



## Original article

# Outcomes of patients with decompression illness transported by physician-staffed helicopter according to Japanese Registry data (2015–2020)

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## Abstract

**Objective:** No nationwide reports have focused on patients with decompression illness (DCI) transported by doctor helicopter (DH) in Japan. We performed this retrospective study to examine this population using data from the Japan DH registry system (JDRS).

**Patients and Methods:** Patients were initially selected from the JDRS database. They were divided into two groups: those transported by the Eastern Shizuoka DH (ES-DH) and those transported by other DHs. Variables were compared between the two groups.

**Results:** There were 44 patients who had DCI out of 41,592 patients in the JDRS. The majority of cases (70%) were transported by the ES-DH. In the ES-DH group, age, rate of request type using key words, and rate of instrumental intervention to secure an airway were significantly greater, and the median Glasgow Coma Scale score was significantly lower than that of the other DH group. However, there was no statistically significant difference in the rate of cases with fatal outcomes between the two groups.

**Conclusions:** This is the first report regarding the current status of patients with DCI transported by DH in Japan. Most patients were transported by ES-DH to the Izu Peninsula. In addition, the patients transported by ES-DH due to decompression illness tended to be severely ill; however, the outcomes of the ES-DH and other DH groups did not differ to a statistically significant extent and therefore effective recompression therapy could be successfully performed at suitable hospitals owing to timely transportation.

**Key words:** decompression illness, doctor helicopter, outcome, aviation, treatment

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## Introduction

The physician-staffed helicopter emergency medical service (HEMS), also called the doctor helicopter (DH) in Japan, transports a flight doctor and flight nurse to the scene of an emergency during the day (<https://hemnet.jp/en>). As of April 2022, 56 DHs have been deployed in 47 prefectures across Japan. The Japan DH Registry System (JDRS) established by the Japanese Society for Aeromedical Services,

prospectively collects dispatch data. These data (including the final outcome at one month) are registered for all DH base hospitals in Japan from April 2015 to March 2020<sup>1</sup>. The collected data were made available to each base hospital from December 2022.

DHs have been reported to carry patients with various conditions including trauma, acute coronary syndrome, stroke, and cardiopulmonary arrest<sup>2–5</sup>. DHs have also been employed to evacuate patients with decompression illness (DCI) from the scene and transport them to medical facilities that can provide recompression treatment<sup>6, 7</sup>. Our hospital is located in Eastern Shizuoka and is the base of the Eastern Shizuoka DHs. We have developed a cooperative medical system for treating DCI in the Izu Peninsula in Eastern Shizuoka involving the fire department, coast guard, HEMS, and professional divers belonging to local dive shops<sup>6</sup>. Our hospital has one monoplace chamber for hyperbaric oxygen therapy, and this is not suitable for patients with severe DCI. The HEMS can transport patients from the scene to a suitable hospital within 15 to 20 min.

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In contrast, a ground ambulance would take at least 1.5 h to reach the receiving hospitals. Accordingly, we recommend the early dispatch of the DH when patients with DCI are encountered. However, there have been no nationwide reports focusing on the outcomes of patients with DCI transported by DHs in Japan. Therefore, we conducted the present retrospective study to examine this population using data from the JDRS.

## Patients and Methods

The protocol for this retrospective study was approved by our institutional review board, and the research was conducted according to the standards of good clinical practice and the Declaration of Helsinki. The approval number for this study was 733 by the Juntendo University Review Board.

We initially selected subjects from the JDRS database using the key words “DCI”, “diving”, and “caisson disease”. The following details of the dispatch activity were collected from the JDRS database: transportation by Eastern Shizuoka or other DH, subjects’ age and sex, type of DH dispatch request (before emergency medical technicians [EMTs] encountered the patient or after), the period from the first call requesting the dispatch of the DH, to first contact by the DH staff, and finally arrival at the receiving hospital. The other information collected were details regarding the presence of cardiac arrest when EMTs first examined the patient, vital signs (Glasgow Coma Scale [GCS], systolic blood pressure, heart rate, respiratory rate) when the DH staff encountered the patient, components of the medical intervention (tracheal intubation and securing venous route), destination (base hospital/other hospital), and outcome (fatal or otherwise). The data on oxygen saturation were not analyzed because these levels were not evaluated by the JDRS database.

