

# Helicopter emergency medical services (doctor-helicopters) in Fukushima provide appropriate field triage for trauma patients

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## ABSTRACT

**Background:** Many studies have commented on the usefulness of helicopter emergency medical services (HEMS) for the transportation of trauma patients. However, several studies have also noted that the majority of patients transported by HEMS to Level I trauma centers had minor injuries, and warned of inappropriate use of HEMS and the need for appropriate prehospital triage. In Japan, information about the injury severity of trauma patients transported by HEMS is lacking, and the appropriateness of field triage performed by HEMS is not clear. The purpose of this study was to investigate the validity of HEMS transportation in terms of the injury severity of trauma patients who were transported to our Emergency and Critical Care Medical Center (ECCMC) in Fukushima, Japan. **Methods:** We retrospectively evaluated all trauma patients who were brought to our ECCMC from the scene of an accident between March 1, 2009 and January 31, 2012. We compared Injury Severity Score (ISS), Revised Trauma Score (RTS), and probability of survival (Ps) as indicators of trauma severity, and emergency operation rate, intensive care unit (ICU) admission rate, and mechanical ventilation rate as indicators of specialized trauma care between patients transported by HEMS and those transported by ground ambulance (GA).

**Results:** We identified 450 trauma patients (324 males and 126 females, aged  $51 \pm 24$  years), of which 110 (24.4%) were transported by HEMS. The HEMS group had significantly more severe trauma than the GA group (ISS:  $17.7 \pm 11.5$  vs.  $12.4 \pm 9.5$ ,  $p < 0.001$ ; RTS:  $6.8 \pm 1.8$  vs.  $7.4 \pm 1.1$ ,  $p < 0.01$ ; Ps:  $0.82 \pm 0.29$  vs.  $0.92 \pm 0.19$ ,  $p < 0.01$ , respectively), and needed significantly more specialized trauma care (emergency operation rate: 32.7% vs. 20.6%,  $p < 0.01$ ; ICU admission rate: 52.7% vs. 32.6%,  $p < 0.001$ ; mechanical ventilation rate: 41.8% vs. 17.6%,  $p < 0.001$ , respectively).

**Discussion:** HEMS field triage by flight medical teams is almost ideal in terms of the injury severity of patients transported to our ECCMC. This triage is one of the great advantages of the service. Dispatchers should activate HEMS without hesitation if severe injury is suspected. Some over-triage by dispatchers is justified because flight medical teams provide important secondary triage, including further evaluation of trauma severity and choosing of the most appropriate hospital for treatment.

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## Introduction

Helicopter emergency medical services (HEMS) are one of the best ways of providing immediate lifesaving medical treatment at the scene of an incident, and have played an important role in prehospital emergency care in recent years. In Japan, HEMS are called doctor-helicopter services, and are staffed with specially trained physicians and nurses. The need for HEMS was recognized after the Great Hanshin-Awaji Earthquake on January 17, 1995, and a government-funded HEMS trial was

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developed in 1999. Since 2001, several HEMS have been implemented in Japan<sup>1,2)</sup>. As part of this project, HEMS have been used since January 28, 2008 in Fukushima prefecture, which lies approximately 200 km north of Tokyo, the capital city of Japan.

Many studies have commented on the usefulness of HEMS for the transportation of trauma patients<sup>3-5)</sup>. However, some studies have also noted that the majority of patients transported by HEMS to Level I trauma centers had minor injuries with Injury Severity Score (ISS) <9, and warned of inappropriate use of HEMS<sup>6,7)</sup> and the need for appropriate prehospital triage. In Japan, information about the severity of trauma patients transported by HEMS is lacking, and the current status of prehospital triage performed by HEMS is unclear. We therefore investigated the injury severity, management after admission, and survival of trauma patients who were transported by HEMS compared with those who were transported by ground ambulance (GA). This report aimed to evaluate the current management of trauma patients by HEMS, and the appropriateness of HEMS transportation in terms of the injury severity of trauma patients who were transported to our Emergency and Critical Care Medical Center (ECCMC) in Fukushima, Japan.

