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Original article

The utility of physician-staffed helicopters for managing individuals who experience severe isolated head trauma

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Abstract

Objective: The authors retrospectively investigated prognostic factors for severe isolated head trauma in patients evacuated by a physician-staffed helicopter emergency medical service (HEMS) or ground ambulance using data from the Japan Trauma Data Bank (JTDB).

Patients and Methods: This study was a retrospective analysis of data housed in the JTDB database. The study period was from January 2004 to May 2019. Subjects were divided into two groups according to the method of transportation: helicopter (i.e., HEMS), which included patients transported by a physician-staffed helicopter; and ambulance, which included patients transported by ground ambulance.

Results: A total of 41,358 patients were enrolled in the study, including 2,029 in the helicopter group and 39,329 in the ambulance group. The ratio of males, median head Abbreviated Injury Scale and Injury Severity Scale (ISS) scores were significantly greater in the helicopter group than in the ambulance group, while the average age, median Glasgow Coma Scale, average Revised Trauma Score (RTS), and survival rate were significantly lower in the helicopter group than in the ambulance group. Of the variables that demonstrated statistical significance in the univariate analysis and classification of transportation and included in the multivariate analysis, the following were identified as significant predictors of survival outcomes: younger age, lower ISS, female sex, and greater RTS. HEMS was not a significant predictor of survival.

Conclusion: The present study revealed no effect of HEMS transport on the outcomes of patients who experienced severe isolated head trauma compared with ground ambulance transportation. Further prospective studies, including an analysis of the operation time or distance traveled by the HEMS and the functional outcome(s) of patients with severe head injury transported by HEMS, are warranted.

Key words: physician-staffed helicopters, ambulance, head trauma, outcome, Japan Trauma Data Bank

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Introduction

The Ministry of Health, Labor and Welfare established a physician-staffed helicopter emergency medical service (HEMS) in 2001. The HEMS operates during the daytime. The main purpose of the HEMS is early medical intervention rather than early transportation to a hospital for various patients, including those with intrinsic and extrinsic diseases[1]. Since January 2021, 53 helicopters have been deployed in 44 prefectures across Japan. In 2019, 23,922 patients have been transported via HEMS.

The Japan Trauma Data Bank (JTDB) was established in 2003 and was authorized by the Japanese Association for the Surgery of Trauma (Trauma Surgery Committee) and the Japanese Association for Acute Medicine (Committee for Clinical Care Evaluation). In 2016, 256 major emergency medical institutions in Japan were included in the JTDB[2–4]. Most of the registered institutions are acute critical care and trauma centers, including hospitals with a physician-staffed helicopter base. An analysis of data housed in the JTDB revealed that, among patients who experienced major trauma in Japan, transport by helicopter with a physician was associated with improved survival to hospital discharge compared to transport by ground emergency services[4]. However, the types of major trauma that

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are typically involved when patients are transported by the HEMS has not yet been investigated, except in cases of severe chest trauma[5)]. Compared with emergency medical technicians (EMTs) in ground ambulances in Japan, physicians in the HEMS can administer drugs and perform transfusion and tracheal intubation before cardiac arrest, even in a prehospital setting[5, 6)]. Accordingly, we hypothesized that HEMS may positively influence the outcomes of patients with severe isolated head trauma compared with ground ambulance.

Therefore, we retrospectively investigated the prognostic factors of patients who experienced severe isolated head trauma and were evacuated by the HEMS or ground ambulance using data from the JTDB.

Patients and Methods

The protocol for this retrospective study was approved by the institutional review board of the authors' institution, and examinations were conducted according to the standards of good clinical practice and the Declaration of Helsinki. The approval number was 401.

This study was a retrospective analysis of data retrieved from the JTDB database. The study period was from January 2004 to May 2019. After the application of the exclusion criteria, all severely isolated head traumatized patients transported by the HEMS and ground ambulance, whose data were registered in the JTDB database, were included in the present study. Patients who experienced severe isolated head trauma were defined as having an Abbreviated Injury Scale (AIS) score of 3 to 5 because an AIS score of 1 or 2 is considered a minor injury, while a score of 6 represents instantaneous deadly trauma[7)]. Patients for whom data were missing, including age, sex, mechanism of injury (penetrating or blunt), origin of transportation (evacuation from scene or inter-hospital transportation), Injury Severity Score (ISS), Revised Trauma Score (RTS) on arrival, and unknown outcome, were excluded[7, 8)]. Data including subject age, sex, treatments (oxygen, drip infusion, and any other treatments, including oxygen, drip infusion, ultrasound, spinal immobilization, use of drugs, transfusion, tracheal intubation, thoracostomy, thoracotomy, and drainage for cardiac tamponade), prehospital and in-hospital vital signs (systolic blood pressure, heart rate, respiratory rate, Japan Coma Scale [JCS], Glasgow Coma Scale [GCS]) score on arrival), head AIS, ISS, RTS on arrival, and outcome (survival or death), were investigated[6)]. The subjects were divided into two groups: helicopter, which included patients who were transported by HEMS; and ambulance, which included patients who were transported by ground ambulance. Selected variables were compared between the two groups and the changes in vital signs between the prehospital and in-hospital settings, and the medical treatments administered during transportation in the helicopter and ambulance groups, were analyzed. Variables demonstrating statistical significance ($P<0.01$) in the univariate analysis and the classification of transportation (helicopter or ambulance) were included in a multivariate analysis to evaluate independent predictors of survival.

