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Clinical paper

Emergency airway management in Japan: Interim analysis of a multi-center prospective observational study☆,☆☆

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ABSTRACT

Objectives: Emergency medicine is increasingly recognized as a medical specialty in Japan. However, comprehensive studies evaluating emergency airway management practice are lacking. We describe emergency department (ED) airway management using a large multi-center registry.
Methods: We formed the Japanese Emergency Airway Network, a consortium of 10 academic and community medical centers in Japan, and prospectively collected data on ED intubations from April 2010 to February 2011. All patients undergoing emergency intubation were eligible for inclusion. Data were entered in real time by the intubator using a standardized data form. Variables included patient's age, sex, weight, indication for intubation, methods of intubation, drugs, level of training and specialty of the intubator, number of attempts, success or failure, and adverse events. We present descriptive data as proportions with 95% confidence intervals.
Results: We recorded 1486 intubations (compliance rate 99%). Intubation was ultimately successful in 99.7%. The initial method of intubation varied substantially among the hospitals, including rapid sequence intubation (0–79%), sedation without paralysis (4–88%), paralysis without sedation (0–18%), and oral without medication (12–67%), in non-cardiac arrest encounters. Success rates in first and ≤3 attempts ranged from 40 to 83% and from 74 to 100%, respectively. The overall adverse event rate was 11%, without significant difference by the method used.
Conclusions: In this multi-center study characterizing ED airway management across Japan, we observed a high overall success rate but a high degree of variation among hospitals in the methods of intubation and success rates.

1. Introduction

Airway management by emergency physicians is becoming more common in Japan as the specialty continues to grow yet little is known about intubation practices in this country. One study suggests that emergency physicians in Japan still resist the administration of rapid sequence intubation drugs,[1] although it is accepted practice in emergency physicians in North America.[2–7] Several previous smaller studies in Japan have reported intubation methods and success rates within single institutions, but comprehensive large multi-center studies are lacking.[8–10]

Although intubation is frequently performed in EDs in Japan, only limited data describe the patients, techniques or providers involved in these procedures. Surveillance of critical emergency procedures is essential for reasons of policy, training, and clinical practice development. Our goal was to describe emergency intubation indications, methods used for intubation, devices and medication regimens used, operator characteristics, success rates by method and by encounter, and adverse event rates using a multi-center registry model in Japan.

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2. Methods

2.1. Study design

This was a prospective observational multi-center data registry, with all data collection planned a priori. The Institutional Review Board of each participating center approved the protocol with waiver of informed consent prior to data collection.

2.2. Study setting

Data in this analysis were obtained in the Japanese Emergency Airway Network (JEAN). JEAN was initiated in April 2010 as a consortium of 10 academic and community medical centers from different geographic regions across Japan (Appendices A and B).

All ten emergency departments were staffed by emergency attending physicians, and nine had affiliations with emergency medicine residency training programs. Non-emergency medicine resident physicians also rotated through all of these departments and participated in intubations. The participating institutions were certified as Level I ($n = 9$) or Level II equivalent ($n = 1$) trauma centers. They had an average ED census of [illegible]7,000 patient visits per year (range 9000–42,000); the population of the 10 respective cities ranged from 21,000 to 13 million habitants. Paediatric patients were treated in all of these departments. Each hospital maintained individual protocols about the policy and procedures for ED airway management. Intubations were performed by attending physicians, or by resident physicians at the discretion of attending physicians.

2.3. Selection of participants

Data were gathered prospectively during an 11-month period (April 2010 to February 2011). All patients who presented to one of these institutions and underwent emergency tracheal intubation were eligible for inclusion.

2.4. Data collection and processing

Case ascertainment was passive, relying on self-report by intubators on duty in the ED. We monitored compliance continuously. To verify that all intubations performed in the ED during the study period were captured in our database, the professional billing codes were cross-referenced with the intubation data forms. When a patient who underwent an intubation but for whom we had received no data collection form was identified, the intubator was interviewed by one of the investigators to fill out the data form. After each intubation, the intubator completed a standardized form that included the patient's age, sex, weight, indication for intubation, methods of intubation, names and dosages of all medications used to facilitate intubation, operator level of training and specialty, number of attempts, success or failure, and adverse events. Adverse event variables were recorded using a pre-specified list, with free comments if necessary.

