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Outcome in intoxicated patients transported by a physician-staffed helicopter in Japan from 2015 to 2020

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Abstract

Aim: We retrospectively investigated the current status of poisoned patients who had been transported by a physician-staffed helicopter emergency medical service and their final outcomes using data from the JAPAN DOCTOR HELICOPTER REGISTRY SYSTEM.

Methods: The following details of dispatch activity were collected from the database of the JAPAN DOCTOR HELICOPTER REGISTRY SYSTEM: patient age and sex, timing of dispatch request, presence of cardiac arrest, vital signs, medical intervention, main etiology of intoxication, and final outcome. The patients were divided into two groups: those with a good outcome and those with a poor outcome. The variables were compared between the two groups.

Results: A total of 336 patients were intoxicated. Psychotropic drug overdose was the dominant cause, followed by carbon monoxide and ethanol. The median Glasgow Coma Scale score was significantly higher in the good outcome group than in the poor outcome group. The rates of cardiac arrest, interventions to secure an airway and/or assist with ventilation, and drug administration were significantly lower in the good outcome group than in the poor outcome group. There were no records concerning the decontamination of the intoxicating substance at the scene or during air evacuation.

Conclusion: The study suggests that various factors may influence the outcomes of patients with different types of intoxication. These findings offer valuable insights that could help to establish effective treatment strategies and the operation of doctor helicopters for intoxicated patients.

KEYWORDS
doctor helicopter, intoxication, outcome

INTRODUCTION

The physician-staffed helicopter emergency medical service, also called the doctor helicopter in Japan, transports a flight doctor and nurse to the scene of an emergency during the day (HEM-NET; https://hemnet.jp/en). As of April 2022, 56 doctor helicopters have been deployed in 47 prefectures across Japan. The JAPAN DOCTOR HELICOPTER REGISTRY SYSTEM, established by the Japanese Society for Aeromedical Services, prospectively collected data on dispatches. These data (including the final outcome at 1 month) were registered for all doctor helicopter base hospitals in Japan from April 2015 to March 2020.[1] The collected data were made available to each base hospital in December 2022.

Doctor helicopters have been reported to carry patients with a variety of symptoms, including trauma, acute coronary syndrome, stroke, and cardiac arrest.[2] Doctor helicopters also evacuate intoxicated patients from the scene or perform interhospital transportation.[6,7] Additionally, medical helicopters with or without doctors have been reported to carry intoxicated patients in other countries.[5–10] However, few original reports have focused on intoxicated patients transported by helicopters, with the largest population investigated thus far being 133 patients in the report by Maloney et al.[3–6]

Therefore, we performed a retrospective study to examine this population using data from the JAPAN DOCTOR HELICOPTER REGISTRY SYSTEM.

METHODS

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. The approval number for this study is 733. All institutes belonging to the JAPAN DOCTOR HELICOPTER REGISTRY SYSTEM received institutional review board approval.

The following details of the dispatch activity were collected from the database of the JAPAN DOCTOR HELICOPTER REGISTRY SYSTEM: patient age and sex, timing of doctor helicopter dispatch request (before emergency medical technicians encountered the patient or after), duration of activity of the doctor helicopter (time from request to scene, at the scene, and from scene to hospital), presence of cardiac arrest when emergency medical technicians encountered the patient, vital signs (Glasgow Coma Scale, systolic blood pressure, heart rate, and respiratory rate) when doctor helicopter staff encountered the patient, contents of the medical intervention (tracheal intubation, securing venous route, infusion of drugs, and/or decontamination), main etiology of intoxication, and final outcome (cerebral performance category [CPC] at 1 month as well as the survival outcome: CPC 1, good cerebral performance; CPC 2, disabled but independent; CPC 3, conscious but disabled and dependent; CPC 4, vegetative state; and CPC 5, dead).[11] The exclusion criterion was the absence of data on cerebral performance.

The patients were divided into two groups: those with a good outcome (cerebral performance categories 1 and 2) and those with a poor outcome (cerebral performance categories 3–5). The variables were compared between the two groups. Then, patients were again divided into two groups: those with a survival outcome and those with a fatal outcome (CPC 5), and the variables were compared between these two groups.

The data were analyzed using Wilcoxon's test for age, systolic blood pressure, heart rate, and respiratory rate; the median test for the Glasgow Coma Scale; and the chi-square test for sex, dispatch timing, and medical interventions. Statistical significance was set at $p < 0.05$. Data are shown as the mean ± standard deviation, median with interquartile range, or n (%).