All statistical analyses were performed using JMP software (SAS Japan Incorporation, Tokyo, Japan). Data were analyzed using the paired Student's *t*-test for changes in vital signs between prehospital and in-hospital, and the non-paired Student's *t*-test or χ^2 test for comparisons between the two groups. Differences with $P<0.01$ were considered to be statistically significant. All data are expressed as mean ± standard deviation or median with corresponding interquartile range.

Results

During the investigation period, data from 353,582 patients were registered in the JTDB, with 134,270 cases of head trauma transported by HEMS or ground ambulance, 101,712 cases of severe head trauma, and 51,556 cases of severe isolated head trauma. After excluding patients with missing data regarding age, sex, mechanism of injury, origin of transportation, ISS, RTS on arrival, or outcome, a total of 41,358 patients were enrolled, including 2,029 in the helicopter group and 39,329 in the ambulance group.

Results of analysis of the two groups are summarized in Table 1. The ratio of males, median head AIS, and median ISS were significantly greater in the helicopter group than in the ambulance group, while the average age, median GCS, average RTS, and survival rate were significantly lower in the helicopter group than in the ambulance group.

Variables that demonstrated statistical significance in the univariate analysis (Table 1) with classification of transportation were included in a multivariate analysis The following variables were identified to be significant predictors of survival outcomes: younger age, lower ISS, female sex, and greater RTS (Table 2). Transportation using HEMS did not influence survival.

Changes in vital signs between the prehospital and in-hospital settings in the helicopter group are summarized in Table 3. Average systolic blood pressure and respiratory rate were significantly greater in the prehospital setting than in the in-hospital setting. The average heart rate was significantly lower in the prehospital setting than in the in-hospital setting. Changes in vital signs between prehospital and in-hospital settings in the ambulance group are summarized in Table 4. Average systolic blood pressure, respiratory rate, and JCS were significantly greater in the prehospital setting than in the in-hospital setting (improving unconsciousness).

Medical treatments administered during transportation between the two groups are summarized in Table 5. The

Table 1 A comparison between the Helicopter and Ambulance groups concerning severe isolated head injury (6 > abbreviated injury scale > 2)

	Ambulance n = 39,329	Doctor helicopter n = 2,029	*P* value
Age (years)	60.7 ± 24.5	56.8 ± 26.3	<0.0001
Male/Female	2,6224/13,105 (2.0)	1,487/547 (2.7)	<0.0001
Penetrating/Blunt injury	12/2,017	286/39,043	n.s.
Scene/inter-hospital	32,921/6,408 (5.1)	1,725/304 (5.6)	n.s.
Glasgow Coma Scale	14 (9, 15)	12 (6, 14)	<0.0001
Head AIS	4 (3, 4)	4 (3, 5)	<0.0001
Injury severity score	16 (10, 18)	16 (10, 25)	<0.0001
Revised trauma score	6.9 ± 1.4	6.5 ± 1.6	<0.0001
Survival rate (%)	85.7 ± 34.9	79.8 ± 40.0	<0.0001

AIS: abbreviated injury scale.

Table 2 Results of a multivariate nominal logistic regression analysis for the survival

Factor	Odds ratio	95% confidence interval
Age	0.96	0.96–0.96
Injury severity score	0.87	0.87–0.88
Female	1.20	1.11–1.31
Revised trauma score	2.48	2.42–2.55
Helicopter	1.07	0.91–1.26

Table 3 Changes in vital signs between the prehospital and in-hospital setting in the Helicopter group (n=2,029)

	Prehospital	In-hospital	*P* value
Systolic blood pressure (mmHg)	147.9 ± 33.7	140.6 ± 36.4	<0.0001
Heart rate (beats per minute)	84.4 ± 23.6	86.5 ± 24.9	<0.01
Respiratory rate (breaths per minute)	21.8 ± 7.7	20.4 ± 7.1	<0.0001
Japan Coma Scale	90.7 + 118.7	84.7 ± 115.7	n.s.

n.s.: not significant.