We described each encounter by "method" and number of "attempts". We defined a "method" as a single set of medications or devices, such as rapid sequence intubation with a Macintosh laryngoscope.[2] An oral "attempt" was defined as a single insertion of the laryngoscope (or other device) past the teeth. For nasal intubations, an attempt was defined as a single insertion of an endotracheal tube past the turbinates. An attempt was successful if it resulted in an endotracheal tube being placed through the vocal cords.[2] Each encounter could have one or more methods, and each method could have one or more attempts. This allowed us to track different methods in sequence.

Table 1
Principal indication for intubation.

	n	% of total
Medical encounters		
Cardiac arrest	502	33.8%
Airway obstruction	33	2.2%
Respiratory failure	198	13.3%
Asthma	9	0.6%
Shock	117	7.9%
Altered mental status	344	23.1%
Others	5	0.3%
Subtotal	1208	81.3%
Trauma encounters		
Traumatic arrest	110	7.4%
Burn/inhalation	16	1.1%
Facial/neck trauma	25	1.7%
Shock	53	3.6%
Head trauma	64	4.3%
Others	10	0.7%
Subtotal	278	18.7%
Total	1486	100%

2.5. Measurements

We report information about the distribution of:

1. Intubators' specialties.
2. Indications for intubation.
3. Methods used to intubate, including devices and medication regimens.
4. Success rate of intubation by method.
5. Adverse event rates.

We planned to report methods and success rates subdivided by three indications for intubations: medical cardiac arrest, medical non-cardiac arrest, and trauma.

2.6. Data analysis

We analyzed the compiled data with simple descriptive statistics with 95% confidence intervals (95% CIs). We described the ranges, interquartile ranges and medians among sites for the proportions of the methods of ED intubations, for the success rates and adverse event rates in non-cardiac arrest encounters. Odds ratio (OR) is reported with 95% CI and *P*-value via chi-squared testing; *P*-values < 0.05 were considered significant. We performed all analyses with Stata statistical software (version SE/11.0, StataCorp, College Station, TX).

3. Results

During the 11-month pilot period, there were 1490 encounters requiring emergency airway management. Among these, the database recorded 1486 intubations (compliance rate 99.7%). Emergency physicians (including emergency medicine trainees) performed 45.1% of first attempts and transitional year residents (post graduate years 1 and 2) performed 37.5%. Approximately 17% of first attempts were performed by providers of other specialties. Table 1 shows the primary indications for intubation. The intubation was performed for medical emergencies in 1208 encounters (81.3%) and for trauma in 278 (18.7%); 612 patients (41.2%) were in cardiac arrest.

Table 2 shows the initial method of airway management in the subjects. Rapid sequence intubation was the initial method chosen in 303 (20.4%) of the 1486 intubations. Induction agents or sedatives, without neuromuscular blockade, were chosen in 267 encounters (18.0%). Neuromuscular blockade without sedatives

Table 2
Initial method of airway management.

Initial method	All encounters n (%)	Medical encounters n (%)	Trauma encounters n (%)
Rapid sequence intubation	303 (20.4%)	236 (19.5%)	67 (24.1%)
Sedation without paralysis	267 (18.0%)	215 (17.8%)	52 (18.7%)
Paralysis without sedation	43 (2.9%)	39 (3.2%)	4 (1.4%)
Oral without medication	857 (57.7%)	707 (58.5%)	150 (54.0%)
Surgical cricothyrotomy	7 (0.5%)	3 (0.2%)	4 (1.4%)
Nasotracheal intubation	9 (0.6%)	8 (0.7%)	1 (0.4%)
Total	1486	1208	278

Table 3
Variation in proportion of initial method, success rate, and adverse event rate in non-cardiac arrest encounters at the 10 participating hospitals.

