Rapid sequence intubation	173	23.9	(21.0 - 27.2)	173	35.5	(31.4 - 39.9)
Sedation without paralysis	153	21.2	(18.3 - 24.3)	153	31.4	(27.5 - 35.7)
Paralytics without sedation	19	2.6	(1.7 - 4.1)	19	3.9	(2.5 - 6.0)
Oral without sedation	349	48.3	(44.6 - 52.0)	127	26.1	(22.4 - 30.2)
Surgical	16	2.2	(1.4 - 3.6)	2	0.4	(0.1 - 1.5)
Nasal intubation	13	1.8	(1.1 - 3.1)	13	2.7	(1.6 - 4.5)
Total	723	100		487	100	

Abbreviations: CI, confidence interval

Table 3 summarizes the intubation success rates and adverse event rates. Overall, intubation was successful in the first attempt in 63.8% (95% CI, 60.2%-67.2%) and within 3 attempts in 96.0% (95% CI, 94.3%-97.2%) of all trauma patients. In non-cardiac arrest patients, intubation was successful in the first attempt in 60.2% (95% CI, 55.8%-64.4%) and within 3 attempts in 94.5%

(95% CI, 92.1%-96.2%) of patients. In cardiac arrest patients, intubation was successful in the first attempt in 71.2% (95% CI, 65.1%-76.6%) and within 3 attempts in 99.2% (95% CI, 97.0%-99.8%) of the patients. In the stratified analysis by the specialty (i.e., emergency physicians [n=434] vs. non-emergency physicians [n=289]), emergency physicians had a higher success at the first attempt (72.8 % vs. 50.2 %, p<0.001) compared to non-emergency physicians (including all transitional-year residents [n=237]). Intubation-associated adverse event rates were 10.8% (95% CI, 8.7%-13.3%) in overall trauma patients, 11.5% (95% CI, 9.0%-14.6%) in non-cardiac arrest patients, and 9.3% (95% CI, 6.2%-13.7%) in cardiac arrest patients.

At the ED-level, there was a wide variation in the methods of intubation across the 12 EDs (**Figure 2).** For example, RSI as the initial intubation method was performed in 0% to 50.9% of all trauma patients, and in 0% to 87.5% of non-cardiac arrest patients. Similarly, there was a wide variation in the success rates and adverse event rates across the EDs (**Figure 3**). The range of overall success rates for intubation in the first attempt ranged from 35.5% to 90.5%, and from 85.1% to 100% within 3 attempts. Likewise, overall adverse event rates varied widely (range, 0%-16.7%) across the EDs. These wide variations in intubation success rates and adverse event rates persisted across the non-cardiac arrest and cardiac arrest strata.

Table 3. Success rates and intubation-associated adverse events

	All trauma patients			Non-cardiac arrest patients			Cardiac arrest patients		
	n	%	95% CI	n	%	95% CI	n	%	95% CI
Successful in 1st attempt	461	63.8	(60.2 - 67.2)	293	60.2	(55.8 - 64.4)	168	71.2	(65.1 - 76.6)
Successful in ≤ 3rd attempts	694	96.0	(94.3 - 97.2)	460	94.5	(92.1 - 96.2)	234	99.2	(97.0 - 99.8)
Adverse events	78	10.8	(8.7 - 13.3)	56	11.5	(9.0 - 14.6)	22	9.3	(6.2 - 13.7)
Details of adverse events*									
Esophageal intubation	25	3.5	(2.2 - 5.1)	15	3.1	(1.7 - 5.0)	10	4.2	(2.0 - 7.7)
Mainstem bronchus intubation	18	2.5	(1.5 - 3.9)	9	1.8	(0.8 - 3.5)	9	3.8	(1.7 - 7.1)
Airway trauma	17	2.4	(1.4 – 3.7)	14	2.9	(1.6 - 4.8)	3	1.3	(0.3 - 3.7)
Hypotension†	8	1.1	(0.5 - 2.2)	8	1.6	(0.7 - 3.2)			
Vomiting	6	0.8	(0.3 - 1.8)	6	1.2	(0.5 - 2.7)			
Hypoxia‡	3	0.4	(0.1 - 1.2)	3	0.6	(0.1 - 1.8)			
Cardiac arrest	1	0.1	(0.0 - 0.8)	1	0.2	(0.0 -1.1)			

Abbreviations: CI, confidence interval

*Patients may have more than 1 adverse event.

†Hypotension was defined as systolic blood pressure less than 90 mm Hg.

‡Hypoxia was defined as pulse oximetric oxygen saturation of less than 90% during intubation attempts, not as a result of esophageal intubation.

4. DISCUSSION

In this prospective, multicenter, observational study in Japan, we observed an acceptable success rate of airway management in trauma patients in EDs. However, we also found a wide range of variation in the initial method of intubation, success rates, and adverse event rates during trauma airway management across the EDs. Indeed, the overall success rates in the first intubation attempt ranged from 35.5% to 90.5%.

We were struck by the high degree of variation in the methods of airway management in trauma cases across the 12 EDs. The reasons for the observed practice variations are unclear and are likely multifactorial. It is possible that non-RSI methods were attempted in patients who were predicted to have a difficult intubation. However, the difference in the patient population across the EDs cannot fully explain the observed three-fold difference in the use of RSI. Therefore, some of the patients might have been inappropriately considered as "difficult intubation," and intubated with non-RSI methods. Alternatively, it is also plausible that non-RSI methods were more frequently used in certain EDs because of the physicians' preference, procedural experiences, training background, or differences in ED staffing and institutional policies.