RESULTS

During the investigation period, 41,592 patients were registered in the JAPAN DOCTOR HELICOPTER REGISTRY SYSTEM. Among them, there were 376 intoxicated patients. We then excluded 40 patients with missing data in the final CPC, all of whom were enrolled as patients. The patients' background characteristics are listed in Table 1. All patients were evacuated from the scene, and there were no cases of interhospital transportation. There were no records concerning the decontamination of the intoxicating substance at the scene or during the air evacuation.

Table 2 shows the etiology of the intoxication. Psychotropic drug overdoses were the most common, followed by gas and alcohol overdoses. Among intoxication cases with poor outcomes, psychotropic drugs were the dominant cause, followed by carbon monoxide. In addition, the etiology of a fatal outcome in the poor group was overdose in three patients (agent's name not described); carbon monoxide in two

TABLE 1 Findings for patients evacuated by a physician-staffed helicopter ($n = 336$).

Variables	Value	Undescribed data
Age (years)	56.2 ± 21.8	
Sex, male/female	200 (59.5)/136 (40.5)	0
Request before/after EMT contact	151 (44.9)/185 (55.1)	0
Duration (minutes)		
From request to scene	20.7 ± 8.1	0
Scene time	15.7 ± 7.5	
From scene to hospital	9.3 ± 4.6	
Cardiac arrest on contact, yes/no	6 (1.7)/330 (98.3)	0
Glasgow Coma Scale	10 (6.14)	13
Respiratory rate (breaths/minute)	19.9 ± 6.7	67
Heart rate (beats/minute)	85.3 ± 27.2	24
Systolic blood pressure (mmHg)	121.3 ± 35.2	53
Intervention with instruments		
Tracheal intubation	57 (16.9)	50
Bag valve mask ventilation	11 (3.2)	
Nasal airway	7 (2.0)	
Supraglottic airway	1 (0.2)	
Securing venous route	300 (89.2)	0
Drug administration	105 (31.2)	0
Cerebral performance category at 1 month		
1 Normal	268 (80.0)	0
2 Moderate disability	27 (8.0)	
3 Severe disability	23 (6.8)	
4 Coma or vegetative state	5 (1.4)	
5 Death	13 (3.8)	

Abbreviation: EMT, emergency medical technician.
Data are presented as n (%) or mean ± standard deviation.

TABLE 2 Etiology of intoxication between the good (CPC 1–2) and poor (CPC 3–5) groups (n = 336).

Classification	Diagnosis	Good, *n*	Poor, *n*	Total, *n*
Psychotropic drug	Overdose (name was not described)	116	15	131
	Hypnotic	14	0	14
	Benzodiazepine class	14	0	14
	Lithium	2	0	2
	Tricyclic antidepressant	1	0	1
	Selective serotonin reuptake inhibitor	1	0	1
	Antidepressant	1	0	1
Nonpsychotropic drug	Acetaminophen	3	0	3
	Theophylline	2	1	3
	β-blocker	1	0	1
	Isomytal	1	0	1
	Carbamazepine	1	0	1
	Barbiturate	1	0	1
	Valproic acid	1	0	1
	Phenobarbital	0	1	1
	Amphetamine	0	1	1
Alcohol	Ethanol	49	1	50
	Ethylene glycol	0	1	1
	Methanol	2	0	2
Organic solvent	Methylbenzene	1	0	1
	Petroleum product	1	0	1
	Organic solvent (name was not described)	1	0	1
Gas	Carbon monoxide	56	13	69
	Chlorine	2	0	2
	Carbon dioxide	1	1	2
	Hydrogen sulfide	1	0	1
Agricultural chemicals	Agricultural chemicals (name was not described)	5	1	6
	Organophosphorus	3	1	4
	Glyphosate	3	0	3
	Paraquat	1	2	3
	Herbicide	2	0	2
	Insecticide	2	0	2
	Metofluthrin	0	1	1
Chemicals	Esophagitis (name was not described)	2	0	2
	Cresol	0	1	1
	Hydrochloric acid	1	0	1
	Bleach	1	0	1
	Surfactant	1	0	1
Natural toxins	Globefish	1	0	1
	Food	1	0	1

Abbreviation: CPC, cerebral performance category.

patients; and phenobarbital, amphetamine, ethylene glycol, carbon dioxide, agricultural chemicals (agent's name not described), organophosphorus, paraquat, and cresol in one patient each.

