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Prehospital emergency life-saving technicians promote the survival of trauma patients: A retrospective cohort study

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ABSTRACT

Objective: Appropriate decisions by medical technicians at a trauma scene may influence a patient's prognosis. Emergency life-saving technicians (ELSTs) are certified specialists trained with the knowledge to provide advanced techniques for prehospital emergency care in Japan. However, the benefit of treatment by ELSTs compared to basic emergency medical technicians (BEMTs) remains unclear. The aim of this study is to determine whether treatment by ELSTs improves outcomes for trauma patients.

Methods: We retrospectively reviewed the Japan Trauma Data Bank for the years 2004 to 2017. Patients transferred to the hospital directly from the trauma scene and at least 16 years old were included in this study. The following criteria were used to exclude patients; presence of burns, untreatable severe traumas, unknown ELST attendance, and missing prognosis. We compared two groups (ELST group: patients transported by emergency medical services (EMS) with the presence of at least one ELST; BEMT group: patients transported only by BEMTs). Primary outcome was survival to discharge. Secondary outcomes were the need of definitive treatments defined by surgical intervention, intravascular radiology and blood transfusion at the receiving hospital within 24 h. A multivariable logistic regression model was used to calculate odds ratio (OR) and confidence intervals (CI) adjusted by age, sex, revised trauma score, and Injury severity score (ISS).

Results: Overall survival to discharge did not improve significantly (adjusted OR 1.13, 95% CI 0.99–1.30) with ELST intervention. In-hospital blood transfusion was more frequently required in the ELST group (adjusted OR 1.10, 95% CI 1.01–1.20). Emergency interventions (adjusted OR 1.03, 95% CI 0.97–1.09) were not different between the groups. In stratified analysis, the benefit of ELST attendance for survival was observed among patients with ISS <16 (adjusted OR 1.53, 95% CI 1.10–2.15), aged 65 years or older (adjusted OR 1.27, 95% CI 1.07–1.52), during the earlier study period (2004–2008, adjusted OR 1.50, 95% CI 1.14–1.97), and shorter transportation time (adjusted OR 1.21, 95% CI 1.03–1.41).

Conclusions: Dispatch systems with ELST should be considered for trauma transports, which may benefit elderly or moderate severity trauma groups, with shorter transportation time conditions.

1. Introduction

Early initiation of advanced trauma care may be critical for decreasing prehospital death and reducing downstream complications attributable to hemorrhage [1]. Seamless trauma care, known as the trauma chain of survival, is necessary to rescue patients who have suffered severe trauma and includes early application of first aid, life support, advanced therapy, and rehabilitation [2]. As the first line of trauma care for patients with critical needs, emergency medical services (EMS) play an important role in prehospital treatment [3].

Trauma transports vary widely among EMS systems, depending on the country or area where they operate [4]. In Japan, the Fire and Disaster Management Agency employs two levels of public prehospital medical providers: emergency life-saving technicians (ELSTs) and basic emergency medical technicians (BEMTs). ELSTs are certified specialists who undergo additional training compared to that received by BEMTs, giving them advanced knowledge and skills specifically for prehospital emergency care [5]. According to regulations amended in 2014, specially trained ELSTs, in addition to performing basic trauma life support,

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are allowed to give fluid resuscitation to patients in shock or Crush syndrome, as well as protect unsecured airways. BEMTs, in contrast, are not trained to perform these additional procedures and are limited to basic trauma life support techniques.

In general, each Japanese ambulance has a crew of three providers, including at least one ELST. During the early years of EMS, Japan adopted the Anglo-American system, in which a patient is brought by prehospital medical providers to a hospital for further care by physicians [6]. For the purpose of the highest standard of prehospital care, the Fire and Disaster Management Agency has been promoting the use of ELSTs with a subsequent increase in the number of ELSTs in recent years. Between 2004 and 2017, the number of prehospital teams that included at least one ELST increased from about 3500 (73% of EMS dispatches) to more than 5000 (99% of EMS dispatches), though the distribution of ELSTs is still uneven from region to region.