Our study also demonstrated a high degree of variations in success and adverse event rates among the EDs. Particularly, the success rate at first attempts was highly variable. To the best of our knowledge, this is the first study to demonstrate such inter-hospital variations in success and adverse event rates in trauma airway management in different EDs. The reasons for the variations among the EDs are likely multifactorial; the potential explanations include

inter-hospital differences in patient population, skills or education backgrounds of intubators,[15] drug and device availability in the ED, or any combination of these factors. Alternatively, the observed wide variation in the intubation method may have led to these variations in success and adverse event rates. Furthermore, there are no requirements for procedural credentials to perform ED intubations both in individuals and institutions in Japan.[10] This lack of procedural requirements would have contributed, at least partially, to the observed inter-hospital variations in the success rates. Indeed, we observed that intubation success rates performed by non-emergency physicians were significantly lower; this was, at least in part, explained by the intubation attempts by transitional-year residents. However, it is well documented in the literature that first-pass success is important in critically-ill patients[11]; therefore, the observed lower success rate by these non-skilled physicians cannot be justified. Our data underscore the reinforcement of Japanese methodology of training for non-skilled physicians (e.g., the use of simulators and training in a more controlled setting[16-18] to improve their intubation skill set, which will, in turn, improve patients' outcomes.

Although international and Japanese trauma care guidelines recommend the use of RSI as the initial method of emergency airway management in most trauma patients,[1 4 5] the evidence for accurately predicting patients in whom RSI should be avoided remain limited.[19 20] It is, therefore, plausible that the scarcity of evidence may have contributed to the practice variations across the EDs. Our observations should facilitate further investigation of any barriers to the delivery of safer trauma care nationally. Additionally, building more robust evidence on trauma airway management, coupled with improved dissemination of these findings, could decrease the variations in trauma care across the EDs in Japan.

Our study has several potential limitations. First, this passive surveillance of the study data is subject to self-reporting bias, leading to a possible underestimation of failed intubations and adverse events. However, active independent monitoring of ED intubations is difficult to accomplish. We did, however, use a self-reporting system with structured data forms, uniform definitions, and a high capture rate. Second, we did not design this study to measure patient outcomes, such as long-term mortality or morbidity. A more detailed analysis of adverse events and outcomes requires following the patients for a longer period. Third, we did not account for several potential confounders, such as severities (the Injury Severity Score, the Revised Trauma Score, etc.) of cases and training levels of physicians. However, this prospective multicenter data reflect the current airway management in the natural setting of a "real" population and current clinical practice, therefore enhancing the potential generalizability of the findings. Finally, all EDs in this study were designated as tertiary or academic general hospitals, and all but one of the EDs were affiliated with an emergency medicine residency program in Japan. Therefore, our inferences may not be generalizable to trauma airway management in non-academic EDs or other developed nations. These observations, however, are highly relevant from a policy standpoint. As these EDs provide advanced care for trauma victims and train the majority of emergency physicians, these EDs have a disproportionate impact on current and future trauma care in EDs.

5. CONCLUSION

In this multicenter prospective study of emergency airway management in Japan, we found an acceptable overall success rate in trauma airway management. However, we also found that the method of intubation, success rates and adverse event rates were highly variable among EDs. For

researchers, our observations should facilitate further investigations to identify the reasons of the inter-hospital variations. Additionally, for policy makers and professional organizations, our findings suggest that development and dissemination of nationwide protocols are warranted to achieve safer airway management for trauma victims in Japan.

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Author Contribution

K.H. designed the study, for which S.N. and Y.H. contributed to the data collection and analysis. S.N. wrote the manuscript, which A.K. reviewed.

Data Sharing Statement

No additional data available

References

1. American College of Surgeons CoT. *Advanced Trauma Life Support for Doctors, Student Course Manual*. 8th ed. Chicago, IL, 2008.
2. Walls RM, Brown CA, 3rd, Bair AE, et al. Emergency airway management: a multi-center report of 8937 emergency department intubations. The Journal of emergency medicine 2011;**41**(4):347-54 doi: 10.1016/j.jemermed.2010.02.024[published Online First: Epub Date]|.
3. Hussain LM, Redmond AD. Are pre-hospital deaths from accidental injury preventable? Bmj 1994;**308**(6936):1077-80 doi: 10.1136/bmj.308.6936.1077[published Online First: Epub Date]|.
4. *Japan Advanced Trauma Evaluation and Care (JATEC™) guideline*. 3rd edition ed, 2008.
5. Dunham CM, Barraco RD, Clark DE, et al. Guidelines for emergency tracheal intubation immediately after traumatic injury. The Journal of trauma 2003;**55**(1):162-79 doi: 10.1097/01.ta.0000083335.93868.2c[published Online First: Epub Date]|.
6. Graham CA. Emergency department airway management in the UK. Journal of the Royal Society of Medicine 2005;**98**(3):107-10 doi: 10.1258/jrsm.98.3.107[published Online First: Epub Date]|.
7. Sakles JC, Laurin EG, Rantapaa AA, et al. Airway management in the emergency department: a one-year study of 610 tracheal intubations. Annals of emergency medicine 1998;**31**(3):325-32 doi: 10.1016/S0196-0644(98)70342-7[published Online First: Epub Date]|.
8. Sagarin MJ, Barton ED, Chng YM, et al. Airway management by US and Canadian emergency medicine residents: a multicenter analysis of more than 6,000 endotracheal

intubation attempts. Annals of emergency medicine 2005;**46**(4):328-36 doi: 10.1016/j.annemergmed.2005.01.009[published Online First: Epub Date]|.

