Original report

An analysis of patients with anaphylaxis treated by a physician-staffed helicopter

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Abstract

Purpose: To determine whether or not anaphylactic patients treated by the doctor helicopter (DH)staff and transported from the scene obtained a favorable outcome by analyzing the changes in the vital signs and clinical manifestation before and after treatment during flight.

Methods: We retrospectively investigated all of the patients with anaphylaxis who were transported by the DH between March 2004 and February 2017.

Results: A total of 68 cases were enrolled in the present study. The average age was 48 years old, and most were males. The most frequent cause of anaphylaxis was bee or wasp sting

followed by food allergy. Adrenaline injections were executed at the scene for 48 cases. The condition of 64 (94%) subjects improved or totally subsided (n=25, 37%) after arriving at the hospital. The Glasgow Coma Scale, peripheral capillary oxygen saturation and systolic blood pressure after transportation to a hospital were higher than before transportation. All subjects who were treated by the DH staff obtained a survival outcome without sequelae.

Conclusion: The vital signs and clinical conditions of the patients who were treated by the DH staff when they were in an anaphylactic state at the scene showed improvement when they arrived at the hospital.

1. Introduction

A physician-staffed helicopter in Japan is called a doctor helicopter (DH). The crew of the DH generally consists of one pilot, one mechanic, one doctor and one nurse. Our hospital in eastern Shizuoka prefecture began to provide a DH service in 2004. Since then, the service has been used to directly transport patients with variety of diseases and trauma, including patients with anaphylaxis, from the scene to a medical facility.[1-5] Eastern Shizuoka is a mountainous region of approximately 4,090 km^2 in size and a population of approximately 2 million with relatively few hospitals.[1] The journey from the southern tip of the peninsula to the critical care medical center of our hospital takes 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 more time 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 patients, including trauma patients. The fire department requests the dispatch of the DH based on either the contents of the first call before emergency medical technicians (EMTs) contact 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 one-tier emergency system. Usually, the fire department dispatches the EMS team (three EMTs) in an ambulance after receiving a 119 call. Recently, EMTs, who can secure a venous route, secure an airway with instruments, and inject adrenaline for patients in cardiac arrest, have been allowed to inject adrenaline for patients in anaphylactic shock who have already been treated with an adrenaline autoinjector in a previous anaphylactic attack.

Previous studies have reported the usefulness of the early injection of adrenaline for patients with anaphylaxis at the scene.[6-9] However, there has been only one report concerning the treatment of patients with anaphylaxis by air ambulances during transport from the scene due to the small number of patients.[10] In addition, an adrenaline autoinjector can be used to treat anaphylaxis today.[11,12]

We herein report the results of a retrospective analysis investigated the changes in patients' vital signs and clinical manifestations during transportation and the outcomes of treating anaphylactic patients transported from the scene using a government-funded medical DH.

2. Methods

The purpose of the current study was to determine whether or not anaphylactic patients treated by staff of the DH while being transported from the scene 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 anaphylaxis who were transported by the DH between March 2004 and February 2017, using the registry data of the DH control room of our hospital. We did not include the anaphylactic 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 after seeing the patients or 2) patients were in cardiac arrest. The diagnosis of anaphylaxis was determined by an interview and physical examination.

The patients' age, sex, cause of anaphylaxis, month of dispatch, duration from first call to first contact, duration from dispatch call to first contact, treatment, clinical manifestations (respiratory or/and cardiovascular, and none), improvement of clinical manifestations, vital signs, including 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), the admission and survival rates were investigated. Changes in the vital signs and the resolution of the clinical manifestations during the flight, at first contact and on arrival at the hospital were statistically analyzed.

The data were analyzed using the Wilcoxon test for Glasgow Coma Scale, the paired Student's *t*-test for variables, including systolic blood pressure, heart rate and peripheral capillary oxygen saturation, and a χ^2 analysis for the resolution of clinical manifestations during the flight. The data were expressed as the mean ± standard deviation (SD) or median (interquartile range) for continuous variables and as the number for categorical variables. P values of <0.05 were considered to indicate statistical significance.