Hospital site[a]	Patients n	Proportion of initial method				Success rate		Adverse event rate
		Rapid sequence intubation	Sedation without paralysis	Paralysis without sedation	Oral without medication	Successful on 1st attempt	Successful in ≤3 attempts	
1	194	2 (1.0%)	126 (65.0%)	0 (0%)	61 (31.4%)	134 (69.1%)	188 (97.0%)	24 (12.4%)
2	157	99 (63.1%)	14 (8.9%)	24 (15.3%)	19 (12.1%)	105 (66.9%)	151 (96.2%)	22 (14.0%)
3	116	92 (79.3%)	4 (3.5%)	0 (0%)	20 (17.2%)	96 (82.8%)	115 (99.1%)	18 (15.5%)
4	108	33 (30.6%)	32 (29.6%)	2 (1.9%)	39 (36.1%)	72 (66.7%)	102 (94.4%)	15 (13.9%)
5	106	1 (1.0%)	31 (29.2%)	0 (0%)	71 (67.0%)	66 (62.3%)	106 (100%)	21 (19.8%)
6	80	42 (52.5%)	12 (15.0%)	14 (17.5%)	12 (15.0%)	57 (71.3%)	80 (100%)	7 (8.6%)
7	43	4 (9.3%)	20 (46.5%)	0 (0%)	19 (44.2%)	17 (39.5%)	32 (74.4%)	15 (34.9%)
8	39	23 (59.0%)	10 (25.6%)	1 (2.6%)	5 (12.8%)	26 (66.7%)	39 (100%)	5 (12.8%)
9	17	0 (0%)	15 (88.2%)	0 (0%)	2 (11.8%)	8 (47.1%)	16 (94.1%)	3 (17.7%)
10	14	7 (50%)	3 (21.4%)	0 (0%)	3 (21.4%)	7 (50%)	13 (92.9%)	0 (0%)
Median (%)		40.3%	27.4%	0%	19.3%	66.7%	96.5%	14.0%
Interhospital range (%)[b]		0–79.3%	3.5–88.2%	0–17.5%	11.8–67.0%	39.5–82.8%	74.4–100%	0–34.9%

[a] Names of hospital were blinded.
[b] Range from lowest to highest proportion and success rate among hospitals.

was chosen in 43 encounters (2.9%). Oral intubation without any medications was used in 857 encounters (57.7%). Nasal intubations were reported in 9 encounters (0.6%). Surgical cricothyrotomy was the initial method in 7 encounters (0.5%) among all of the cases and in 4 encounters (1.4%) among the trauma cases.

Table 3 displays the proportions of non-cardiac arrest encounters managed by various intubation methods and show a wide range in proportions among the hospitals for almost all methods. Most notably, the proportions of encounters managed with rapid sequence intubation ranged from a low of 0% at one hospital to a high of 79.3% at another hospital (median 40.3%; interquartile range [IQR] 1.0–59.0%). Similarly, the proportion of sedation without paralysis varied from 3.5% to 88.2% of encounters per hospital (median 27.4%; IQR 15.0–46.5%), and the proportion of oral intubation without medication ranged from 11.8% to 67.0% of encounters per hospital (median 19.3%; IQR 12.8–36.1%).

Neuromuscular blockade without sedation was performed at 4 hospitals. The primary indications of those 43 encounters included overdose in 12 cases (27.9%), trauma in 5 cases (11.6%), cardiac arrest in 4 cases (9.3%), and others in 22 cases (51.2%). In non-cardiac arrest encounters, the proportion of cases managed by neuromuscular blockade alone ranged from 0% at 8 hospitals to 17.5% at one hospital. The mean Glasgow Coma Scale (GCS) of those patients was 4.5 (range 3–11).

The first method chosen was successful on the first attempt in 70.8% (95% CI 68.4–73.1%; Table 4) and in ≤3 attempts in 97.1% (95% CI 96.1–97.8%) of all encounters. The success rate on the first attempt of rapid sequence intubation was higher than that of sedation alone in all encounters (77.6% vs. 60.7%, 95% CI for difference [9.0–24.7%]; $P < 0.001$). By the first method of intubation, the success rate in ≤3 attempts was 97.0% for medical (95% CI 95.9–97.8%) and 97.4% for trauma encounters (95% CI 94.9–98.8%). Including all methods, intubation was ultimately successful in 1482 (99.7%; 95% CI 99.3–99.9%) of all encounters. The outcome of the remaining four encounters was recorded: two patients died due to cessation of resuscitative efforts, attempts failed in one paediatric patient by a paediatric attending physician in the ED, and an attempt failed in one patient by a resident physician, resulting in an oesophageal intubation and death.

Table 4
Success for initial method.

