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Original Research

Convulsion Treated by a Physician-Staffed Helicopter

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A B S T R A C T

Objective: There have been no reports focusing on patients with convulsion treated by a doctor helicopter (DH). We herein report the results of a retrospective analysis investigating the changes in patients' vital signs and clinical manifestations during transportation and the outcomes of treating convulsive patients using a government-funded medical DH.

Methods: We retrospectively investigated all of the patients with convulsion who were transported by the DH between January 2013 and December 2018.

Results: A total of 118 cases were enrolled in the present study. The average age was 32 years old, and most were men. Fifty cases showed remaining convulsion when the staff of the DH made contact with the subject. All subjects obtained a survival outcome. Regarding anticonvulsants administered, diazepam was the most frequently used followed by midazolam. The frequency of convulsion after transportation was significantly lower than that before transportation. The Glasgow Coma Scale and peripheral capillary oxygen saturation after transportation to a hospital were higher than before transportation. The heart rate after transportation to a hospital was lower than before transportation.

Conclusion: The present study indicated the usefulness of a physician-staffed helicopter for treating convulsive patients at the scene.

A physician-staffed helicopter in Japan is called a doctor helicopter (DH). The crew of the DH generally consists of 1 pilot, 1 mechanic, 1 doctor, and 1 nurse. Our hospital in eastern Shizuoka Prefecture began to provide DH service in 2004. Since then, the service has been used to directly transport patients with a variety of diseases and trauma, including patients with convulsion, from the scene to a medical facility.[1-6]

Eastern Shizuoka is a mountainous region approximately 4,090 km^2 in size with a population of approximately 2 million and relatively few hospitals.[1] The journey from the southern tip of the peninsula to the critical care medical center of our hospital takes at least 1.5 hours by ambulance along a winding road that crosses over mountain passes. In contrast, the trip only takes 15 minutes by DH.[1] The road often becomes congested because eastern Shizuoka is a sightseeing resort area that is located near Tokyo. In such situations, ground ambulances take even longer to transport patients. Only the fire department and doctors in hospitals that have a heliport can request the dispatch of the DH for critically ill or traumatized patients. The fire department requests the dispatch of the DH based on either the contents of the first call before emergency medical technicians (EMTs) make contact with patients or the presence of critically ill patients as confirmed by EMTs at the scene.

In Japan, local governments have established the emergency medical system (EMS) as a public service, and anyone can call for an ambulance free of charge by dialing 119. Most local governments use a 1-tier emergency system. Usually, the fire department dispatches the EMS team (3 EMTs) in an ambulance after receiving a 119 call. Recently, Japanese EMTs have been allowed to secure a venous route, secure an airway with instruments, and inject adrenaline for patients in cardiac arrest; however, they still cannot administer anticonvulsants to patients with convulsions. Accordingly, before the establishment of the DH system, uncontrolled convulsive patients in Japan were transported as quickly as possible by an ambulance to a receiving hospital without any treatment by EMTs. However, evidence-based guidelines concerning the treatment of convulsive status

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epilepticus recommend the administration of anticonvulsants as early as possible in order to minimize brain injury.[7-9] Accordingly, EMTs or the fire department have routinely requested the dispatch of the DH in eastern Shizuoka in cases of patients with convulsion that is not self-resolving.

There have been a few reports concerning patients with convulsion during air transportation.[10-13] However, none of those reports focused on the significance of using a helicopter for patients with convulsion. We herein report the results of a retrospective analysis investigating the changes in patients' vital signs and clinical manifestations during transportation and the outcomes of treating convulsive patients using a government-funded medical DH.

Methods

The purpose of the current study was to determine whether or not convulsive patients treated by the staff of the DH while being transported from the scene or referring hospital obtained a favorable outcome by analyzing the changes in the vital signs and clinical manifestations before and after treatment. The protocol of this retrospective study was approved by our institutional review board, and the examinations were conducted in accordance with the standards of good clinical practice and the Declaration of Helsinki.