3. Results

There were 72 cases in which anaphylaxis was diagnosed in patients transported by the DH during the investigation period. The following cases were excluded from the study: cases in which dispatch of the DH was cancelled (n=3) and cases in cardiac arrest (n=1). The 68 remaining cases were enrolled in the present study. Among them, 7 cases were inter-hospital transportation, and the rest (61 cases; 90%) were directly evacuated from the scene.

Table 1 shows the background characteristics of the subjects. The average age was 48 years old, and most were males. The most frequent cause of anaphylaxis was bee or wasp sting followed by food allergy (**Figure 1**). The most dispatches were received from July to October (**Figure 2**).

Figure 3 shows the clinical manifestations of the patients. **Figure 4** describes the treatments executed at the scene. Adrenaline injections were executed at the scene for 48 cases. Among them, three cases had already received adrenaline via autoinjector. Two of the three underwent additional adrenaline at the judgment of the staff of the DH. Aside from these three cases, five additional subjects received adrenaline from doctors at the local medical facilities. The EMTs provided only oxygen before patients encountered the staff of the DH. There were no subjects who underwent tracheal intubation at the scene in this study.

Table 2 shows the changes in the vital signs before and after transportation via DH. The analyses show that after transportation to a hospital, the patients' Glasgow Coma Scale,

peripheral capillary oxygen saturation, and systolic blood pressure values were higher than they had been before transportation. However, the heart rate did not differ to a statistically significant extent.

Table 3 shows the outcomes. The clinical manifestations of 16 subjects had completely resolved by the time they encountered the staff of the DH. Among them, five subjects underwent adrenaline injection by doctors at the local medical facilities. The condition of 63 (93%) subjects improved or totally subsided (n=25, 37%) after arriving at our hospital. The number of patients whose clinical manifestations subsided increased from 16 to 25 when the subjects arrived at the hospital, a statistically significant difference ($p<0.0001$). All subjects who were treated by the staff of the DH obtained a survival outcome without sequelae.

We herein report a case of cardiac arrest due to a bee sting that developed before the staff of the DH arrived. A 58-year-old male who had been stung by a bee while playing golf lost consciousness after arrival at the reception facility. This was his first instance of anaphylactic shock, so he did not have an adrenaline autoinjector. When EMTs checked him, he was in cardiac arrest. The initial rhythm was pulseless electrical activity. As the EMTs could not secure a venous route, they performed only basic life support for him. Even after the staff of the DH encountered the patient, he remained in cardiac arrest. He underwent tracheal intubation and infusion of adrenaline (total 3mg during flight; 1mg every 4minutes 3 times until landing at the heliport of our hospital). However, he was unable to obtain spontaneous

circulation.

4. Discussion

This is the first study indicating the usefulness of a physician-staffed helicopter to treat anaphylactic patients at the scene by analyzing 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 were limited based on their scope of practice in Japan).

The most important treatment for severe anaphylaxis is the injection of adrenaline as soon as possible.[6] This study showed that a survival outcome was achieved for all of the patients with anaphylaxis, except for the patient in cardiac arrest. The early provision of treatment including adrenaline by the staff of the DH resulted in obtaining a favorable outcome. In some foreign countries, EMTs or health care providers can inject adrenaline for patients with anaphylaxis even if the patients are not in cardiac arrest.[7,13] Accordingly, if Japanese EMTs also could inject adrenaline in such patients, even if they were not in cardiac arrest, a more favorable outcome might be obtained. Given the mountainous topography of the Izu peninsula, the staff of the DH can often reach a patient with anaphylaxis faster than they could in a ground ambulance. Such situations would still prove beneficial, even if Japanese EMTs were able to inject adrenaline in all patients suffering from anaphylaxis. 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, probably due to their decision-making ability and not procedural

skills.[14] This might hold similarly true for severe anaphylactic patients. Other benefits of the DH include response within a large geographic area, the highest level of prehospital medical care, identification of hospitals able to treat patients in a severe medical condition, and the facilitation of transport even in rural areas.

Søreide et al. reported the treatment of 27 patients with severe anaphylactic reactions by 2 anesthesiologist-staffed ambulance helicopters during a 5-year period.[10] All patients had signs of respiratory and/or circulatory failure. Epinephrine was employed in 78% of patients. Among them, 18 had already been administered adrenaline by the local doctor. This means that 18/27 (66%) had received first-line therapy before the anesthesiologist arrived. However, the time from the onset of symptoms to medical attendance exceeded 45 min in 2 patients, both of whom died. Of the surviving patients, 23 were hospitalized. The majority had no signs of respiratory or circulatory failure on arrival in the emergency room and needed only observation in the hospital. These results are very similar to our own, although that report did not present vital signs to show how their patients' conditions improved.