## Materials and Methods

The ECCMC of Fukushima Medical University Hospital is an HEMS base hospital and a referral trauma center for about 2.0 million people in Fukushima prefecture, corresponding to a Level I trauma center in the United States. The dispatch criteria for the Fukushima HEMS are as follows: (1) a need for specialized care, (2) a life-threatening (or possibly life-threatening) injury or illness, and (3) a need for immediate diagnosis or lifesaving treatment by physicians. Any one of these three criteria is sufficient for HEMS dispatch. The HEMS flight medical teams and GA paramedics evaluate vital signs, anatomical injury severity, and mechanism of injury of trauma patients at the scene, and transport patients to our ECCMC based on the Centers for Disease Control and Prevention (CDC) guidelines for field triage of injured patients<sup>8,9)</sup>. We retrospectively evaluated all blunt trauma patients who were brought to our ECCMC from the scene of an accident between March 1, 2009 and January 31, 2012. We compared patient characteristics such as gender and age between patients transported by HEMS and those transported by GA. We categorized patients into three age groups: pediatric (age <15 years), adult

(age 15-55 years), and elderly (age >55 years). The age limit of 55 years for the elderly category was defined based on previous literature, which used this cutoff to delineate an age above which trauma mortality risk is increased<sup>10)</sup>. We compared the Abbreviated Injury Scale (AIS) for each anatomical region, ISS, Revised Trauma Score (RTS), and probability of survival (Ps) between the two groups as indicators of trauma severity. We categorized ISS scores into the following groups: <9, 9-15, 16-24, and >24. We compared emergency operation rate, intensive care unit (ICU) admission rate, and mechanical ventilation rate as indicators of specialized trauma care, and survival rate as an indicator of outcome, between the two groups. As the GA service was not staffed by physicians, all patients transported by GA were initially treated by paramedics. Statistical analyses were performed using SPSS software (Version 17.0, Japan Inc.). Interval scales were assessed using the t-test, and categorical data were assessed using the chi-square test and residual analysis. P-values less than 0.05 were considered statistically significant.

## Results

We identified 450 blunt trauma patients who were transported to our ECCMC during the study period (324 males and 126 females, aged  $51 \pm 24$  years), of which 110 (24.4%) were transported by HEMS. The Fukushima HEMS were dispatched to the scene of the accident for 506 blunt trauma patients, of which 17 (3.4%) were transported to primary medical institutions, including 5 (1.0%) who were transported without a flight medical team because they had a minor injury, 114 (22.5%) who were transported to secondary medical institutions, 265 (52.4%) who were transported to one of the other three ECCMCs in Fukushima prefecture, and 110 (21.7%) who were transported to our ECCMC. Patient characteristics are shown in **Table 1**. A higher proportion of HEMS patients than GA patients were in the pediatric age group (10.0% vs. 5.0%), but this difference was not statistically significant (chi-square test:  $p=0.137$ ; adjusted standardized residuals (Radj)=1.9). Comparisons of AIS and ISS categories between the HEMS and GA groups are shown in **Table 2**. We found significant differences between the HEMS and GA groups in the AIS of the head or neck ( $1.98 \pm 1.52$  vs.  $1.69 \pm 1.25$ ; t-test:  $p<0.05$ ), chest ( $1.46 \pm 1.72$  vs.  $0.93 \pm 1.38$ ; t-test:  $p<0.01$ ), and extremities or pelvic girdle ( $1.14 \pm 1.28$  vs.  $0.84 \pm 1.13$ ; t-test:  $p<0.05$ ). We also found significant differences between the HEMS

**Table 1.** Comparisons of trauma patient characteristics between groups transported by HEMS and GA.

Patient characteristics	All patients (n=450)	HEMS (n=110)	GA (n=340)	p-value HEMS vs. GA
Gender				
Male (%)	324 (72.0)	84 (76.4)	240 (70.6)	NS
Age (mean ± SD)	51 ± 24	50 ± 24	51 ± 24	NS
Age group				
Pediatric (<15 years) (%)	28 (6.2)	11 (10.0)	17 (5.0)	NS
Adult (15-55 years) (%)	204 (45.3)	45 (40.9)	159 (46.8)	NS
Elderly (>55 years) (%)	218 (48.4)	54 (49.1)	164 (48.2)	NS

HEMS: helicopter emergency medical services, GA: ground ambulance, NS: not significant.