9. Graham CA, Beard D, Henry JM, et al. Rapid sequence intubation of trauma patients in Scotland. The Journal of trauma 2004;**56**(5):1123-6 doi: 10.1097/01.TA.0000109066.62811.8A[published Online First: Epub Date]|.
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**(4):428-33 doi: 10.1016/j.resuscitation.2011.11.027[published Online First: Epub Date]|.
11. 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. Annals of emergency medicine 2012;**60**(6):749-54 e2 doi: 10.1016/j.annemergmed.2012.04.005[published Online First: Epub Date]|.
12. Imamura T, Brown CA, 3rd, Ofuchi H, et al. Emergency airway management in geriatric and younger patients: analysis of a multicenter prospective observational study. The American journal of emergency medicine 2013;**31**(1):190-6 doi: 10.1016/j.ajem.2012.07.008[published Online First: Epub Date]|.
13. Hasegawa K, Hagiwara Y, Imamura T, et al. Increased incidence of hypotension in elderly patients who underwent emergency airway management: an analysis of a multi-centre prospective observational study. International journal of emergency medicine 2013;**6**(1):12 doi: 10.1186/1865-1380-6-12[published Online First: Epub Date]|.
14. Hospital Intelligence Agency. Secondary Hospital Intelligence Agency. http://hospia.jp/.

15. Graham CA, Beard D, Oglesby AJ, et al. Rapid sequence intubation in Scottish urban emergency departments. Emergency medicine journal : EMJ 2003;**20**(1):3-5

16. Mayo PH, Hackney JE, Mueck JT, et al. Achieving house staff competence in emergency airway management: results of a teaching program using a computerized patient simulator. Critical care medicine 2004;**32**(12):2422-7

17. Cook DA, Hatala R, Brydges R, et al. Technology-enhanced simulation for health professions education: a systematic review and meta-analysis. JAMA : the journal of the American Medical Association 2011;**306**(9):978-88 doi: 10.1001/jama.2011.1234[published Online First: Epub Date]|.

18. Bernhard M, Mohr S, Weigand MA, et al. Developing the skill of endotracheal intubation: implication for emergency medicine. Acta anaesthesiologica Scandinavica 2012;**56**(2):164-71 doi: 10.1111/j.1399-6576.2011.02547.x[published Online First: Epub Date]|.

19. Reed MJ, Dunn MJ, McKeown DW. Can an airway assessment score predict difficulty at intubation in the emergency department? Emergency medicine journal : EMJ 2005;**22**(2):99-102 doi: 10.1136/emj.2003.008771[published Online First: Epub Date]|.

20. Soyuncu S, Eken C, Cete Y, et al. Determination of difficult intubation in the ED. The American journal of emergency medicine 2009;**27**(8):905-10 doi: 10.1016/j.ajem.2008.07.003[published Online First: Epub Date]|.

Figure Legends

Figure 1. Flow chart showing inclusion of patients in this study

Figure 2. Inter-hospital variations in initial methods of intubation

Boxplots of inter-hospital variations in the initial methods of intubation. The line in the middle of the box represents the median, with the lower and upper limits of the box representing the 25th and 75th percentiles, respectively. The whiskers from the box extend to the minimum and maximum values.

Figure 3. Inter-hospital variations in success rates and adverse event rates

Boxplots of inter-hospital variations in success rates and adverse event rates. The line in the middle of the box represents the median, with the lower and upper limits of the box representing the 25th and 75th percentiles. The whiskers from the box extend to the minimum and maximum values.

Trauma airway management in emergency departments: A multicenter, prospective, observational study in Japan

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Conflict of Interest: None of the authors have any conflict of interest to declare.

Keywords: Airway management, intubation, emergency department, practice variation, rapid sequence intubation

Abstract

Objectives: Although successful airway management is essential for emergency trauma care, comprehensive studies are limited. We sought to characterize the current trauma care practice of airway management in the emergency departments (EDs) in Japan.

Design: Analysis of data from a prospective, observational, multi-center registry – the Japanese Emergency Airway Network (JEAN) registry.

Setting: 13 academic and community EDs from different geographic regions across Japan.

Participants: 723 trauma patients who underwent emergency intubation from March 2010 through August 2012.

Outcome measures: ED characteristics, patient and operator demographics, methods of airway management, intubation success or failure at each attempt, and adverse events.

Results: A total of 723 trauma patients who underwent emergency intubation were eligible for the analysis. Traumatic cardiac arrest comprised 32.6% (95% CI, 29.3%-36.1%) of patients. Rapid sequence intubation (RSI) was the initial method chosen in 23.9% (95% CI, 21.0%-27.2%) of all trauma patients, and in 35.5% (95% CI, 31.4%-39.9%) of non-cardiac arrest trauma patients. Overall, intubation was successful in ≤3 attempts in 96.0% of patients (95% CI, 94.3%-97.2%). There was a wide variation in the initial methods of intubation; RSI as the initial method was performed in 0% to 50.9% of all trauma patients among 12 EDs. Similarly, there was a wide variation in success rates and adverse event rates across the EDs. Success rates varied between 35.5% and 90.5% at the first attempt and 85.1% and 100% within 3 attempts across the 12 EDs.

Conclusion: In this multicenter prospective study in Japan, we observed a high overall success rate in airway management during trauma care. However, the methods of intubation and success rates were highly variable among hospitals.

Article summary

Article focus

This paper characterizes the current practice of airway management for trauma patients in emergency departments (EDs) in Japan by using data from the Japanese Emergency Airway Network (JEAN) Study.

Key messages

The method of intubation, success rates, and adverse event rates are highly variable among EDs. Development and dissemination of nationwide protocols are warranted to achieve safer airway management for trauma victims in Japan.

Strengths and limitations of this study

This is the first study to report disparities in trauma airway management based on multicenter, prospective data.

Passive surveillance of data is subject to self-reporting bias, leading to a possible underestimation of failed intubations and adverse events.

1. INTRODUCTION

Successful airway management is a cornerstone in the modern practice of emergency and trauma care. Failure of emergency airway management is often associated with morbidity and mortality in trauma patients.[1-3] Consequently, training in and understanding of airway management is a distinct discipline that is essential for successful trauma resuscitation.