The adrenaline autoinjector (EpiPen®; Mylan Incorporation, Pennsylvania) has been sold since 2003 in Japan. In this study, among the patients with anaphylaxis who required adrenaline injection, only 3 of 48 (6.3%) used the adrenaline autoinjector. Two of those three patients who used the adrenaline autoinjector required additional adrenaline for improvement of anaphylactic symptoms. Accordingly, given the very low frequency of using an adrenaline

autoinjector and the additional requirement for adrenaline injection for the treatment of anaphylaxis, dispatch of the DH to the scene is inevitable in Japan.

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

5. Conclusion

The vital signs and clinical conditions of patients who were in an anaphylactic state when they were treated by the DH staff at the scene showed improvement when they arrived at the hospital.

Conflict of Interest

The authors declare no conflicts of interest in association with the present study.

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Table 1 The background characteristics of the subjects (n=68)

Age (years)	48.1 ± 24.0 (1-81)
Sex (Male/Female)	53/15
First call – first contact (minute)	29.8 ± 11.5 (14-62)
Dispatch call – first contact (minute)	16.3 ± 6.9 (7-36)

Table 2 Comparison of vital signs between at the scene and arrival at the hospital

	At the scene	At the hospital	p value
Glasgow Coma Scale	15 (0.5)	15 (0)	<0.0001
SPO_2 (%)	96.2 ±12.9	97.5 ± 11.9	< 0.05
Systolic BP (mmHg)	112.0 ± 31.7	120.4 ± 30.3	< 0.01
HR (beats per minute)	92.2 ± 21.3	89.8 ± 22.8	n.s.

BP: blood pressure, HR: heart rate, SPO2; peripheral capillary oxygen saturation

Glasgow Coma Scale: Median (interquartile range)

Other variables: Mean ± standard deviation

n.s.: not significant

Table 3. Outcome

	Number
Change of clinical manifestation before and after contact with doctor helicopter staff	
Improvement or disappearance	63
No change	5
Outcome	
Admission/Go home	49/19
Survival rate (%)	100

Figure 1 The causes of anaphylaxis

The most frequent cause of anaphylaxis was bee or wasp sting followed by food allergy.

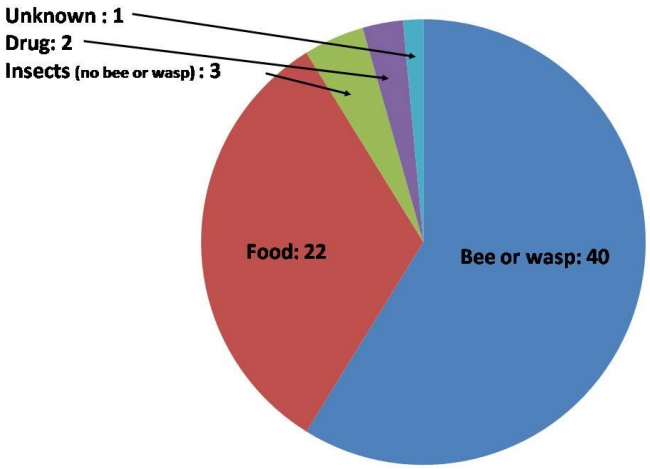


Figure 2 Number of dispatches per month

The most dispatches are received from July to October.