**Table 2.** Comparisons of AIS and ISS categories between groups transported by HEMS and GA.

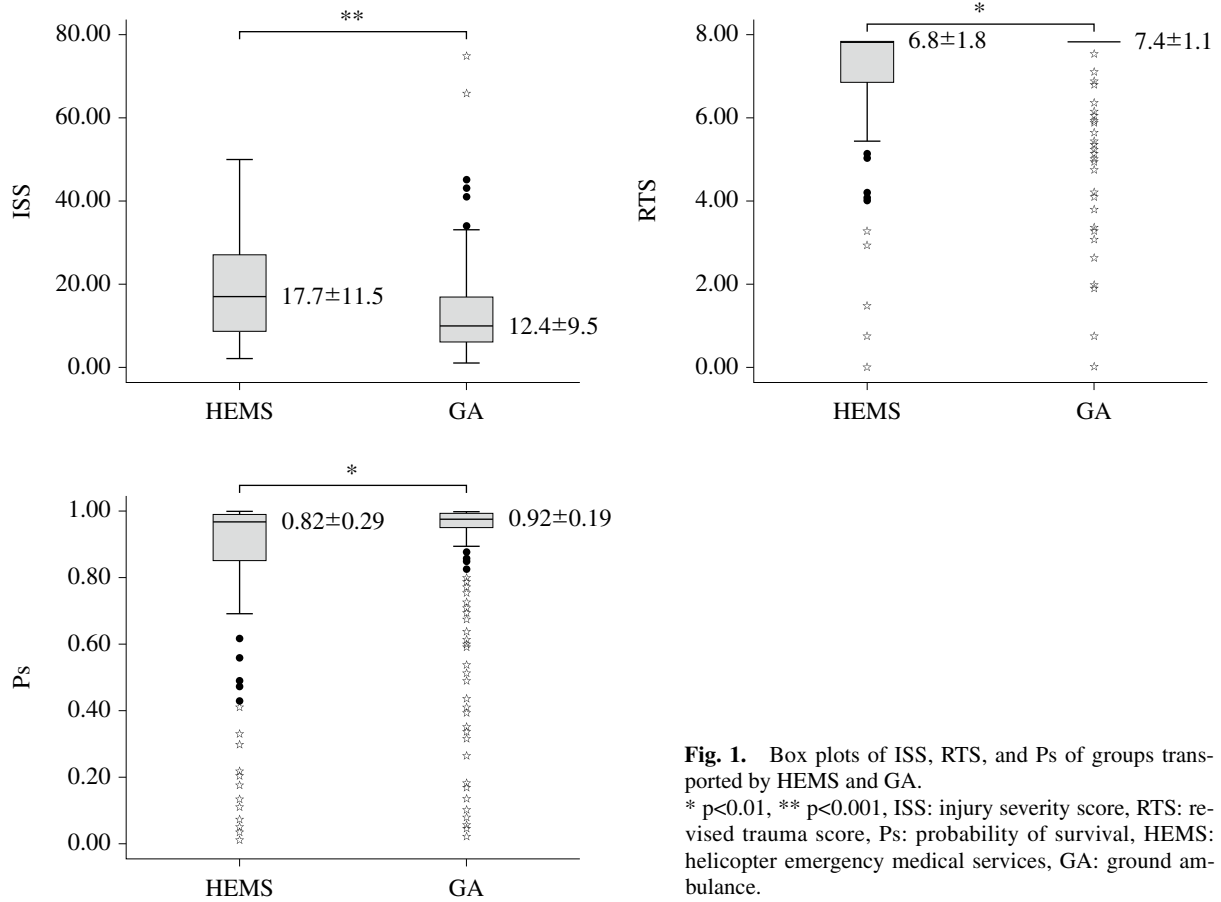
Injury score	All patients (n=450)	HEMS (n=110)	GA (n=340)	p-value HEMS vs. GA
AIS				
Head or neck	1.76 ± 1.33	1.98 ± 1.52	1.69 ± 1.25	p<0.05
Face	0.0	0.0	0.0	NS
Chest	1.06 ± 1.49	1.46 ± 1.72	0.93 ± 1.38	p<0.01
Abdomen or pelvic contents	0.60 ± 1.13	0.69 ± 1.20	0.57 ± 1.11	NS
Extremities or pelvic girdle	0.91 ± 1.18	1.14 ± 1.28	0.84 ± 1.13	p<0.05
External	1.11 ± 0.42	1.17 ± 0.38	1.10 ± 0.44	NS
ISS category (%)				
<9	161 (35.8)	28 (25.5)	133 (39.1)	p<0.05
9-15	139 (30.9)	26 (23.6)	113 (33.2)	NS
16-24	84 (18.7)	23 (20.9)	61 (17.9)	NS
>24	66 (14.7)	33 (30.0)	33 (9.7)	p<0.001

HEMS: helicopter emergency medical services, GA: ground ambulance, AIS: abbreviated injury scale, ISS: injury severity score; NS: not significant.