Evidence-based recommendations for airway management during trauma care exist within international and national guidelines of the United States. These guidelines indicate rapid sequence intubation (RSI) as the initial method of emergency airway management in most trauma patients.[1 4 5] Recent studies reported that RSI is the most common airway management method in emergency departments (EDs) in North America and Europe.[6-9] Despite the ubiquitous practice of emergency airway management in trauma patients, little is known about its current practice and performance in other industrialized nations. Therefore, we sought to describe the current practice of airway management for trauma patients in the EDs in Japan.

2. METHODS

Study Design and Setting

We analyzed the data of a prospective, observational, multi-center registry, the Japanese Emergency Airway Network (JEAN) registry. The study design, setting, methods of measurement, and measured variables have been reported elsewhere.[10-13] Briefly, the registry is a consortium of 13 academic and community EDs from different geographic regions across Japan. These EDs consisted of 10 tertiary medical centers that have a capability to manage the most severe trauma patients and 3 secondary medical centers that are designated to treat moderately severe trauma patients. The participating EDs had a median ED census of 30,000 patient visits per year (range 9,000 to 67,000). **The participating hospitals had a median trauma admission of 1,000 per year (range, 300 to 1,500).[14]** All 13 EDs were staffed by attending emergency physicians, and 12 had affiliations with emergency medicine residency training programs. Each hospital maintained individual protocols, policies, and procedures for emergency airway management. Intubations were performed by attending physicians or by resident physicians at the discretion of the ED attending physician. The ethics committee of each participating center approved the protocol, with waiver of informed consent before data collection.

Patients

The registry prospectively collected information on consecutive patients who underwent airway management in the participating EDs during a 30-month period, from March 2010 to August 2012. All adult and pediatric trauma patients who underwent intubation were eligible for this

analysis. We excluded an ED in which the number of trauma intubations was less than 10 from the current analysis.

Data Collection

Data collection was passive, relying on self-reports by the intubators on duty. After each intubation, the intubators completed a standardized data sheet, including the patient's age, sex, estimated weight, primary indication for intubation, methods used to facilitate intubation, intubator's level of training (emergency physicians, resident physicians, and transitional year residents) and specialty (emergency physician or not), number of attempts, success or failure, and intubation-related adverse events. Method was defined as the set of medications and devices used, such as RSI with a Macintosh laryngoscope. Transitional-years residents were post-graduate year 1-2 physicians who rotate through the ED. An intubation attempt was defined as a single insertion of the laryngoscope (or other device) past the teeth.[2 10-13] For nasal intubations, an attempt was defined as a single insertion of a tracheal tube past the turbinates. An attempt was successful if it resulted in the tracheal tube being passed through the vocal cords. One or more methods could be used in each patient, and each method could be attempted several times.

Adverse events were recorded using a pre-specified list, with the option to include additional comments, if necessary. Adverse events were defined as cardiac arrest, hypotension, hypoxemia, dysrhythmia, vomiting, esophageal intubation, mainstem bronchial intubation, and airway trauma that are considered to be intubation-related.[11] Cardiac arrest included asystole, bradycardia, or dysrhythmia with nonmeasurable blood pressure and cardiopulmonary

resuscitation during or after intubation. Hypotension was defined as systolic blood pressure less than 90 mm Hg. Hypoxemia was defined as pulse oximetric saturation less than 90% during an intubation attempt, not a result of esophageal intubation. Preexisting hypotension or hypoxemia before an intubation attempt were not counted as an adverse event. Esophageal intubation was defined as misplacement of the endotracheal tube in the upper esophagus or hypopharynx, with a lapse of time and desaturation (pulse oximetric saturation <90%) before the removal of the misplaced tube. We monitored compliance with data form completion by reviewing professional billing records. Where the data collection form was missing, the intubator was interviewed by one of the investigators within 2 weeks of the patient encounter, to fill out the data form.

The outcomes of interest were the primary indication for intubation, initial method used for intubation, intubation success rates (on the first attempt and within three attempts), and intubation-related adverse event rates.

Statistical Analysis

We performed all analysis with JMP 10 software (SAS Institute Inc., Cary, NC, USA). At the patient-level, we described patient demographics, the primary indication for intubation, initial method of intubation, success rates, and adverse event rates as proportions with 95% confidence intervals (CIs) and medians with interquartile ranges (IQR). Then, at the ED-level, we described medians, IQR and ranges for each outcome for all trauma patients. We also repeated the analysis after stratifying by indication (non-cardiac arrest vs. cardiac arrest) and specialty (emergency physicians vs. non-emergency physicians). All *P*-values were two-tailed, with $P<0.05$ considered statistically significant.

3. RESULTS

During the 30-month study period, 4,268 patients required emergency airway management. Of these, the registry recorded 4,094 intubations (capture rate, 95.9%; **Figure 1**), of which 3370 patients who underwent airway management for medical reasons were excluded from the analysis. One of the 13 hospitals, in whom only 1 trauma patient required airway intervention during the study period, was excluded because the number of intubations for trauma care was less than 10 during the study period. Hence, 723 trauma patients were eligible for analysis. Emergency physicians, including emergency medicine residents, performed the first intubation attempts in 60.0% (95% CI, 56.4%-63.5%) of all trauma patients and 66.7% (95% CI, 62.4%-70.8%) of non-cardiac arrest patients. Transitional-year residents (postgraduate years 1 and 2) performed the first intubation attempts in 31.4% (95% CI, 28.1%-34.9%) of all trauma patients and 25.7% (95% CI, 22.0%-29.7%) of non-cardiac arrest patients.