Initial method	All encounters		Medical cardiac arrest encounters		Medical non-cardiac arrest encounters		Trauma encounters	
	Successful on 1st attempt n (%)	Successful in ≤3 attempts n (%)	Successful on 1st attempt n (%)	Successful in ≤3 attempts n (%)	Successful on 1st attempt n (%)	Successful in ≤3 attempts n (%)	Successful on 1st attempt n (%)	Successful in ≤3 attempts n (%)
Rapid sequence intubation	235 (77.6%)	298 (98.3%)	0 (0%)	0 (0%)	185 (78.4%)	233 (98.7%)	50 (74.6%)	65 (97.0%)
Sedation without paralysis	162 (60.7%)	255 (95.5%)	0 (0%)	0 (0%)	130 (60.5%)	205 (95.3%)	32 (61.5%)	50 (96.2%)
Paralysis without sedation	27 (62.8%)	41 (95.3%)	1 (50%)	2 (100%)	22 (59.5%)	35 (94.6%)	4 (100%)	4 (100%)
Oral without medication	617 (72.0%)	833 (97,2%)	393 (76.8%)	501 (97.9%)	134 (64.1%)	199 (95.3%)	90 (66.2%)	133 (97.8%)
Surgical cricothyrotomy	7 (100%)	7 (100%)	2 (100%)	2 (100%)	1 (100%)	1 (100%)	4 (100%)	4 (100%)
Nasotracheal intubation	4 (44.4%)	9 (100%)	0 (0%)	0 (0%)	3 (38%)	8 (100%)	1 (100%)	1 (100%)
Total	1052 (70.8%)	1443 (97.1%)	396 (76.7%)	505 (97.9%)	475 (67.3%)	681 (96.5%)	181 (68.6%)	257 (97.4%)

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Table 5
Adverse events by method of intubation.[a]

	Complications in RSI		Complications in intubations with non-RSI		Complications in all methods	
	n	%	*n*	%	*n*	%
Vomiting	2	0.7%	10	0.9%	12	0.8%
Airway trauma	0	0%	1	0.1%	1	0.1%
Dental trauma	2	0.7%	14	1.2%	16	1.1%
Mainstem bronchus intubation	6	2.0%	24	2.1%	30	2.0%
Oesophageal intubation with delayed recognition[b]	10	3.3%	47	4.0%	57	3.9%
Dysrhythmia	1	0.3%	1	0.1%	2	0.1%
Hypotension[c]	12	4.0%	10	0.9%	22	1.5%
Cardiac arrest	2	0.7%	0	0%	2	0.1%
Death	0	0%	1	0.1%	1	0.1%
Other	7	2.3%	24	2.1%	31	2.1%
Total	40	13.2%	129	11.1%	169	11.5%

[a] Patients my have had more than 1 adverse event.
[b] Unrecognized oesophageal intubation with a lapse of time and clinical deterioration (such as oxygen saturation <90%).
[c] Systolic blood pressure <90 mmHg.

There was a wide range in the success rate in non-cardiac arrest encounters among the hospitals (Table 3). The success rate in the first attempt ranged 2-fold, from a low of 39.5% to a high of 82.8% (median 66.7%; IQR 62.3–66.9%); the success rate in ≤3 attempts ranged from 74.4% to 100% (median 96.5%; IQR 94.4–99.1%).

Table 5 lists intubation-associated adverse events by the method (rapid sequence intubation vs. non-rapid sequence intubation). The common adverse events by method included hypotension in 12 cases (4.0%) and oesophageal intubation with delayed recognition in 10 cases (3.3%) with rapid sequence intubation; and oesophageal intubation with delayed recognition in 47 cases (4.0%), and mainstem bronchus intubation in 24 cases (2.1%) with non-rapid sequence intubation. Hypotension events were significantly more frequent in rapid sequence intubation than in non-rapid sequence intubation (4.0% vs. 0.9%; OR 4.8, 95% CI 1.9–12.4; $P<0.001$), although there may have been relevant patient differences at baseline. Major adverse events, defined as dysrhythmia, hypotension, cardiac arrest or death were identified in 14 cases (4.9%) with rapid sequence intubation and in 27 cases (1.9%) with non-rapid sequence intubation. There were no significant differences in the total or major adverse event rate by method, although the sample size may have been too small to detect a significant difference.

4. Discussion

In Japan the practice of emergency medicine has been historically viewed as an adjunct to other clinical specialties rather than as a unique specialty. Its focus has been trauma and critical care with a multi-specialty staffing model.[11] Japanese emergency medicine practitioners therefore receive their principal training in surgery, anesthesia, or medicine and then undergo additional training in the management of acutely ill patients. In addition, because of the absence of bodies responsible for the accreditation of graduate medical training programs in Japan, residency programs vary in length and educational offerings. Training in emergency airway management education depends on the institution. Recently, efforts to improve the delivery of emergency medical care in Japan and encourage formal emergency medicine training have occurred in reaction to high-profile disasters, such as the Tokyo subway sarin attack in 1995 and several earthquakes.[11,12]

Successful emergency airway management is a cornerstone of the modern practice of emergency medicine. Consequently, training and understanding in airway management is one of the most essential components for the advent of emergency medicine as a distinct discipline. However, broadly applicable inferences can be difficult to make because of the absence of multi-center data characterizing current airway practices. Additional barriers include variations in population settings, patients, staffing configurations and protocols. Previous studies of ED airway management in Japan have been limited to retrospective, single-center reviews.[8–10] To our knowledge, our study is the first attempt to prospectively describe ED intubation at multiple hospitals in Japan.