Previous studies have shown significant benefits for cardiac arrest patients when ELSTs are involved in out-of-hospital treatment and transport [7,8]. However, the effectiveness of ELSTs over BEMTs regarding trauma patients has yet to be fully elucidated. The current study aims to analyze the Japan Trauma Data Bank, a large-scale, nationwide trauma patient database, to determine whether ELST attendance improves the outcomes of trauma patients compared to treatment by BEMTs alone.

2. Materials and methods

2.1. Emergency medical system and providers

Japan has a unique EMS system. The fire defense headquarters of each local government manages their own EMS. Responsibilities of the local EMS include overseeing their allocated ambulances (one ambulance per 50,000 people up to 150,000, with one additional ambulance for every additional 70,000 people) and accrediting their BEMTs. BEMTs are certified after 250 h of basic life support medical education [6]. ELST certification, in contrast, requires passing a national ELST examination after training. ELST training can be acquired in one of two ways, either by completing two years of ELST education at an emergency medical technician (EMT) school, or by serving as a BEMT in prehospital care and transportation for five years, followed by six months of ELST education. ELST training provides a higher level of physical assessment, enabling them to triage and care for trauma patients more effectively in the scene [6].

2.2. Study design and data collection

The Hyogo Emergency Medical Center Ethics Committee approved the study (#2021004) and waived the requirement for written informed consent.

We reviewed the Japan Trauma Data Bank (JTDB; 2004–2017), a nationwide trauma registry. All trauma patients registered in the Data Bank were screened. In 2018, 280 major emergency medical institutions across Japan equal to Level I trauma centers in the United States were contributing to the database. JTDB data is collected through a web-based form and registered by emergency physicians in cooperation with medical assistants. This information regarding trauma centers participating in the JTDB has been described in previous papers [9,10]. However, the information about contributing hospitals, including location and trauma center level, was anonymized.

The JTDB includes patients' characteristics (age, sex), date of injury (year, hour), ISS (Injury Severity Score), AIS (Abbreviated Injury Scale), RTS (Revised Trauma Score), type and mechanism of trauma, transportation time from trauma scene to hospital arrival, blood transfusion, emergency treatment, and survival to discharge.

The criteria for inclusion in this study were patients transported directly from trauma scene to the hospital, and patients at least 16 years old. The exclusion criteria were burn patients, AIS score of 6 (lethal trauma) or 9 in any region (unknown or missing AIS), unknown ELST attendance, and missing survival data.

We compared two trauma groups: the ELST group, defined as patients attended by at least one ELST when transported by EMS; and the BEMT group, defined as patients attended only by BEMTs during transport. Transportation time was defined as the elapsed time of transport from the trauma scene to arrival at the hospital. Transport times exceeding 60 min were counted as 60 min. The primary outcome measured was survival to discharge. The secondary outcome was whether emergency treatment was needed, including craniotomy, thoracotomy, laparotomy, bone fixation, interventional embolization within 24 h, and blood transfusion. Patients needing transfusion of red blood cells, fresh frozen plasma, or platelets within 24 h of arrival at the hospital were counted as blood transfusions. Of note, neither ELSTs nor BEMTs are allowed to administer blood products at the scene or during transportation in Japan. Both primary and secondary outcomes were compared between the two groups. Survival to discharge is influenced by various factors such as the patient's age and trauma severity. Furthermore, in the current analysis, the number of ELSTs varied from year to year, and worktime shifts may influence outcomes. Therefore, a subgroup analysis was conducted to examine which subgroup's survival benefited the most after trauma.

2.3. Data analysis

We characterized the study population with descriptive statistics. Continuous variables were described using means with standard deviation (SD). Ordinal variables were described using medians with interquartile range (IQR). Categorical variables were described using percentages.

Multivariable logistic regression analysis was performed with primary outcome (survival to discharge) or secondary outcomes (blood transfusion or emergency treatment) as the dependent variable and ELST attendance as the independent variable. Outcomes were adjusted for age, sex, RTS, and ISS. The results of logistic regression are described with odds ratio (OR) and 95% confidence interval (CI).

Additionally, analysis for survival was conducted among the following subgroups: trauma patients with ISS (<16, or ≥16), age (<65 years-old or ≥65); study period (2004–2008, 2009–2013, 2014–2017); transportation time (0–29 min or 30- min); and time of day (daytime was defined as 9:00–16:59, night time as 17:00–8:59). Subgroups were also adjusted with multivariable logistic analysis using the same independent variables.