Table 1 shows the baseline characteristics and primary indications in patients who required trauma airway management. Median age was 56 years; two-thirds of the patients were male. Traumatic cardiac arrest was the reason for intubation in 32.6% (95% CI, 29.3%-36.1%) of all trauma patients, while head trauma accounted for 30.4% (95% CI, 27.2%-33.9%). **Table 2** shows the initial method of airway management in the trauma patients. RSI was the initial method chosen in 23.9% (95% CI, 21.0%-27.2%) of all trauma patients and 35.5% (95% CI, 31.4%-39.9%) of non-cardiac arrest patients. Cricothyrotomy was performed as the initial airway management strategy in 2.2% (95% CI, 1.4%-3.6%) of all trauma patients and 0.4% (95% CI, 0.1%-1.5%) of non-cardiac arrest patients. The direct laryngoscope was used in most of intubations (n=654, 90.5%), and the remaining were intubated using a video laryngoscope (n=30,

4.1%), a bronchoscope (n=17, 2.4%), a lighted stylet (n=1, 0.1%) on the first attempt.

Table 1. Characteristics of the 723 trauma patients who required intubation

Patient characteristics		
Age (y), median, (IQR)	56	(34 - 73)
Male, % (95% CI)	66.9	(63.4 - 70.3)
Estimated weight (kg), median, (IQR)	60	(50 - 70)
Indication for intubation, % (95% CI)		
Cardiac arrest	32.6	(29.3 - 36.1)
Head trauma	30.4	(27.2 - 33.9)
Shock	16.6	(14.1 - 19.5)
Facial/Neck trauma	8.4	(6.6 - 10.7)
Airway burn	6.8	(5.2 - 8.8)
Others	5.1	(3.3 - 8.0)

Abbreviations: CI, confidence interval; IQR, interquartile range

Table 2. Initial method of intubation

	All trauma patients			Non-cardiac arrest patients		
	n	%	95% CI	n	%	95% CI
Rapid sequence intubation	173	23.9	(21.0 - 27.2)	173	35.5	(31.4 - 39.9)
Sedation without paralysis	153	21.2	(18.3 - 24.3)	153	31.4	(27.5 - 35.7)
Paralytics without sedation	19	2.6	(1.7 - 4.1)	19	3.9	(2.5 - 6.0)
Oral without sedation	349	48.3	(44.6 - 52.0)	127	26.1	(22.4 - 30.2)
Surgical	16	2.2	(1.4 - 3.6)	2	0.4	(0.1 - 1.5)
Nasal intubation	13	1.8	(1.1 - 3.1)	13	2.7	(1.6 - 4.5)
Total	723	100		487	100	

Abbreviations: CI, confidence interval

Table 3 summarizes the intubation success rates and adverse event rates. Overall, intubation was successful in the first attempt in 63.8% (95% CI, 60.2%-67.2%) and within 3 attempts in 96.0% (95% CI, 94.3%-97.2%) of all trauma patients. In non-cardiac arrest patients, intubation was successful in the first attempt in 60.2% (95% CI, 55.8%-64.4%) and within 3 attempts in 94.5%

(95% CI, 92.1%-96.2%) of patients. In cardiac arrest patients, intubation was successful in the first attempt in 71.2% (95% CI, 65.1%-76.6%) and within 3 attempts in 99.2% (95% CI, 97.0%-99.8%) of the patients. In the stratified analysis by the specialty (i.e., emergency physicians [n=434] vs. non-emergency physicians [n=289]), emergency physicians had a higher success at the first attempt (72.8 % vs. 50.2 %, p<0.001) compared to non-emergency physicians (including all transitional-year residents [n=237]). Intubation-associated adverse event rates were 10.8% (95% CI, 8.7%-13.3%) in overall trauma patients, 11.5% (95% CI, 9.0%-14.6%) in non-cardiac arrest patients, and 9.3% (95% CI, 6.2%-13.7%) in cardiac arrest patients.

At the ED-level, there was a wide variation in the methods of intubation across the 12 EDs (**Figure 2).** For example, RSI as the initial intubation method was performed in 0% to 50.9% of all trauma patients, and in 0% to 87.5% of non-cardiac arrest patients. Similarly, there was a wide variation in the success rates and adverse event rates across the EDs (**Figure 3**). The range of overall success rates for intubation in the first attempt ranged from 35.5% to 90.5%, and from 85.1% to 100% within 3 attempts. Likewise, overall adverse event rates varied widely (range, 0%-16.7%) across the EDs. These wide variations in intubation success rates and adverse event rates persisted across the non-cardiac arrest and cardiac arrest strata.

Table 3. Success rates and intubation-associated adverse events

	All trauma patients			Non-cardiac arrest patients			Cardiac arrest patients		
	n	%	95% CI	n	%	95% CI	n	%	95% CI
Successful in 1st attempt	461	63.8	(60.2 - 67.2)	293	60.2	(55.8 - 64.4)	168	71.2	(65.1 - 76.6)
Successful in ≤ 3rd attempts	694	96.0	(94.3 - 97.2)	460	94.5	(92.1 - 96.2)	234	99.2	(97.0 - 99.8)
Adverse events	78	10.8	(8.7 - 13.3)	56	11.5	(9.0 - 14.6)	22	9.3	(6.2 - 13.7)
Details of adverse events*									
Esophageal intubation	25	3.5	(2.2 - 5.1)	15	3.1	(1.7 - 5.0)	10	4.2	(2.0 - 7.7)
Mainstem bronchus intubation	18	2.5	(1.5 - 3.9)	9	1.8	(0.8 - 3.5)	9	3.8	(1.7 - 7.1)
Airway trauma	17	2.4	(1.4 – 3.7)	14	2.9	(1.6 - 4.8)	3	1.3	(0.3 - 3.7)
Hypotension†	8	1.1	(0.5 - 2.2)	8	1.6	(0.7 - 3.2)			
Vomiting	6	0.8	(0.3 - 1.8)	6	1.2	(0.5 - 2.7)			
Hypoxia‡	3	0.4	(0.1 - 1.2)	3	0.6	(0.1 - 1.8)			
Cardiac arrest	1	0.1	(0.0 - 0.8)	1	0.2	(0.0 -1.1)			

Abbreviations: CI, confidence interval

*Patients may have more than 1 adverse event.