The results of the analysis of the good and poor groups are shown in Table 3. There were no significant differences between the groups in terms of age, sex, timing of doctor helicopter request, duration of activity, respiratory rate, heart rate, systolic blood pressure, or rate of securing a venous route. However, the median Glasgow Coma Scale score was significantly higher in the good outcome group than in the poor outcome group. The rates of cardiac arrest, intervention

TABLE 3 A comparison between the Good (CPC 1–2) and Poor (CPC 3–5) groups.

Variables	Good (*n* = 295)	Poor (n = 41)	*p* value
Age	56.1 ± 21.6	57.7 ± 23.8	0.57
Sex, male/female	175/120	25/16	0.93
Request before/after EMT contact	134/161	16/25	0.51
Duration (minutes)			
From request to scene	20.5 ± 8.0	22.4 ± 8.8	0.11
Scene time	15.4 ± 7.5	17.2 ± 7.5	0.06
From scene to hospital	9.3 ± 4.7	9.5 ± 4.7	0.56
Cardiac arrest on contact, yes/no	0/277	6/35	<0.0001
Glasgow Coma Scale score	10 (6-14)	7 (3-12)	0.03
Respiratory rate (breaths/minute)	20.3 ± 6.0	17.8 ± 9.7	0.61
Heart rate (beats/minute)	86.4 ± 24.7	77.3 ± 40.5	0.81
Systolic blood pressure (mmHg)	123.3 ± 32.3	105.7 ± 50.5	0.39
Intervention with instruments, yes/no	58/227	18/23	0.001
Securing venous route, yes/no	263/32	37/4	0.83
Drug administration, yes/no	82/213	23/18	0.0002

Data are presented as *n* or mean ± standard deviation or median (interquartile range).
Abbreviations: CPC, cerebral performance category; EMT, emergency medical technician.

TABLE 4 A comparison between the survival and fatal groups.

Variables	Survival (*n* = 323)	Fatal (*n* = 13)	*p* value
Age	56.1 ± 21.6	50.1 ± 27.9	0.46
Sex, male/female	191/132	9/4	0.93
Request before/after EMT contact	144/179	7/6	0.51
Duration (minutes)			
From request to scene	20.5 ± 7.9	22.2 ± 12.0	0.76
Scene time	15.7 ± 7.5	15.3 ± 7.2	0.91
From scene to hospital	9.3 ± 4.7	8.5 ± 2.6	0.87
Cardiac arrest on contact yes/no	0/323	6/7	<0.0001
Glasgow Coma Scale	10 (6-14)	4 (3-12.5)	0.23
Respiratory rate (breaths per minute)	20.2 ± 6.1	11.2 ± 13.5	0.12
Heart rate (beats per minute)	86.6 ± 25.2	50.7 ± 50.7	0.04
Systolic blood pressure (mmHg)	122.9 ± 32.4	71.5 ± 71.4	0.07
Intervention with instruments, yes/no	70/253	6/7	0.03
Securing venous route, yes/no	290/33	10/3	0.19
Drug administration, yes/no	95/228	10/3	0.0003

Data are presented as *n* or mean ± standard deviation or median (interquartile range).
Abbreviation: EMT, emergency medical technician.

with instruments to secure an airway and/or assist with ventilation, and drug administration were significantly lower in the good outcome group than in the poor outcome group.

The results of the analysis between the survival and mortality groups are presented in Table 4. There were no significant differences between the groups with regard to age, sex, timing of doctor helicopter request, duration of activity, median Glasgow Coma Scale score, respiratory rate, systolic blood pressure, or rate of securing a venous route. However, heart rate in the survival outcome group was significantly higher than that in the fatal outcome group. The rates of cardiac arrest, intervention with instruments to secure an airway and/or assist with ventilation, and drug administration in the survival group were also significantly lower than those in the mortality group.

DISCUSSION

This is the first report to describe the current status of intoxicated patients transported by helicopter doctors using registry data from the JAPAN DOCTOR HELICOPTER

TABLE 5 Previous original reports.