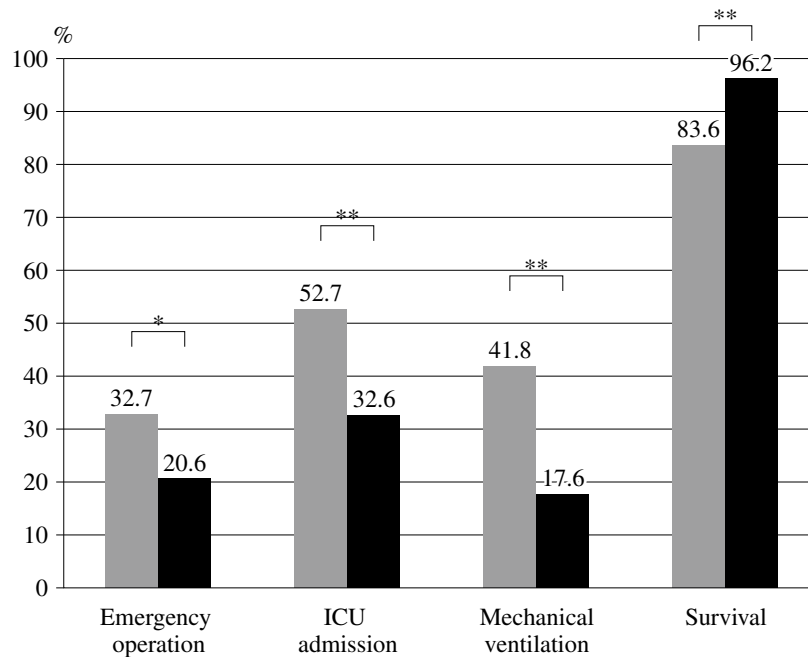
and GA groups in the proportion of patients with ISS <9 (25.5% vs. 39.1%; chi-square test:  $p<0.05$ ;  $R_{adj}=2.6$ ) and with ISS >24 (30.0% vs. 9.7%; chi-square test:  $p<0.001$ ;  $R_{adj}=5.2$ ). Of the trauma patients transported by HEMS, 50.9% had severe injuries (ISS >15). **Fig. 1** shows box-plots of ISS, RTS, and Ps in both groups. We found significant differences between the HEMS and GA groups in ISS (17.7±11.5 vs. 12.4±9.5; t-test:  $p<0.001$ ), RTS (6.8 ± 1.8 vs. 7.4 ± 1.1; t-test:  $p<0.01$ ), and Ps (0.82±0.29 vs. 0.92 ± 0.19; t-test:  $p<0.01$ ). Differences between the two groups in clinical indicators of specialized trauma care and outcome are shown in **Fig. 2**. We found significant differences between the HEMS and GA groups in the emergency operation rate (32.7% vs. 20.6%; chi-square test:  $p<0.01$ ), ICU admission rate (52.7% vs. 32.6%; chi-square test:  $p<0.001$ ), mechanical ventilation rate (41.8% vs. 17.6%; chi-square test:  $p<0.001$ ), and survival rate (83.6% vs. 96.2%; chi-square test:  $p<0.001$ ).

## Discussion

The most important role of HEMS is rapid transportation of a flight medical team to the scene of an accident to provide immediate, lifesaving medical treatment such as fluid resuscitation, drug administration, tracheal intubation, and tube thoracostomy. During the period of this study, flight medical teams attending trauma patients administered fluid resuscitation in 109 cases (99.1%) and drugs in 41 cases (37.3%), and performed tracheal intubation in 21 cases (19.1%) and tube thoracostomy in 10 cases (9.1%). In the United States, paramedics can undertake such prehospital interventions. In Japan, however, paramedics are not trained or permitted to undertake such interventions. HEMS in Japan are therefore expected to play a more important role in prehospital emergency care than their counterparts in the United States<sup>11</sup>. Many re-



**Fig. 1.** Box plots of ISS, RTS, and Ps of groups transported by HEMS and GA.  
 \* p<0.01, \*\* p<0.001, ISS: injury severity score, RTS: revised trauma score, Ps: probability of survival, HEMS: helicopter emergency medical services, GA: ground ambulance.