†Hypotension was defined as systolic blood pressure less than 90 mm Hg.

‡Hypoxia was defined as pulse oximetric oxygen saturation of less than 90% during intubation attempts, not as a result of esophageal intubation.

4. DISCUSSION

In this prospective, multicenter, observational study in Japan, we observed an acceptable success rate of airway management in trauma patients in EDs. However, we also found a wide range of variation in the initial method of intubation, success rates, and adverse event rates during trauma airway management across the EDs. Indeed, the overall success rates in the first intubation attempt ranged from 35.5% to 90.5%.

We were struck by the high degree of variation in the methods of airway management in trauma cases across the 12 EDs. The reasons for the observed practice variations are unclear and are likely multifactorial. It is possible that non-RSI methods were attempted in patients who were predicted to have a difficult intubation. However, the difference in the patient population across the EDs cannot fully explain the observed three-fold difference in the use of RSI. Therefore, some of the patients might have been inappropriately considered as "difficult intubation," and intubated with non-RSI methods. Alternatively, it is also plausible that non-RSI methods were more frequently used in certain EDs because of the physicians' preference, procedural experiences, training background, or differences in ED staffing and institutional policies.

Our study also demonstrated a high degree of variations in success and adverse event rates among the EDs. Particularly, the success rate at first attempts was highly variable. To the best of our knowledge, this is the first study to demonstrate such inter-hospital variations in success and adverse event rates in trauma airway management in different EDs. The reasons for the variations among the EDs are likely multifactorial; the potential explanations include

inter-hospital differences in patient population, skills or education backgrounds of intubators,[15] drug and device availability in the ED, or any combination of these factors. Alternatively, the observed wide variation in the intubation method may have led to these variations in success and adverse event rates. Furthermore, there are no requirements for procedural credentials to perform ED intubations both in individuals and institutions in Japan.[10] This lack of procedural requirements would have contributed, at least partially, to the observed inter-hospital variations in the success rates. Indeed, we observed that intubation success rates performed by non-emergency physicians were significantly lower; this was, at least in part, explained by the intubation attempts by transitional-year residents. However, it is well documented in the literature that first-pass success is important in critically-ill patients[11]; therefore, the observed lower success rate by these non-skilled physicians cannot be justified. Our data underscore the reinforcement of Japanese methodology of training for non-skilled physicians (e.g., the use of simulators and training in a more controlled setting[16-18] to improve their intubation skill set, which will, in turn, improve patients' outcomes.

Although international and Japanese trauma care guidelines recommend the use of RSI as the initial method of emergency airway management in most trauma patients,[1 4 5] the evidence for accurately predicting patients in whom RSI should be avoided remain limited.[19 20] It is, therefore, plausible that the scarcity of evidence may have contributed to the practice variations across the EDs. Our observations should facilitate further investigation of any barriers to the delivery of safer trauma care nationally. Additionally, building more robust evidence on trauma airway management, coupled with improved dissemination of these findings, could decrease the variations in trauma care across the EDs in Japan.

Our study has several potential limitations. First, this passive surveillance of the study data is subject to self-reporting bias, leading to a possible underestimation of failed intubations and adverse events. However, active independent monitoring of ED intubations is difficult to accomplish. We did, however, use a self-reporting system with structured data forms, uniform definitions, and a high capture rate. Second, we did not design this study to measure patient outcomes, such as long-term mortality or morbidity. A more detailed analysis of adverse events and outcomes requires following the patients for a longer period. Third, we did not account for several potential confounders, such as severities (the Injury Severity Score, the Revised Trauma Score, etc.) of cases and training levels of physicians. However, this prospective multicenter data reflect the current airway management in the natural setting of a "real" population and current clinical practice, therefore enhancing the potential generalizability of the findings. Finally, all EDs in this study were designated as tertiary or academic general hospitals, and all but one of the EDs were affiliated with an emergency medicine residency program in Japan. Therefore, our inferences may not be generalizable to trauma airway management in non-academic EDs or other developed nations. These observations, however, are highly relevant from a policy standpoint. As these EDs provide advanced care for trauma victims and train the majority of emergency physicians, these EDs have a disproportionate impact on current and future trauma care in EDs.

5. CONCLUSION

In this multicenter prospective study of emergency airway management in Japan, we found an acceptable overall success rate in trauma airway management. However, we also found that the method of intubation, success rates and adverse event rates were highly variable among EDs. For

researchers, our observations should facilitate further investigations to identify the reasons of the inter-hospital variations. Additionally, for policy makers and professional organizations, our findings suggest that development and dissemination of nationwide protocols are warranted to achieve safer airway management for trauma victims in Japan.

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Author Contribution

K.H. designed the study, for which S.N. and Y.H. contributed to the data collection and analysis. S.N. wrote the manuscript, which A.K. reviewed.

Data Sharing Statement

No additional data available

References

1. American College of Surgeons CoT. *Advanced Trauma Life Support for Doctors, Student Course Manual*. 8th ed. Chicago, IL, 2008.
2. Walls RM, Brown CA, 3rd, Bair AE, et al. Emergency airway management: a multi-center report of 8937 emergency department intubations. The Journal of emergency medicine 2011;41:347-54 doi: 10.1016/j.jemermed.2010.02.024.
3. Hussain LM, Redmond AD. Are pre-hospital deaths from accidental injury preventable? Bmj 1994;308:1077-80 doi: 10.1136/bmj.308.6936.1077.
4. *Japan Advanced Trauma Evaluation and Care (JATEC™) guideline*. 3rd edition ed, 2008.
5. Dunham CM, Barraco RD, Clark DE, et al. Guidelines for emergency tracheal intubation immediately after traumatic injury. The Journal of trauma 2003;55:162-79 doi: 10.1097/01.ta.0000083335.93868.2c.
6. Graham CA. Emergency department airway management in the UK. Journal of the Royal Society of Medicine 2005;98:107-10 doi: 10.1258/jrsm.98.3.107.
7. Sakles JC, Laurin EG, Rantapaa AA, et al. Airway management in the emergency department: a one-year study of 610 tracheal intubations. Annals of emergency medicine 1998;31:325-32 doi: 10.1016/S0196-0644(98)70342-7.
8. Sagarin MJ, Barton ED, Chng YM, et al. Airway management by US and Canadian emergency medicine residents: a multicenter analysis of more than 6,000 endotracheal intubation attempts. Annals of emergency medicine 2005;46:328-36 doi: 10.1016/j.annemergmed.2005.01.009.
9. Graham CA, Beard D, Henry JM, et al. Rapid sequence intubation of trauma patients in Scotland. The Journal of trauma 2004;56:1123-6 doi:

10.1097/01.TA.0000109066.62811.8A.

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 doi: 10.1016/j.resuscitation.2011.11.027.

11. 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. Annals of emergency medicine 2012;60:749-54 e2 doi: 10.1016/j.annemergmed.2012.04.005.

12. Imamura T, Brown CA, 3rd, Ofuchi H, et al. Emergency airway management in geriatric and younger patients: analysis of a multicenter prospective observational study. The American journal of emergency medicine 2013;31:190-6 doi: 10.1016/j.ajem.2012.07.008.

13. Hasegawa K, Hagiwara Y, Imamura T, et al. Increased incidence of hypotension in elderly patients who underwent emergency airway management: an analysis of a multi-centre prospective observational study. International journal of emergency medicine 2013;6:12 doi: 10.1186/1865-1380-6-12.

14. Hospital Intelligence Agency. DPC statistics. http://hospia.jp/ (accessed 8 Dec 2014)

15. Graham CA, Beard D, Oglesby AJ, et al. Rapid sequence intubation in Scottish urban emergency departments. Emergency medicine journal : EMJ 2003;20:3-5

16. Mayo PH, Hackney JE, Mueck JT, et al. Achieving house staff competence in emergency airway management: results of a teaching program using a computerized patient simulator. Critical care medicine 2004;32:2422-7

17. Cook DA, Hatala R, Brydges R, et al. Technology-enhanced simulation for health

professions education: a systematic review and meta-analysis. JAMA : the journal of the American Medical Association 2011;306:978-88 doi: 10.1001/jama.2011.1234.

18. Bernhard M, Mohr S, Weigand MA, et al. Developing the skill of endotracheal intubation: implication for emergency medicine. Acta anaesthesiologica Scandinavica 2012;56:164-71 doi: 10.1111/j.1399-6576.2011.02547.x.

19. Reed MJ, Dunn MJ, McKeown DW. Can an airway assessment score predict difficulty at intubation in the emergency department? Emergency medicine journal : EMJ 2005;22:99-102 doi: 10.1136/emj.2003.008771.

20. Soyuncu S, Eken C, Cete Y, et al. Determination of difficult intubation in the ED. The American journal of emergency medicine 2009;27:905-10 doi: 10.1016/j.ajem.2008.07.003.

Figure Legends

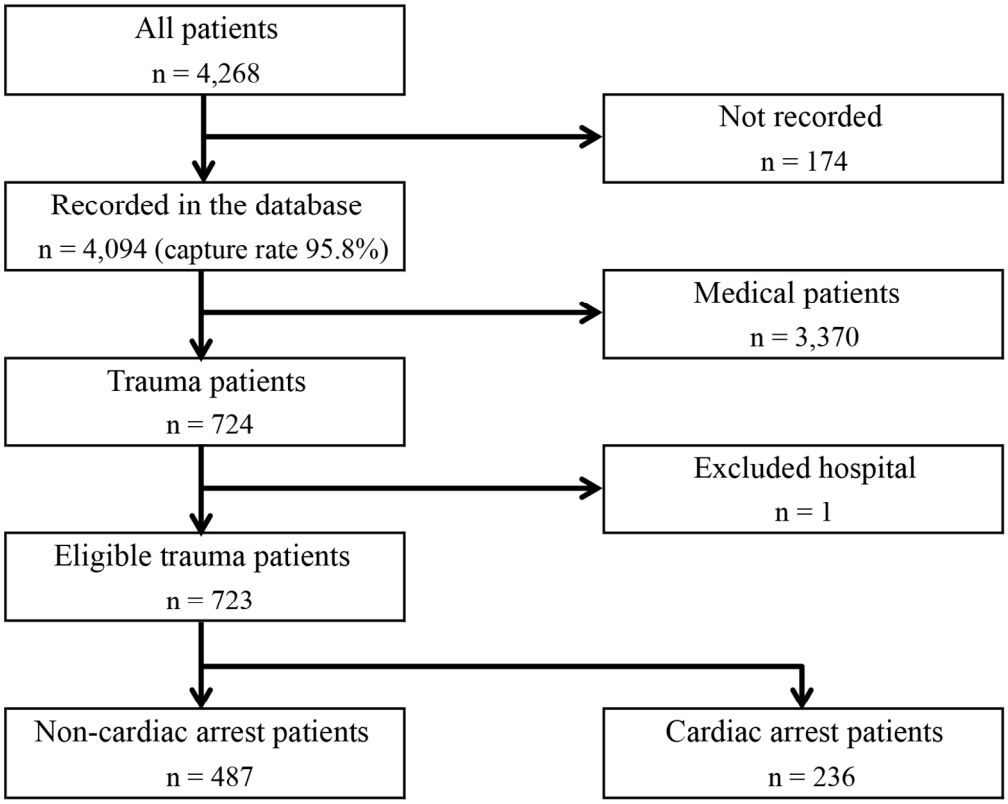
Figure 1. Flow chart showing inclusion of patients in this study

Figure 2. Inter-hospital variations in initial methods of intubation

Boxplots of inter-hospital variations in the initial methods of intubation. The line in the middle of the box represents the median, with the lower and upper limits of the box representing the 25th and 75th percentiles, respectively. The whiskers from the box extend to the minimum and maximum values.