Author	Year	Number of patients	Etiology	Main findings
Maloney	2008	133	Carbon monoxide 16%, acetaminophen 12%, antidepressants 9%, benzodiazepines 8%, cardiac medications 4%, unknown substance 4%	Acute toxicologic emergencies accounted for a small percentage of total transports. The most common additional intervention by flight crews was endotracheal intubation.
Sugita	2017	131	Psychiatric prescription drugs in 39.7% of cases; pesticides in 29.7%; alcohol in 8.4%; analgesics in 5.3%; detergent or bleach in 6.1%; and oil, natural gas, or thinner in 4.6%	Outcomes were more likely to be improved by appropriate early treatment by the HEMS.
Galazkowski	2017	42	Sedative-hypnotic medications 16.7%; carbon monoxide poisoning 16.7%; non-opioid analgesics 11.9%; psychotropic medications 11.9%; diuretics 11.9%; pesticides 11.9%; medications originally acting on the autonomic nervous system 9.6%; corrosive substances 4.7%; gases, fumes, and vapors 4.7%.	Poisoning in the 5-year period accounted for only 0.8% of all HEMS medical interventions in pediatric patients. This is a real emergency situation requiring immediate medical attention and patient transport to a specialized medical center.
Yanagawa	2018	48	Major tranquilizer 31%, minor tranquilizer 22%, agricultural agent 16%, medical drug 12%, disinfectant 8%, alcohol 4%, medicinal plant 2%, illegal drug 2%	The level of consciousness and shock index may be important factors dictating whether or not to dispatch the doctor helicopter to prevent secondary damage induced by unstable circulation.
Present		376	Overdose unknown 37.5%, gas 24.5%, alcohol 15.1%, psychotropic drug 9.2%, agricultural chemicals 6.2%, nonpsychotropic drug 3.8%, chemicals 1.6%, organic solvent 1.1%	

Abbreviation: HEMS, physician-staffed helicopter emergency medical service.

REGISTRY SYSTEM. The present findings suggest that intoxicated patients who had poor outcomes tended to experience cardiac arrest when emergency medical technicians arrived, were unconscious, and received substantial medical intervention.

For comparison with previous findings, we summarized several original reports that investigated intoxicated patients evacuated by helicopters (Table 5).[3–6] The number of patients in the present study was the highest among all these reports. Most patients suffered a psychotropic overdose, except for those in the report by Maloney and Pakiela[5] from the United States, which showed that the number of cases of carbon monoxide poisoning was the highest. Takeuchi et al.[3] excluded patients with carbon monoxide poisoning from their analysis. Among all the intoxicated patients transported by helicopter, the number of patients with carbon monoxide poisoning was the highest. Such methodological differences might have resulted in the different frequencies of intoxicated patients among the reports. However, as this study did not exclude cases of carbon monoxide poisoning and data were registered from doctor helicopter bases across Japan, we believe that the present data indicate the actual status of intoxicated patients transported by doctor helicopters in Japan.

The present study demonstrated that cardiac arrest and unconsciousness were prognostic factors associated with poor outcomes. In previous reports, prognostic analysis was performed mainly for single-drug or opioid-related overdose cases.[12–14] However, in our clinical Japanese setting, single-drug overdose cases are rare, as are opioid-related overdose cases.[3,4] Accordingly, it was difficult to compare the results of the present study with those of previous studies. We treated the cases of intoxication as a single group, regardless of the source. However, vital signs react differently to each poisonous substance. For example, the consumption of massive amounts of sedatives induces hypotension, whereas the consumption of amphetamines induces hypertension. Accordingly, other physiological data may have failed to show a marked difference between the two groups. In cases of intoxication with certain specific substances, unconsciousness may be a prognostic factor for poor outcome, which is in accordance with the present findings.[15–17] However, previous reports have shown that the initial lactate level in patients with an acute drug overdose or a high blood concentration of the drug is useful for predicting prognosis.[18–20] Unfortunately, the JAPAN DOCTOR HELICOPTER REGISTRY SYSTEM did not collect such data. Unconscious intoxicated patients require securing the airway or assisted ventilation using instruments, along with sedatives and/or muscle relaxants.[15] Accordingly, the poor-outcome group receiving medical interventions more frequently than the good-outcome group in the present study is reasonable.