Statistical analysis was performed using STATA 15 (StataCorp, Lakeway, TX, USA).

3. Results

3.1. Baseline characteristics

Among 292,027 patients recorded in the JTDB from January 2004 to December 2017, 222,829 were transferred to the hospital directly from the trauma scene. After applying our exclusion criteria, 139,436 patients were enrolled. Of these, 133,076 patients were transported by ambulances staffed with at least one ELST, and 6360 patients were transported by BEMTs only (Fig. 1).

The characteristics of patients in both groups are shown in Table 1. The mean ages were 59.9 (SD: 21.7) in the BEMT group and 57.0 (SD: 22.2) in the ELST group. Males comprised 63.4% of the BEMT group and 64.4% of the ELST group. Almost all trauma cases were blunt (falls and motor vehicle accidents). Patients' median ISS was 10 (IQR: 9–20) in the BEMT group and 13 (IQR: 9–21) in the ELST group. Median RTS was 7.84 (7.55–7.84) in the BEMT group and 7.84 (7.11–7.84) in the ELST group. Mean transportation time was 17.0 min (SD: 13.8) in the BEMT group and 14.5 min (SD: 11.9) in the ELST group.

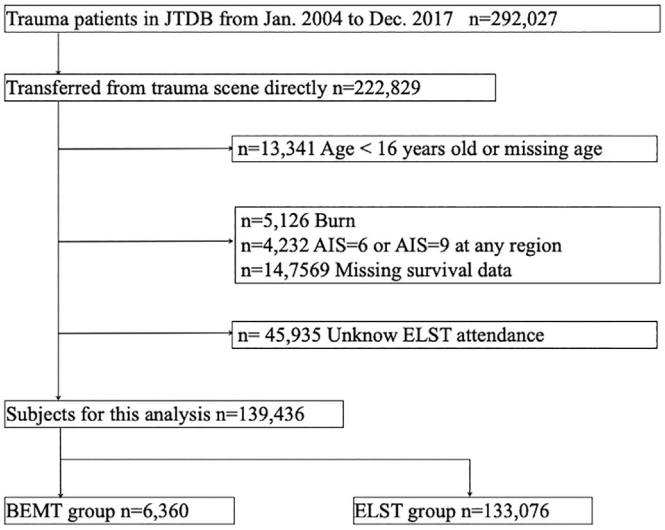

Fig. 1. Study population flowchart.
Abbreviations: JTDB - Japan Trauma Data Bank, AIS - Abbreviated Injury Scale, ELST - emergency life-saving technician, BEMT - basic emergency medical technician

Table 1
Comparison of BEMT and ELST characteristics.

		BEMTs $N = 6360$	ELSTs $N = 133,076$
Age, mean (SD)		59.9 (21.7)	57.0 (22.2)
Sex (%)	Male	4034 (63,4)	85,765 (64.4)
Time periods, years	2004–2008	1159 (18.2)	17,213 (12.9)
	2009–2013	2911 (45.8)	60,484 (45.5)
	2014–2017	2290 (36.0)	55,379 (41.6)
Type of trauma (%)	Blunt	6041 (95.0)	125,461 (94.3)
	Penetrating	225 (3.5)	5580 (4.2)
	Other	94	2035
Mechanism of trauma	MVA	2480 (39.0)	57,613 (43.3)
	Fall	2933 (46.1)	58,030 (43.6)
	Other	947	17,433
ISS (IQR)		10 (9–20)	13 (9–21)
RTS (IQR)		7.84 (7.55–7.84)	7.84 (7.11–7.84)
Prehospital trauma care	Intravenous access	515 (8.1)	4174 (3.1)
	Respiratory ventilation	156 (2.5)	5019 (3.8)
	Chest conmpression	133 (2.1)	4698 (3.5)
	Defibrillation	5 (0.079)	238 (0.18)
Blood transfusion within 24 h		845 (13.3)	19,656 (14.8)
Surgical intervention	Craniotomy	209 (3.3)	4916 (3.7)
	Thoracotomy	101 (1.9)	2064 (1.6)
	Celiotomy	189 (3.0)	4095 (3.1)
	Bone fixation	1790 (28.1)	33,240 (25.0)
	Transarterial embolization	150 (2.4)	3832 (2.9)
Time†	Daytime	2167 (34.1)	37,344 (28.1)
	Night-time	2268 (35.7)	54,239 (40.8)
Transportation time, mean, min (SD)*		17.0 (13.8)	14.5 (11.9)
	0–29 (%)	4616 (72.6)	112,458 (84.5)
	30 - (%)	761 (12.0)	10,493 (7.9)