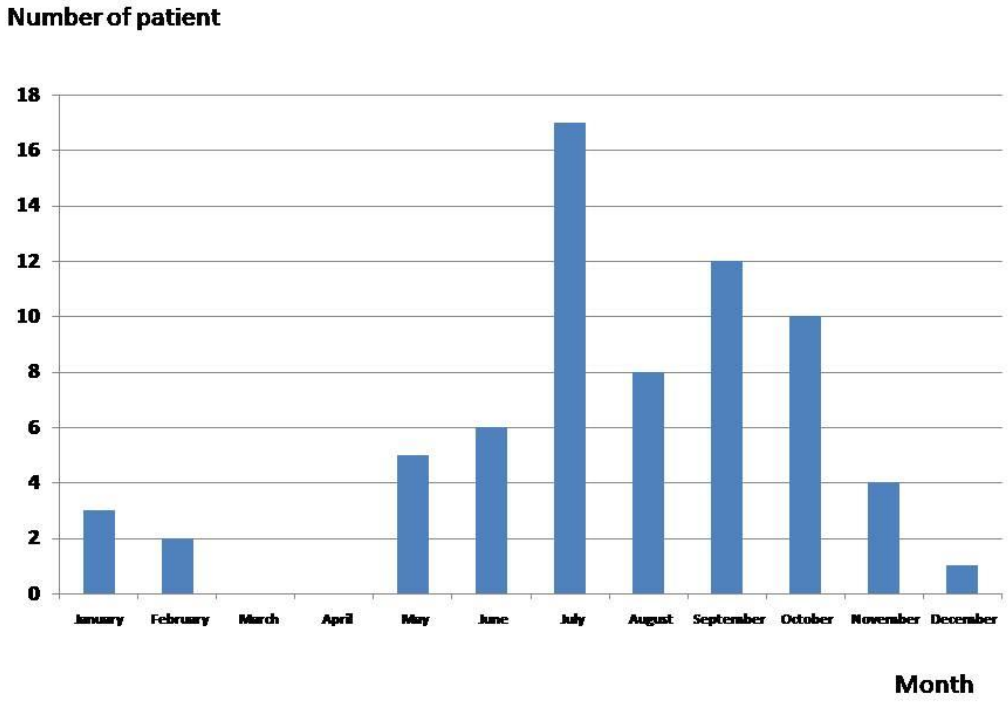


Figure 3 The clinical manifestations at the scene

Cardiovascular manifestations were most common, followed by respiratory manifestations.

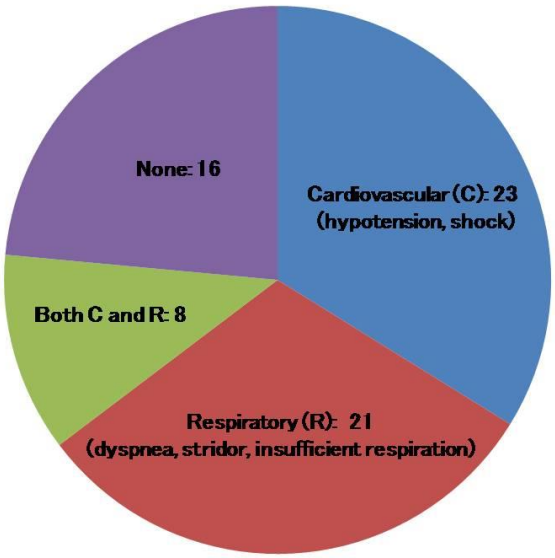
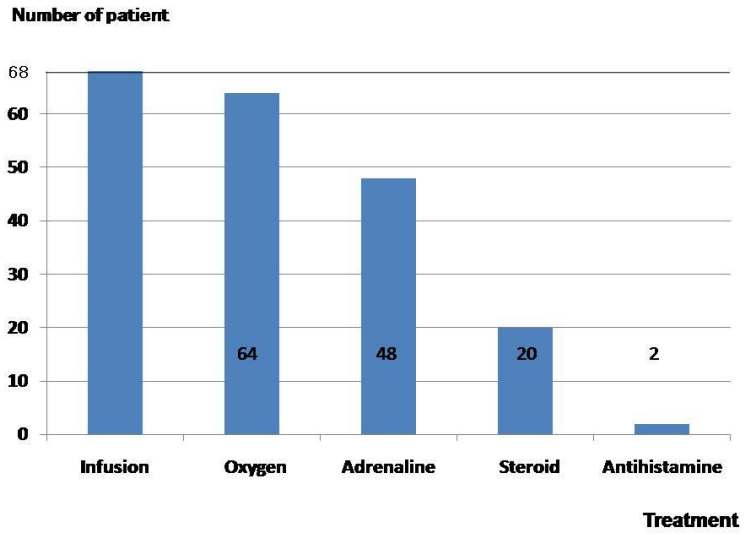


Figure 4 The treatments performed at the scene

Adrenaline injections were administered at the scene in 48 cases.



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