How can the findings of the present study improve the outcomes of patients with intoxication? For fire departments, an early dispatch request for a doctor helicopter might be necessary, as this can result in an improved outcome in intoxicated patients.[21] Early dispatch requests can be followed by the early provision of medical interventions in the doctor helicopter, including decontamination, tracheal intubation, antagonist provision, and infusion of drugs to improve blood pressure and/or heart rate, none of which can be executed by emergency medical technicians for patients not in cardiac arrest. In the present study, requests for the dispatch of a doctor helicopter were not high in the poor group, which tended to have a severe state of unconsciousness and a high rate of cardiac arrest, so there is still room for improvement. For physicians, there were no records of decontamination at the scene or during air evacuation. Early decontamination might be necessary to improve the outcomes in intoxicated patients.[22]

We used the CPC of the JAPAN DOCTOR HELICOPTER REGISTRY SYSTEM to evaluate the outcomes. CPC is now the gold standard for assessing neurological recovery after cardiac arrest.[11] In an analysis of intoxicated patients, CPC was also used to monitor recovery from cardiac arrest induced by intoxication, as well as carbon monoxide poisoning, which can cause hypoxic brain damage.[23–26] This study included patients with cardiac arrest and carbon monoxide poisoning. To our knowledge, no studies have investigated the outcomes at 1 month among intoxicated patients, except for those with cardiac arrest or carbon monoxide poisoning. Accordingly, the present study provides unique reference data for future analyses of patients with intoxication.

Interestingly, the main etiology of the poor outcome in the present study was a psychotropic overdose (agent's name not described). One reason for this might be insult to the brain caused by unstable circulation induced by the psychotropic overdose itself, or by hypoxia induced by airway obstruction due to glossoptosis, suffocation from vomiting, convulsion, aspiration pneumonia, and/or pulmonary embolism during an unconscious state caused by psychotropic overdose.[27] Another possible reason for this finding might be the inherent limitations of CPC. The main cause of intoxication was previously reported to be suicide attempts due to psychiatric diseases.[28] Psychomotor abnormalities induced by psychiatric diseases can make it difficult to precisely determine the CPC,[29] which might have resulted in the apparent worsening of the CPC in the present study.

When evacuating intoxicated patients by helicopter, attention must be paid to whether the poisonous substance is volatile to ensure safe aviation. Transporting dangerously intoxicated patients exposed to highly volatile substances may affect the pilot's steering ability. Indeed, previous reports have shown that in some cases, medical staff became sick after treating intoxicated patients.[10] Unfortunately, the JAPAN DOCTOR HELICOPTER REGISTRY SYSTEM did not collect data on how the transportation type was selected (air or ground) for intoxicated patients.

Several limitations of the present study warrant mention. First, no statistical analyses were performed to adjust the multiple confounders. There were no multiple regression models in this study, and we did not judge the independent predictors of the outcomes. Second, the JAPAN DOCTOR HELICOPTER REGISTRY SYSTEM did not collect data focusing on intoxicated patients concerning the etiology of poisoning or the details of decontamination. In addition, the researchers were not private to the name of the registered hospital. Therefore, these data could not be further investigated. Third, the JAPAN DOCTOR HELICOPTER REGISTRY SYSTEM did not collect data on the costs of medical treatments, so we could not analyze the results from a medical economy perspective. Fourth, the JAPAN DOCTOR HELICOPTER REGISTRY SYSTEM did not collect data on intoxicated patients transported by ground ambulance. Accordingly, we were unable to compare the final outcomes between the patients evacuated by helicopters and those transported via ground ambulances. Further prospective studies including data on patients transported by ground ambulance and economic aspects are warranted.

CONCLUSIONS

The findings of this study suggest that various factors may influence the outcomes of patients with different types of intoxication. Specifically, the Glasgow Coma Scale score, heart rate, rates of cardiac arrest, the need for airway management and ventilation, and the frequency of drug administration are identified as significant factors related to the outcomes of intoxicated patients. These findings offer valuable insights that could help to establish effective treatment strategies and the operation of doctor helicopters for intoxicated patients.

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CONFLICT OF INTEREST STATEMENT

We do not have conflict of interest to declare. Dr. Youichi Yanagawa is an Editorial Board member of AMS Journal and the corresponding author of this article. To minimize bias, the author was excluded from all editorial decision making related to the acceptance of this article for publication.

DATA AVAILABILITY STATEMENT

We do not have data availability.

ETHICS STATEMENT

Approval of the research protocol: The prospective study protocol was approved by the review board of the Juntendo Shizuoka Hospital (approval number: 298).
Informed consent: We obtained informed consent from the patient.
Registry and the registration no. of the study/trial: N/A.
Animal studies: N/A.

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