**Fig. 2.** Comparisons of specialized trauma care and outcome between groups transported by HEMS and GA.  
 \* p<0.01, \*\* p<0.001, ■ HEMS: helicopter emergency medical services, ■ GA: ground ambulance, ICU: intensive care unit.

cent studies have demonstrated the usefulness of HEMS for the care of trauma patients<sup>3-5</sup>). However, several studies have warned of inappropriate use of HEMS in terms of the injury severity of trauma patients transported to Level I trauma centers<sup>6,7</sup>). Clayton et al. reported that 54.7% of trauma patients who were transported by HEMS to a Level I trauma center in the United States had minor injuries (ISS <9), and emergency operation was needed in only 8.9%, indicating a need for more appropriate prehospital triage<sup>7</sup>). A patient with ISS <9 is considered to have an inappropriately minor injury to justify such a costly and risky method of transportation to a trauma center<sup>12,13</sup>). This study showed that 25.5% of patients who were transported by HEMS to our ECCMC had minor injuries (ISS <9), and emergency operation was needed in 32.7%. In addition, 50.9% of trauma patients had major injuries (ISS >15) and 52.7% needed ICU admission. Trauma patients with ISS >15 are considered to require specialized trauma care<sup>14-16</sup>), so about a half of the trauma patients transported by HEMS in this study were considered to have an injury of appropriate severity. These results suggest that HEMS flight medical teams in Japan are performing appropriate prehospital triage, which is one of the great advantages of the service. It has been reported that prehospital field triage is more precise when performed by physicians than by paramedics: paramedic-staffed prehospital services resulted in a 66% over-triage rate and 17% under-triage rate, and physician-staffed prehospital services resulted in a 35% over-triage rate and 2% under-triage rate<sup>17</sup>), respectively.

HEMS in Japan operate according to a “filter model,” which requires Fire Departments (FD) and paramedics to evaluate the severity of the patient’s condition and the patient’s transportation needs before requesting HEMS. Under the current system, only FD and paramedics can activate HEMS. It is therefore important for them to triage patients and activate HEMS without delay. HEMS should be activated without hesitation if severe injury is suspected according to the emergency call, even before the patient is evaluated at the scene. Specifying that HEMS should always be dispatched when there is a high-energy mechanism of injury can help the dispatcher to make a fast triage decision. Some over-triage by dispatchers is justified, and many minor trauma cases will be assessed at the scene if such a triage method is used. Further evaluation of trauma severity and choosing of the most appropriate hospital for treatment should be performed by the flight medical team. Simultaneous HEMS

and GA dispatches should be increased to enable early lifesaving treatment by flight medical teams. Such a dispatch system would allow FD and GA paramedics to use HEMS more effectively.

This study revealed that 21.7% of blunt trauma patients assessed at the scene by HEMS were brought to our ECCMC, 25.9% were transported to primary or secondary medical institutions, and 52.4% were transported to other ECCMCs. Smooth operation of HEMS depends on the cooperation of staff at the ECCMC as well as at primary and secondary medical institutions. The lack of hospitals that can admit patients with minor injuries leads to chronic bed shortages at the ECCMC, prevents flight medical teams from making appropriate decisions, and causes prehospital delays. We previously reported<sup>18</sup>) that patient placement was to the first choice of hospital in 84.5% of cases if GA was dispatched, and in 95.5% of cases if HEMS was dispatched. We consider these rates to be too low. The most common reason for over-triage (transportation of trauma patients with ISS <9 by HEMS to our ECCMC) was inability to admit the patient to the first choice of primary or secondary hospital. It is necessary to establish good cooperation with HEMS at every hospital to achieve efficient triage, enable choice of an appropriate hospital for the patient’s severity of injury, and reduce prehospital time. In this study, the HEMS group had significantly more severe trauma than the GA group, resulting in a higher mortality rate in the HEMS group. To improve the outcomes of trauma patients who are transported by HEMS, the following are needed: (1) immediate HEMS activation by dispatchers, (2) cooperation by staff in every hospital in the operational area that can receive HEMS patients, and (3) immediate lifesaving treatment by flight medical teams at the scene, and subsequent definitive treatment and critical care at the destination hospital. Dispatchers, medical institutions, and flight medical teams must constantly make a united effort to achieve these goals.

This study showed that the proportion of HEMS patients who were in the pediatric age group was twice the proportion of GA patients in the pediatric age group. This is assumed to be because there are very few hospitals that can provide surgical services for pediatric trauma patients in Fukushima prefecture, because of a shortage of pediatricians and pediatric surgeons. Pediatric patients with severe trauma have been transported to our ECCMC by HEMS from all areas of Fukushima since the system was implemented.