We presented data describing 1486 intubations in 10 EDs. Our observation that 83% of first attempts were performed by emergency physicians or residents vs. 17% by other specialties is encouraging and exemplifies that emergency department intubations are primarily managed by emergency physicians. Intubation success is a common measure of the quality of ED airway management. In our registry, 99.7% of encounters reported successful airway management in EDs. Our observed success rate is consistent with the findings of other studies.[2,5,13,14]

We are struck by the high degree of variation in airway management practices among hospitals, with the proportion of use of rapid sequence induction among non-cardiac arrest patients ranging from 0 to 79% across the hospitals. Even greater variation was observed in the use of sedation without paralysis, with differences in proportion reaching 25-fold. Because of the non-controlled nature of this study, the reasons for this variation are not well defined. It is possible that non-rapid sequence intubation methods were attempted in patients who were predicted to have a difficult-to-manage airway and that any of these methods were used more commonly because it reflected physician preference or institutional policies. Any of these factors or an interaction between them could explain in full or in part the observed variation in intubation method among the hospitals. Furthermore, our data imply considerable variation in intubation success rates, with one hospital demonstrating a success rate of 40% in the first attempt and 74% in ≤3 attempts. The variability in the method of intubation may, in part, account for this variation in success rates among hospitals. However, this descriptive study was not designed to sift out confounding factors such as intubator demographics, procedural experience, training background, differences in ED staffing, or airway difficulty.[5,15–17] Still, interhospital intubation performance variations among EDs are plausible and might be symptoms of larger problems with emergency care nationally. If verified with a larger, more comprehensive data set, interhospital variations could indicate disparities in staffing and structure of Japanese EDs, and inadequate training due to the lack of robust evidence-based airway management education and peer-review process of training programs.

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Assuming the validity of our observations, this study suggests the need for an organized national effort to improve the uniformity of ED airway management in Japan. Historically, the Japanese government and professional organizations have fueled the development of emergency care delivery. The principal goal of this widespread effort was to improve survival from major trauma and critical illness.[18] However, the government and professional organizations have done little to evaluate the results and establish training programs. In fact, there is no body responsible for the accreditation of emergency medicine residency and fellowship programs in Japan. A system-wide approach to improving the quality of vital resuscitative procedures includes refinement of postgraduate training with defined quality and quantity endpoints.[19–21] Implementing accreditation of residency programs and sponsoring institutions via a peer-review process of evaluation and review by a governmental or non-governmental agency has been proposed and debated.[22] This strategy ensures minimum levels of clinical experience in training programs and nurtures qualified practitioners. Another approach includes development of clinical policy statements by Japanese professional organizations, setting an appropriately considered, evidence-based approach towards emergency airway management.

Attempting to provide the best possible care to the largest population with limited resources in a system is a challenging goal. Although the current literature proposes solutions to improve intubation performance through utilization of video-laryngoscope and enhanced training such as simulation-based curricula and supplemental operating room training at individual EDs, they address only isolated aspects of the procedure.[4,23–25] Improvement of the quality of emergency care is the responsibility of Japanese national bureaus and professional organizations as well as the EDs themselves. There may be a stronger chance of improvement of the quality of airway management throughout Japan if the leadership and direction of governmental and professional agencies were strengthened.

4.1. Limitations

Our study has several limitations. First, passive surveillance introduces the potential of reporting bias; therefore, underestimation of the rate of failed intubations is possible. Active compliance monitoring limits this possibility however. Although we perfomed analyses of patient medical records to complete missing data, validation of existing data is not logistically feasible. Therefore, we relied on hundreds of physicians at many centers to complete the data forms accurately and our results depend on the accuracy of their reporting.

Second, self-reporting immediately after intubation can result in incomplete reporting of adverse events.[26] Similarly, this descriptive study was not designed to measure patient outcomes after hospitalization such as mortality nor to evaluate relationships between ED airway management and outcomes. A more accurate analysis of complications and outcomes requires follow-up with patients during the remainder of their hospitalization or on autopsy.