†43,418 missing
*11,108 missing

Abbreviations: BEMTs: basic emergency medical technicians, ELSTs: emergency life-saving technicians, SD: standard deviation, MVA: motor vehicle accident, ISS: Injury Severity Score, IQR: interquartile range, RTS: Revised Trauma Score

3.2. Multivariable logistic regression analyses

In the multivariable logistic regression analysis of all trauma transports, no significant difference was observed in the primary outcome of survival-to-discharge between ELST-attended patients and BEMT-only attended patients (adjusted OR 1.13, 95% CI 0.99–1.30; Table 2). Regarding secondary outcomes, the proportion of blood transfusion within 24 h (adjusted OR 1.10, 95% CI 1.01–1.20) differed between the two groups, even though no difference was observed in the proportion of overall emergency treatment, including surgical procedure and interventional embolization within 24 h (adjusted OR 1.03, 95% CI 1.01–1.20).

3.3. Subgroup analyses

The effectiveness of ELST attendance during trauma transport was also evaluated in several subgroups (Fig. 2). In the multivariable logistic regression, ELST attendance was significantly associated with higher survival to discharge among the patients with ISS <16 (adjusted OR 1.44, 95% CI 1.05–1.97), those 65 or older (adjusted OR 1.25, 95% CI 1.06–1.47), the earliest study period (2004–2008; adjusted OR 1.50, 95% CI 1.14–1.97) and those with shorter transportation times (adjusted OR 1.20, 95% CI 1.02–1.40).

4. Discussion

We evaluated the benefits of ELST attendance during prehospital care of trauma patients for outcome using a Japan nationwide trauma patient registry. Overall, the presence of at least one ELST in the prehospital EMT crew was not significantly associated with an increase in survival to discharge. However, a stratified analysis revealed that in several subgroups of patients, ELST attendance was significantly effective for patients with an ISS <16, those 65 years old or older, those from the earliest study period (2004–2008), and those whose transport times were less than 30 min of first EMT contact.

The observed increase in survival-to-discharge rates for older patients with moderate severe injury (ISS <16) who are attended by ELSTs is likely due to several factors. It may be challenging to make accurate diagnosis for elderly patients with moderate trauma due to their vulnerability and physical impairment in nature [11]. ELSTs' additional training for quick and accurate physical assessment based on higher degree of knowledge over BEMT may have improved to the treatment for the elderly trauma patients. It is well known that swift transport is beneficial for trauma patients. Harmsen et al. reported rapid transport is most beneficial for patients suffering hypotensive penetratingly injury and traumatic brain injury [12]. In this current study, additional advanced training may enable ELSTs to make earlier and more accurate evaluations to find hidden invisible severe injuries and determine required treatment and the appropriate hospital for each trauma patient, resulting in shorter transport time and early initiation of definitive treatment in the receiving hospital compared to those treated by BEMTs alone.

Table 2
Multivariable logistic regression analysis with using survival to discharge, blood transfusion, and emergency treatment as the dependent variable and ELSTs versus BLSTs as the independent variable.

	Adjusted OR*	95% CI
Survival to discharge	1.13	0.99–1.30
Blood transfusion within 24 h	1.10	1.01–1.20
Emergency treatment within 24 h	1.03	0.97–1.09

Abbreviation: BEMT: Basic emergency medical technician, ELST: Emergency life-saving technician, OR: Odds ratio, CI: Confidence interval
* Adjusted with patients' age, sex, RTS, ISS.