When an 119 emergency call reaches the central command room of the fire department, an ambulance is dispatched to the scene, and the central command room of the fire department can request the dispatch of the DH. A DH carrying a flight doctor and flight nurse on board then travels to the rendezvous point. The doctor and nurse board the ambulance and immediately start to treat the patient. Key words can help flight doctors and nurses prepare for such treatment. For example, if the words ‘chest pain’ are mentioned during the first call, the patient might have acute coronary syndrome. Furthermore, in such cases, the fire department can request the dispatch of the DH before the EMT actually checks the patient. In the present study the subjects were divided into two groups: those transported by the Eastern Shizuoka (our) DHs and those transported by other DHs, and the variables were compared between the two groups.

The data were analyzed using Wilcoxon’s test for age, systolic blood pressure, heart rate, and respiratory rate; median GCS Because; and  $\chi^2$  test for sex, dispatch type, and medical interventions. Statistical significance was set at  $P < 0.05$ . Data are shown as the mean  $\pm$  standard deviation, median with interquartile range, or number.

## Results

During the investigation period (April 2015 to March 2020), 41,592 patients were registered in JDRS. Among them, 44 had DCI, all of whom were enrolled as subjects in this study. The background characteristics of the participants are listed in Table 1. All participants had been evacuated from the scene, with no cases of inter-hospital transportation. The majority of cases (70%) were transported by the Eastern Shizuoka DH.

The results of the analyses of these two groups are presented in Table 2. There were no significant differences between the groups with regard to sex, duration from the first call to request the dispatch of the DH to first contact with the DH staff, arrival at the receiving hospital, rate of cardiac arrest, systolic blood pressure, heart rate, respiratory rate, rate of securing a venous route, destination, or outcome. However, in the Eastern Shizuoka DH group, age, rate of request type using keywords, and rate of intervention with instruments to secure an airway were significantly greater than those the other DH groups. The median Glasgow Coma Scale score of the Eastern Shizuoka DH group was significantly lower than that of the other DH groups.

**Table 1** Patients’ demographic details

Total number	44
Eastern Shizuoka DH/other DH	31/13
Sex (male/female)	28/16
Average age	40.4 $\pm$ 14.0
Destination (base hospital/other hospital)	10/34
Request type of DH (after contact/key word)	14/30
Duration from the first call (in minutes)	
Request dispatch of the DH	11.3 $\pm$ 12.2
First contact by the DH staff	38.8 $\pm$ 72.4
Arrival at hospital	72.4 $\pm$ 26.2
Cardiac arrest when EMTs contact	6
Glasgow Coma Scale when EMTs contact	15 (14,15)
Systolic blood pressure (mmHg)	124.6 $\pm$ 23.3
Heart rate (beats per minute)	83.9 $\pm$ 25.0
Respiratory rate (breaths per minute)	21.1 $\pm$ 7.6
Tracheal intubation	7
Securing venous route	42
Fatal outcome	4 (unknown 8)

Mean  $\pm$  standard deviation, median with the inter-quartile range for the Glasgow Coma Scale. DH: doctor helicopter; EMTs: emergency medical technician.

**Table 2** Comparison between Eastern Shizuoka DH and other DHs

	Eastern Shizuoka	Other	<i>P</i> -value
Sex (male/female)	19/12	9/4	0.6
Average age (years)	44.2 ± 13.7	31.5 ± 10.8	0.006
Request type of DH (after contact/key word)	7/24	7/6	0.04
Duration from the first call (minutes)			
Request dispatch of the DH	10.2 ± 11.6	14.4 ± 13.9	0.69
First contact by the DH staff	38.6 ± 19.9	39.4 ± 16.2	0.65
Arrival at hospital	68.1 ± 21.8	84.2 ± 34.0	0.24
Cardiac arrest when EMTs contact (yes/no)	5/26	1/12	0.4
Glasgow Coma Scale when EMTs contact	15 (13,15)	15 (15,15)	0.01
Systolic blood pressure (mmHg)	126.6 ± 27.4	120.8 ± 11.5	0.5
Heart rate (beats per minute)	82.9 ± 25.7	86.3 ± 24.6	0.7
Respiratory rate (breaths per minute)	19.5 ± 7.3	25.4 ± 7.4	0.10
Tracheal intubation (yes/no)	7/24	0/13	0.01
Securing venous route (yes/no)	20/1	12/1	0.5
Destination (base hospital/other hospital)	8/23	2/11	0.4
Fatal outcome	4/25 (missing, 2)	0/10 (missing, 3)	0.10

Mean ± standard deviation, median with the inter-quartile range for the Glasgow Coma Scale. DH: doctor helicopter; EMTs: emergency medical technician.