We retrospectively investigated all of the patients with convulsion who were transported by the DH between January 2013 and December 2018, when medical charts were preserved as dictated by Japanese law, using the registry data of the DH control room of our hospital. We did not include the convulsive patients who were transported to our hospital by self-transport or ground ambulance. The exclusion criteria were as follows: 1) dispatch of the DH after taking off was cancelled based on the judgment of the EMTs who encountered the patients and 2) patients transported by ambulance only with EMTs after their status was checked by the staff of the DH.

The patients' age; proportion who were children (under 13 years old); sex; proportion who were evacuated from the scene or received interhospital transportation; duration from first call to first contact; duration from first call to arrival at the receiving hospital; treatments (secure venous route, oxygenation, administration of drugs, contents of the drugs, and tracheal intubation); clinical manifestations (remaining convulsion or not); improvement of remaining convulsion on arrival at the receiving hospital; survival rate at discharge from the receiving hospital; and vital signs during the flight, including the Glasgow Coma Scale, systolic blood pressure, heart rate, and peripheral capillary oxygen saturation during flight (at first contact, when it was checked by the DH staff, and on arrival at the hospital) were investigated. Changes in the vital signs and the resolution of the remaining convulsions during the flight, at first contact, and on arrival at the hospital were statistically analyzed.

The data were analyzed using the Wilcoxon test for the Glasgow Coma Scale; the paired Student *t*-test for variables, including systolic blood pressure, heart rate, and peripheral capillary oxygen saturation; and the chi-square test for the resolution of clinical manifestations during the flight. The data were expressed as the mean ± standard deviation or median (interquartile range) for continuous variables and as the number for categoric variables. $P < .05$ was considered to indicate statistical significance.

Results

There were 134 dispatches of the DH for convulsive patients during the investigation period. The following cases were excluded from the study: cases in which dispatch of the DH was cancelled because of the patient's condition (convulsion was deemed doubtful after the patient was checked by the EMTs) (n = 2) and cases that were transported by the EMTs after the patient's condition was checked by the staff of the DH (n = 14). The 118 remaining cases were enrolled in the present study.

Table 1 shows the background characteristics of the subjects. The average age was 32 years old, and most were men. Fifty cases showed remaining convulsion when the staff of the DH made contact with the subject. All subjects obtained a survival outcome.

Table 2 describes the drugs administered at the scene and during air transportation. Diazepam was the most frequently used followed by midazolam. All 5 subjects who were administered vecuronium in this study received the drug for tracheal intubation at the scene.

Table 3 shows the clinical diagnosis of convulsion. Idiopathic epilepsy was the most frequently reported diagnosis followed by febrile convulsion.

Table 4 shows the changes in the vital signs and ratio of convulsion before and after transportation via the DH. The analyses show that the frequency of convulsion after transportation was significantly lower than that before transportation. The analysis also showed that the Glasgow Coma Scale and peripheral capillary oxygen saturation after transportation to a hospital were higher than before transportation. The heart rate after transportation to a hospital was lower than before transportation. After excluding subjects with tracheal intubation whose consciousness deteriorated after medical treatment, the difference between the before and after findings according to the Glasgow Coma Scale provided a strong statistical strength.

Discussion

This is the first study indicating the usefulness of the DH for managing convulsive patients at the scene by analyzing the ratio of the

Table 1
Background Characteristics of Subjects

Age (range [average])	0-96 (32.2 ± 30.9)
Number of children (under 13 years old) (%)	58 (49.1)
Sex (male/female)	67/51
Scene/interhospital	106/12
Request–scene time (minute)	15.2 ± 8.4
Request–hospital time (minute)	46.9 ± 13.3
Secure venous route (%)	103 (87.2)
Oxygenation (%)	92 (77.9)
Tracheal intubation (%)	16 (13.5)
Drug (%)	62 (52.5)
Convulsion on contact (%)	50 (42.3)
Survival ratio (%)	118 (100)

Table 2
Drugs Administered at the Scene or During Air Transportation

Drug Administered	n
Diazepam	46
Midazolam	13
Thiopental	1
Propofol	1
Metoclopramide	5
Vecuronium	5