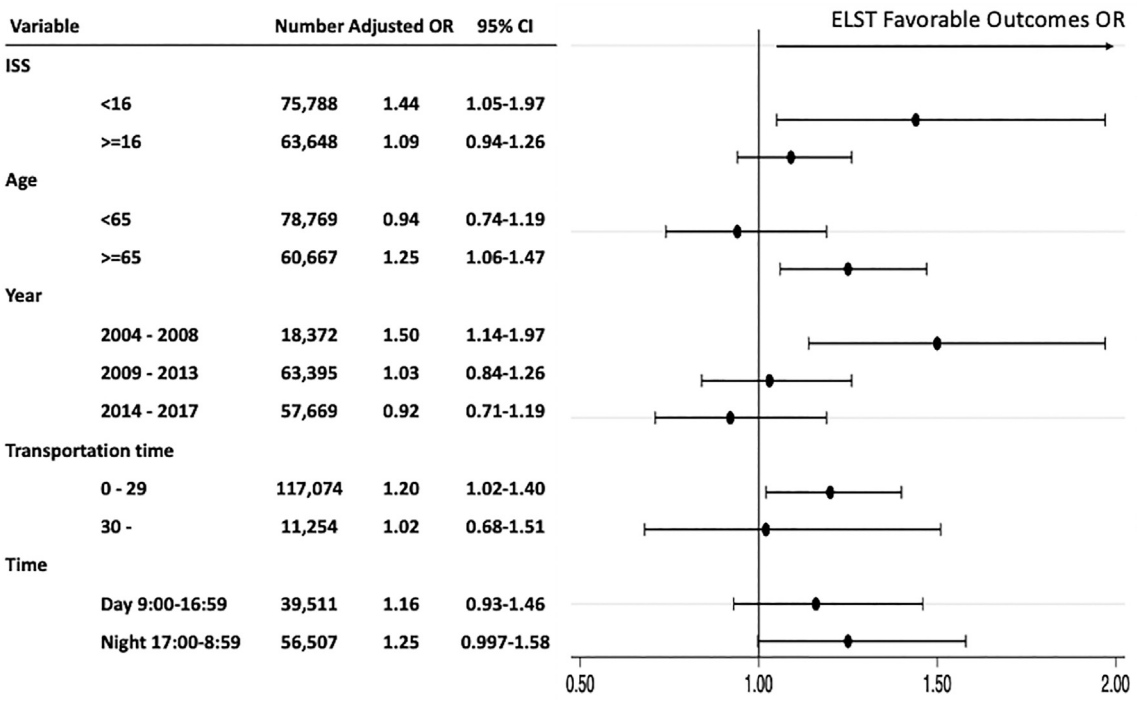

Fig. 2. Stratified multivariable logistic regression analysis with survival to discharge as a dependent variable and ELST attendance as an independent variable. Results are adjusted for age, sex, RTS, and ISS.
*Adjusted for age, sex, RTS, ISS.
Abbreviations: ELST - emergency life-saving technicians, RST - revised trauma score, ISS - injury severe score, OR - odds ratio

The effectiveness of ELST attendance was also supported by increased survival to discharge rates in the earliest study period (2004–2008). As this is the period in which ELSTs were first introduced into the EMS, the observed improvement in survival may be due simply to progress of the standard prehospital care available to trauma patients in the field. Furthermore, ELSTs could direct their partner BEMTs during prehospital care, allowing BEMTs to learn techniques and protocols to which they otherwise would not have been exposed. Presumably, improved prognostic capabilities by BEMTs across the national EMS provided a synergistic effect for patient treatment. During subsequent periods, greater numbers of ELSTs in the EMS meant greater numbers of BEMTs working with ELSTs, contributing to a raised standard of care across the board, as indicated by our results. In addition, an off-the-job training course targeting EMTs (Japan Prehospital Trauma Evaluation and Care) aiming to increase the standard level of prehospital trauma care was launched in 2004. The spread and distribution of this training course may have narrowed the gap between BEMTs and ELSTs. Thus, in addition to the presence of ELSTs in the prehospital setting, improved prehospital trauma protocols and standardization of basic trauma care in Japan during this study period may have resulted in the improvement of trauma patients' prognosis.