Third, this study was purely descriptive and did not adjust for potential confounders. Therefore, we can make no assumptions about the reasons for the observed variations in intubation methods, success rates, and adverse event rate among the hospitals.

Finally, all but one of the participating EDs had emergency medicine residency training programs. Therefore, these results may not represent emergency airway management practices in non-academic hospitals and underestimation of the variation in practices is possible. However, this is highly relevant from a policy standpoint, because these institutions train the majority of emergency physicians. These institutions thus have a disproportionate impact on the quality of current and future ED care. Similarly, it might not be possible to extrapolate our observations to resource-limited environments in developing countries. However, prospective collection of multi-centered data similar to our research strategy would be desirable in those countries where emergency medicine is developing because it would provide a sufficient scale to analyze meaningful clinical differences and bridge variations across different practice settings, ultimately leading to evidence-based approaches to emergency airway management.

5. Conclusion

In this multi-center study characterizing ED airway management across Japan, we observed a high overall intubation success rate but a high degree of variation among hospitals in emergency airway management including method of intubation and success rate. Our study provides a starting point to improve the quality of airway management in Japanese emergency departments.

Conflict of interest statement

There are no conflicts of interest to declare.

Role of funding source

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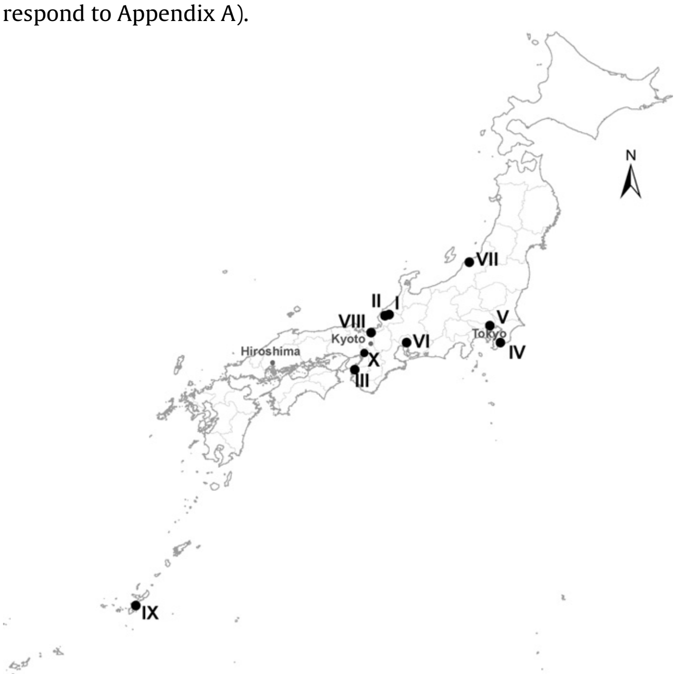
Appendix A.

Japanese Emergency Airway Network (JEAN) centers.

JEAN site (city, prefecture)	Investigator	Total ED census (Pts/year)	Trauma designation	Emergency medicine residency
I. Fukui University Hospital (Eiheiji, Fukui)	Hiroshi Morita, MD	18,000	Level II	Yes
II. Fukui Prefectural Hospital (Fukui-city, Fukui)	Hidenori Higashi, MD	34,000	Level I	Yes
III. Japanese Red Cross Medical Center of Wakayama (Wakayama-city, Wakayama)	Hiroshi Okamoto, MD	42,000	Level I	Yes
IV. Kameda Medical Center (Kamogawa, Chiba)	Kenzo Tanaka, MD	30,000	Level I	Yes
V. National Center for Global Health and Medicine (Shinjuku, Tokyo)	Shunichiro Nakao, MD	25,000	Level I	Yes
VI. Nagoya Ekisaikai Hospital (Nagoya, Aichi)	Shigeki Tsuboi, MD	33,000	Level I	Yes
VII. Nigata City General Hospital (Nigata, Nigata)	Nobuhiro Sato, MD	15,000	Level I	Yes
VIII. Obama Municipal Hospital (Obama, Fukui)	Takuyo Chiba, MD	12,000	Level I	No
IX. Okinawa Chubu Prefectural Hospital (Uruma, Okinawa)	Masashi Okubo, MD	40,000	Level I	Yes
X. Osaka Saiseikai Senri Hospital (Suita, Osaka)	Kazuaki Shigemitsu, MD	9,000	Level I	Yes

Appendix B.

The location of the 10 participating hospitals (the numbers correspond to Appendix A).



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