Table 3
The Clinical Diagnosis of the Etiology of Convulsion

Diagnosis	n
Idiopathic epilepsy	60
Febrile convulsion	25
Symptomatic epilepsy	18
Convulsions with mild gastroenteritis	6
Trauma	1
Alcohol	1
Hepatic failure	1
Hypoglycemia	1
Unknown	5

Table 4
A Comparison Between Before and After Medical Intervention

	Before	After	*P* Value
Glasgow Coma Scale	10 (6,14)	12.5 (6.75, 15)	<.01
Excluding intubation (n = 102)	11 (7.75, 14)	13 (9.75,15)	<.0001
Systolic blood pressure (mm Hg)	129.0 ± 28.9	123.1 ± 26.4	.05
Heart rate (beat/min)	121.0 ± 34.0	116.2 ± 31.7	.01
SpO_2 (%)	97.8 ± 3.4	98.8 ± 1.7	<.01
Convulsion (%)	50/118 (42.3)	2/118 (1.6)	<.0001

SpO_2 = peripheral capillary oxygen saturation.

convulsions and the changes in the patients' vital signs as a result of medical interventions provided by the DH staff, as opposed to those provided by the EMTs (whose interventions are limited based on their permitted scope of practice in Japan).

The most important treatment for prolonged convulsion is the administration of anticonvulsants as soon as possible in order to minimize brain injury.[7] A prolonged convulsive status (ie, status epilepticus) can result in a poor functional or fatal outcome because of direct hypoxic cerebral insult and/or indirect hypoxic multiple acute medical problems induced by massive autonomic activation, such as resultant tachycardia, hyperthermia, increased plasma glucose levels, lactic acidosis, and hypertension or trauma.[14-17] The duration of status epilepticus is the only potentially modifiable determinant of mortality.[15] With an early diagnosis and the prompt initiation and completion of treatment, this duration can be directly medically modified.[15] The present study showed a decreased ratio of convulsive status and improvement of the vital signs after medical intervention, as well as an improvement in the ultimate survival outcome for all of the patients with convulsion. The early provision of treatment with an anticonvulsant by the staff of the DH, appropriate medical support for hemodynamic and airway management, and rapid air transportation facilitating the early initiation of neuroprotective treatment in the intensive care unit for severe cases may help obtain a favorable outcome.

In some foreign countries, EMTs or health care providers can administer anticonvulsants to patients with convulsion.[9,18] Accordingly, if Japanese EMTs were also permitted to administer anticonvulsants to such patients, a more favorable outcome might be able to be obtained. Given the mountainous topography of the Izu peninsula, the staff of the DH can often reach patients with convulsion faster than they could in a ground ambulance. Such situations would still prove beneficial, even if Japanese EMTs were able to administer anticonvulsants to all patients suffering from convulsions. In addition, in the trauma setting in Australia, EMTs are equipped with many of the same procedural skills as physicians, although the mortality rate in physician-staffed units was confirmed to be lower than in EMT-staffed units; however, this is probably because of differences in their decision-making ability and not in their procedural skills.[19] Similar outcomes might be expected for severe convulsive patients. Other benefits of the DH include the ability to respond within a large geographic area, the ability to deliver the highest level of prehospital medical care, the ability to identify hospitals able to treat patients in a severe medical condition, and the ability to facilitate patient transport, even in rural areas.[6]

The first-line treatment for prolonged convulsion is the injection of diazepam or lorazepam as soon as possible in order to minimize brain injury.[7] However, injection-type lorazepam has not been approved for use by the Ministry of Health, so Japanese physicians cannot clinically use this drug. Diazepam and mitazoram are routinely available in the eastern Shizuoka DH, so most subjects were treated with these drugs. This was the reason why diazepam and mitazoram were predominantly used in the present study.

The present study is associated with several limitations. First, this study had a small sample size and was retrospective in design. Second, this study did not directly compare the outcomes of convulsive patients transported by the DH with those transported by a ground ambulance because no such data exist among the registry data of the DH control room at our hospital. Therefore, larger-scale human studies are warranted to determine the usefulness of the DH service for managing convulsive patients.

Conclusion

The present study indicated the usefulness of a physician-staffed helicopter for treating convulsive patients at the scene.

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