Regional differences and variations in the capacity of the receiving hospitals may have had an influence on the results; this information was not available in the JTDB. However, it is clear that appropriate EMT assessment of injury site and severity in the prehospital setting provided sufficient information required for early initiation of emergency treatment to physicians in the hospitals. Assessment of a patient's injury and physiology after trauma by an EMT is a decisive factor in the level of care administered [13]. Previous studies have verified the accuracy of injury assessment by EMTs via the scoring system of receiving hospitals, including an accurate judgement of trauma patients with truly severe injury [14]. This is consistent with a previous study in Mexico, which showed that introducing EMTs who are trained and certified through formal education programs into the EMS leads to a reduction in trauma patient deaths [15]. In Japan, EMS personnel are not allowed to perform advanced interventions (e.g., needle decompression for tension pneumothorax, drug administration for specific physiological changes except adrenaline), which is different from EMS staff in the United States or other countries [9]. As our study was performed using a Japan nationwide trauma patient registry, the results in our study may not always be applicable in the different delivery systems in other countries. However, our study at least suggested that advanced education and training may be critical for improved prehospital care, leading to early/accurate evaluation of patients. We emphasize the importance of the presence of skilled and highly educated EMTs in the prehospital setting, regardless of the emergency medical system.

Unfortunately, our data was not appropriate to find any benefits of prehospital interventions such as intravenous access or advanced airway management because ELSTs in Japan are only allowed to perform these advanced skills for shock patients. Patients enrolled in this study include shock as well as non-shock trauma patients. Previous studies regarding intravenous access and crystalloid administration have shown that aggressive fluid administration prior to definitive care could induce uncontrollable bleeding due to coagulopathy [16]. However, since the mean transportation time in this study is less than 15 min, prehospital crystalloid administration may have provided only a limited effect on patients' prognosis. Certainly, it is reported that on scene fluid administration in Japan was not associated with survival to discharge among traffic accident patients [17]. In our study, mean transportation time was shorter in the ELST group, associated with favorable prognosis. These results support our hypothesis that ELSTs' management of trauma patients contributed to the improvement of patients'.

4.1. Limitations

Our study has several limitations. First, this is a retrospective study, which may cause information bias. In addition, not all hospitals participate in the JTDB registry, which may cause selection bias. We could not

obtain data on events after the patients were admitted to the hospital, such as the number of blood transfusions or long-term mortality/neurological outcomes. Although regional differences in the prevalence of ELSTs may affect participating EMS and receiving hospital capabilities, those data were anonymized in the JTDB. Further, transportation time can be affected by population density (e.g., urban areas may have a higher ELST transport proportion) or distance to the nearest hospital (such as in rural areas). We were also unable to quantify the knowledge, skill, and experience levels of the ELSTs involved in the observed cases. Further studies evaluating ELSTs' ability and how they affect patient outcomes are necessary.

5. Conclusions

Overall, ELST attendance in the prehospital setting was not associated with increased survival to discharge among trauma patients. However, transport by at least one ELST was beneficial for trauma patients with moderate severity of injury (ISS <16), those 65 years old or older, and during shorter transportation times (<30 min). These results indicate that dispatch systems should be organized for trauma transports with at least one ELST.

Author contributions

T.N., T.N., H.N., S.I., S.N., and A.N. participated in the study design and the data acquisition, analysis, and interpretation. All authors were actively involved in drafting and critical revision of the manuscript.

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CRediT authorship contribution statement

Takeshi Nishimura: Conceptualization, Data curation, Formal analysis, Investigation, Writing – original draft, Validation, Project administration. **Tsuyoshi Nojima:** Data curation, Formal analysis, Visualization, Writing – review & editing, Conceptualization. **Hiromichi Naito:** Formal analysis, Data curation, Conceptualization, Investigation, Writing – review & editing, Writing – original draft, Validation, Supervision, Methodology. **Satoshi Ishihara:** Conceptualization, Data curation, Supervision, Validation, Writing – review & editing. **Shinichi Nakayama:** Writing – review & editing, Validation, Supervision, Data curation, Conceptualization. **Atsunori Nakao:** Conceptualization, Data curation, Methodology, Supervision, Validation, Writing – original draft, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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