Figure 3. Inter-hospital variations in success rates and adverse event rates

Boxplots of inter-hospital variations in success rates and adverse event rates. The line in the middle of the box represents the median, with the lower and upper limits of the box representing the 25th and 75th percentiles. The whiskers from the box extend to the minimum and maximum values.



Flow chart showing inclusion of patients in this study

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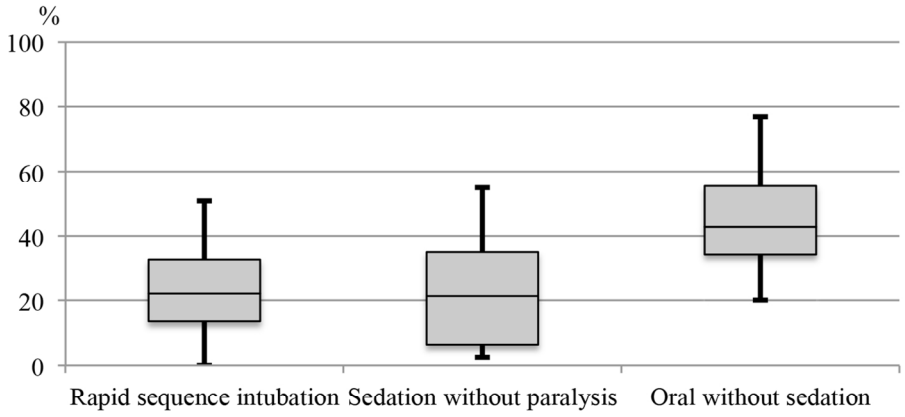
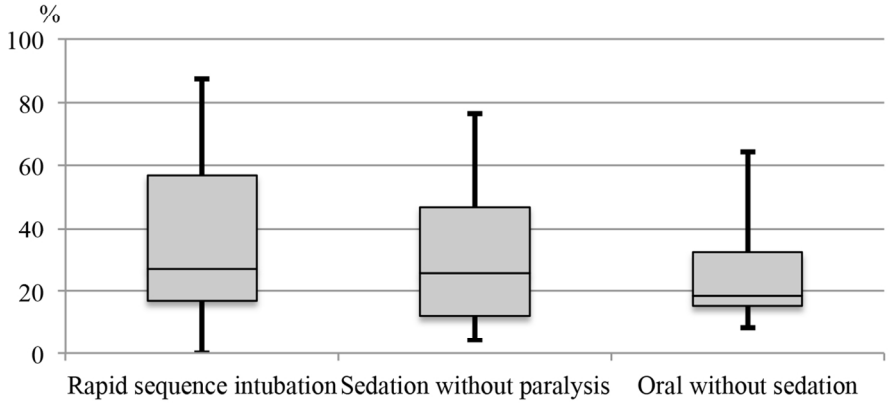
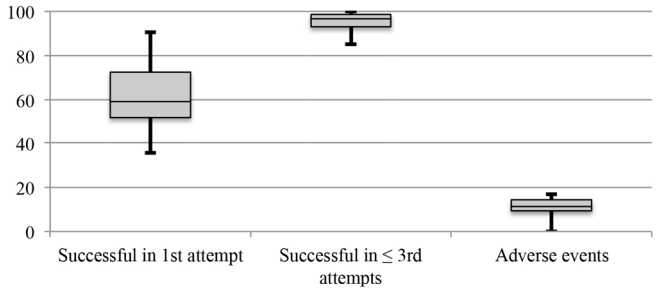


a. Among all trauma patients

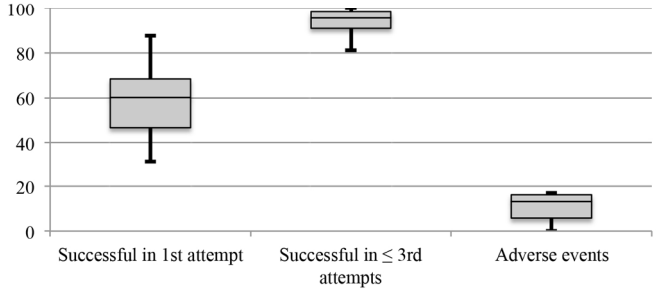


b. Among non-cardiac arrest patients

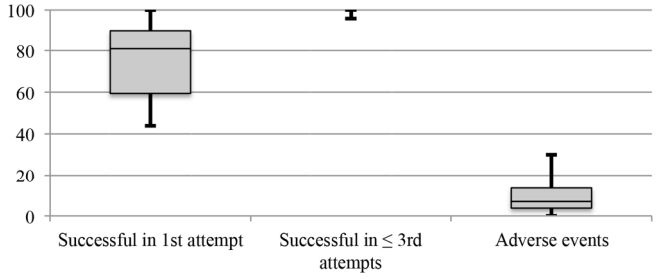
Inter-hospital variations in initial methods of intubation
Boxplots of inter-hospital variations in the initial methods of intubation. The line in the middle of the box represents the median, with the lower and upper limits of the box representing the 25th and 75th percentiles, respectively. The whiskers from the box extend to the minimum and maximum values.
140x165mm (300 x 300 DPI)



a. Among all trauma patients



b. Among non-cardiac arrest patients



c. Among cardiac arrest patients

Inter-hospital variations in success rates and adverse event rates
Boxplots of inter-hospital variations in success rates and adverse event rates. The line in the middle of the box represents the median, with the lower and upper limits of the box representing the 25th and 75th percentiles. The whiskers from the box extend to the minimum and maximum values.
137x233mm (300 x 300 DPI)