## Discussion

To our knowledge, this is the first study to report the current status of patients with DCI transported by DHs in Japan. The majority of cases were transported by Eastern Shizuoka DH in the Izu Peninsula. Moreover, patients transported by the Eastern Shizuoka DH tended to have DCI-associated disturbances of consciousness and were older. Some of the possible reasons for patients with DCI in the Izu Peninsula demonstrating a decreased level of consciousness include the following: 1) DCI tends to worsen easily in elderly individuals. 2) While there are some individuals who spontaneously recover from DCI, it is possible that they may have previously experienced DCI symptoms before achieving a natural recovery<sup>8, 9</sup>. In addition, the prognosis of patients with DCI is poor<sup>10–12</sup>. However, the outcomes of the two groups were not significantly different. This might be due to early medical intervention made possible by the timely dispatch of DH using key words. Early medical interventions, such as securing a venous route, infusion, and clearing the airway, may have contributed to the improved survival of patients with DCI. In Japan, EMTs cannot perform instrumental airway establishment or infusion until a patient experiences cardiac arrest. However, DH can provide such treatment before reaching the hospital, in addition to early transportation. Correction of dehydration induced by diving and a definite increase in oxygenation by tracheal intubation might contribute to clinical improvement in patients with severe DCI. Moreover, early recompression at the receiving hospital may also result in improved survival among patients with DCI. This difference may have improved the outcomes of patients evacuated by the Eastern

Shizuoka DH using the keyword method.

Many diving accidents have occurred in the Izu Peninsula in Eastern Shizuoka, Japan. In this context, in 2011, we began to hold meetings concerning how to manage patients with DCI in our hospital because there was no established medical council protocol regarding patients with DCI<sup>6, 13</sup>. As a result, all representatives of the participating organizations (fire department, coast guard and professional divers belonging to local dive shops on the Izu Peninsula) joined the meeting. These meetings have been held annually since 2011. In these meetings, we hold lectures concerning new topics related to DCI, review the management of patients with DCI at the scene using videos, discuss how to recognize DCI, the importance of early request for dispatch of DH, share information on the diving profile using a diving checklist, and review the proper and prompt management of patients with DCI<sup>14</sup>. To request the early dispatch of the Eastern Shizuoka DH, we recommended using the key words of “accident during diving”. This may explain why the majority of data on patients with DCI came from patients who were transported by the Eastern Shizuoka DH.

The present study has some limitations. We could not assess the following issues: 1) whether DCI developed in other areas (although Japan is surrounded by the sea); 2) whether EMTs in other areas missed patients with DCI; 3) whether EMTs in other areas chose not to transport patient by DH because of deterioration of DCI; 4) whether EMTs in other areas chose not to transport patients by DH because there were no suitable medical facilities for recompression because there are few such hospitals in Japan ([https://www.jshm.net/file/hbo/JSHUM2021\\_0307.pdf](https://www.jshm.net/file/hbo/JSHUM2021_0307.pdf)); and 5) whether registers in other areas simply missed the registration of pa-

tients with DCI. 6) The average of the first call to request the DH until arrival at the receiving hospital was not statistically significant, perhaps because of the small number of cases or the intentionally delayed dispatch of the DH to wait until a patient could be transported to the shore by ship. At least in the Izu Peninsula, we explained that DHs could provide safe air evacuation by flights traveling at altitudes of less than 300 m with the administration of oxygen and fluids<sup>15</sup>).

## Conclusion

This is the first report describing the current status of patients with DCI transported by DH in Japan. The majority of cases were transported by Eastern Shizuoka DH on the Izu Peninsula. In addition, patients transported by the Eastern Shizuoka DH tended to be in a severe condition due to DCI; however, the outcomes were not significantly different from those of the other DH groups, perhaps because the early dispatch of the DH facilitated early medical interven-

tion and therefore effective recompression therapy could be successfully performed at suitable hospitals owing to timely transportation.

**Ethics approval:** The research protocol was approved by the Juntendo University Review Board. Approval No. 733. Obtaining informed consent was waived by the review board.

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**Conflict of interest:** We do not have any conflicts of interest to declare.

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