This study also revealed significant differences in AIS

of the head or neck ( $p < 0.05$ ), chest ( $p < 0.01$ ), and extremities or pelvic girdle ( $p < 0.05$ ) between the HEMS and GA groups. The anatomical region injured can significantly affect physiological parameters (injury of the head or neck can decrease Glasgow coma scale, injury of the chest can increase respiratory rate, and injury of an extremity or the pelvic girdle can decrease blood pressure). Dispatchers should recognize the significance of these injuries and activate HEMS for such patients.

There are several limitations to this study. First, this is a non-randomized, retrospective study with a small sample size, which can increase the risk of bias. However, it is very difficult to conduct randomized prospective clinical studies of HEMS, because HEMS are widely perceived as beneficial. Second, there is no adequate control group. As HEMS operate differently in Japan compared with other countries, it is difficult to conduct a strictly comparative study. Third, patients with blunt trauma who were transported by HEMS to other medical institutions were not assessed. There is currently no system for evaluation of trauma severity, patient care, or outcome of patients transported to other medical institutions by Fukushima HEMS, and there is no feedback system. Such information is essential for further investigation of the appropriateness of HEMS triage and transportation, including detection of under-triage by HEMS. It is important to establish a system that can evaluate the trauma severity, management, and survival of all patients transported by the Fukushima HEMS. We are currently considering implementing such a trauma registry and feedback system. In spite of these limitations, this study describes the current outcomes of HEMS triage and transportation of trauma patients in Fukushima, Japan, and provides important information that can be used to improve HEMS-related trauma care.

In conclusion, HEMS field triage by flight medical teams in Fukushima, Japan is almost ideal in terms of the injury severity of trauma patients transported to our ECCMC. This triage is one of the great advantages of the service. Dispatchers should activate HEMS without hesitation if severe injury is suspected. Some over-triage by dispatchers is justified because flight medical teams provide important secondary triage including further evaluation of trauma severity and choosing of the most appropriate hospital for treatment. HEMS are expected to play an increasingly important role in prehospital emergency medical care in Japan. We should aim to improve the outcomes of trauma patients by appropriate use of HEMS.

**Conflicts of Interest:** The authors report no conflicts of interest.

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原著論文

福島ドクターヘリは適切な現場トリアージを外傷症例に対して提供する

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**要旨** 【背景】ヘリコプター救急システム (helicopter emergency medical services: HEMS) の外傷症例に対する有用性は多くの報告で示唆されている。一方で、外傷症例の重症度の観点から、HEMSにおける不適切な現場トリアージに警鐘を鳴らす報告もある。本邦においては、HEMS (ドクターヘリ) で搬送された外傷症例の重症度、および現場トリアージの実態は明らかになっていない。【対象および方法】2009年3月1日から2012年1月31日の期間に当院救命救急センターへ現場から直接搬送された全ての鈍的外傷症例を後方視的に調査し、重症度 (Injury Severity Score (ISS), Revised Trauma Score (RTS), Probability of survival (Ps)), 入院後管理 (緊急手術率, ICU収容率, 機械換気率) についてHEMS群と救急車 (ground ambulance: GA) 群で比較検討した。【結果】450症例 (男性324名, 年齢  $51 \pm 24$  歳) が特定され, 110例 (24.4%) がHEMSで搬送されていた。HEMS群はGA群に比較して有意に重症で (ISS  $17.7 \pm 11.5$  vs.  $12.4 \pm 9.5$ ,  $p < 0.001$ , RTS  $6.8 \pm 1.8$  vs.  $7.4 \pm 1.1$ ,  $p < 0.01$ , Ps  $0.82 \pm 0.29$  vs.  $0.92 \pm 0.19$ ,  $p < 0.01$ ), 有意に多く特別なケアを必要としていた (緊急手術率 32.7% vs. 20.6%,  $p < 0.01$ , ICU収容率 52.7% vs. 32.6%,  $p < 0.001$ , 機械換気率 41.8% vs. 17.6%,  $p < 0.001$ )。【考察】重症外傷症例がHEMSにより適切にトリアージされ, 当院救命救急センターに搬送されていた。HEMSには適切な2次トリアージ効果が備わっているため, 要請側は疑ったら躊躇せずHEMSを始動すべきであり, オーバートリアージは許容されるべきである。

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