Table 4 Changes in vital signs between the prehospital and in-hospital setting in the Ambulance group (n=39,329)

	Prehospital	In-hospital	*P* value
Systolic blood pressure (mmHg)	147.8 ± 33.2	146.4 ± 37.1	<0.0001
Heart rate (beats per minute)	85.6 ± 20.8	85.3 ± 23.0	n.s.
Respiratory rate (breaths per minute)	20.8 ± 5.5	19.9 ± 6.8	<0.0001
Japan Coma Scale	57.6 + 103.2	54.0 ± 98.9	<0.0001

n.s.: not significant.

Table 5 Treatment(s) during transportation in the two groups

	Helicopter n = 2,029	Ambulance n = 39,329	*P* value
Oxygen (%)	56.9	39.7	<0.01
Drip venous infusion (%)	20.4	2.0	<0.01
Any other treatments (%)	97.7	86.9	<0.01

ratios of oxygen, drip infusion, and any other treatments were significantly higher in the helicopter group than in the ambulance group.

Discussion

The present study demonstrated no marked effect of HEMS on the management of patients who experienced severe head trauma. Regarding changes in vital signs between the two groups, patients who were transported by HEMS may have been treated with sedatives or pain killers for tracheal intubation or surgical intervention. Such early medical intervention would then result in a stabilized airway, breathing, and circulation. Management goals for traumatic brain injury include the prevention and prompt treatment of secondary insults (hypotension, hypoxia, and other physiological derangements)[9]. In contrast, EMTs can use bag valve mask ventilation to improve the airway and breathing before patients enter cardiac arrest. Such interventions may resemble tracheal and mechanical ventilation. At least in the prehospital setting, the available evidence does not suggest any marked benefit from pre-hospital tracheal intubation and mechanical ventilation after traumatic brain injury[10]. Furthermore, decreased cerebral perfusion pressure induced by the administration of sedatives or pain killers in the HEMS may deteriorate the outcome of patients who experience severe brain injury[9, 11]. Of note, Bekelis *et al.* reported that helicopter transport of individuals who experience traumatic brain injury to trauma centers was associated with improved survival compared with transport by ground ambulance[12]. In their report, the raw data revealed that a helicopter was used to transport patients with more severe head injuries than in an ambulance, and the survival ratio of patients transported via helicopter was lower than that of those transported via ambulance. However, after propensity matching analysis, the survival ratio of helicopter-transported patients exceeded that of ambulance-transported patients. The present investigation and the study by Bekelis *et al.* differ in that the latter treated multiple injuries. Transport by HEMS improved the survival rate compared to that by ground ambulance for patients who experienced severe thoracic trauma[5]. Head injury with multiple other injuries, including the chest, may have affected survival following HEMS transport in their report.

Based on the results of the present study, younger age, lower ISS, higher RTS, and female sex were identified as positive prognostic factors for survival. Among these, the three strongest factors (RTS, ISS, and age) are well-known prognostic factors that are included in the trauma and injury severity score (TRISS), which is used to predict survival in trauma patients[8]. Accordingly, the standard predictor of TRISS may also be useful for predicting the viability of patients who experience severe head trauma. However, female sex hormones, such as estrogen and progesterone, are believed to be neuroprotective, acting on the steroidogenic central nervous system to attenuate neural damage following injury[13]. At the behavioral level, in one study, female animals exhibited more favorable outcomes than males after traumatic brain injury, including better cognitive performance, as reflected by a faster response to an aversive stimulus[14].

The present study had some limitations, the first of which was that it failed to describe the medical intervention performed during transportation in detail. Because the JTDB was built to analyze the activity of EMTs in a prehospital setting, details concerning the medical intervention performed by physicians in a prehospital setting were not recorded in the JTDB. Second, we did not investigate the time or distance from the trauma scene to the hospital. Because the survival rate of individuals who experience severe isolated head trauma, who require emergent neurosurgical intervention may be time-dependent[15, 16], these patients may benefit from an expedited process that shortens the time to surgical intervention via helicopter transportation. Third, we did not evaluate functional outcome(s) because the JTDB did not house such data. In patients who experience severe head trauma, it is important to analyze functional outcome(s) because approximately one-fifth of individuals who experience severe brain injury develop severe disability or adopt a vegetative state, and nearly two-thirds exhibit cognitive impairment even when their orientation is normal[17, 18]. Thus, prospective studies are needed to corroborate and/or expand our findings.

Conclusion

The present study revealed no effect of HEMS transport on the outcomes of patients who experienced severe isolated head trauma compared with ground ambulance transportation according to data housed in the JTDB. Younger age, lower ISS, higher RTS, and female sex were identified as positive prognostic factors for survival in our study. Further prospective studies, including an analysis of the operation time and/or distance traveled by HEMS and the functional outcomes of patients with severe head injury transported by HEMS, are warranted.

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Conflicts of interest: The authors declare no conflicts of interest associated with this study.

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