Effectiveness of a "Doctor-Helicopter" System in Japan

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Abstract

Background: In Japan, helicopters have rarely been used for emergency medical services. The use of helicopters not only ensures rapid evacuation but may also serve to provide emergency management to patients with life-threatening injuries in the prehospital setting.

Objectives: To evaluate a Japanese helicopter-based emergency medical system including an onboard physician, particularly in terms of probability of survival.

Methods: We conducted a retrospective review of trauma victims, and calculated two estimates of PS – at the scene and on arrival at the emergency department – based on patient age, Injury Severity Score, and Revised Trauma Score.

Results: We identified trauma victims who had an ISS above 15 and were transported from the scene by helicopter. Excluding cardiopulmonary arrest at the scene, 151 cases were studied. Thirty-two patients had hemodynamic instability with systolic blood pressures below 90 mmHg, caused by hemorrhagic shock (29 cases) or obstructive shock (3 cases). Their PS values were 0.56 ± 0.38 in the prehospital setting and 0.65 ± 0.38 on arrival at the ED, representing a significant difference ($P = 0.0003$). Twenty-four of these patients survived, reflecting successful resuscitation during prehospital and ED management.

Conclusions: A doctor-helicopter system was shown to improve probability of survival for life-threatening trauma in the Japanese emergency medical system.

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For Editorial see page 56

Many helicopters are used by agencies and various organizations in Japan, but very few of these aircraft have been used for emergency medical services because of their high cost and disruptive noise. Helicopters have been used to transport trauma patients since the 1970s in the United States [1] and the 1980s in Britain [2]. In Japan, too, a government-funded medical helicopter service has been developed in recent years. Since October 2001, several "doctor-helicopter systems" have been implemented, one of them in the Chiba Prefecture. This system allows an "on-site emergency department" to initiate certain forms of emergency management prior to arrival at a hospital. The system deployed in the Chiba Prefecture forms the basis for this study.

EMS use of helicopters has provoked considerable debate on costs and benefits. Several reports [3–8] describe enhanced speed of evacuation from the scene as a way of reducing patient mortality, but the effectiveness of helicopter EMS remains controversial. Though EMS providers in the U.S. can carry out certain interventions for patients at the scene, such as tracheal intubation, fluid resuscitation and drug administration, Japanese EMS providers did not have the capacity to perform such interventions prior to the new physician-staffed program. It is hoped that the doctor-helicopter system will make prehospital emergency care in Japan more effective than the current use of medical rotorcraft in the U.S. The goal of the present study was to evaluate the effectiveness of the doctor-helicopter system, comparing clinical indicators between the prehospital setting and arrival at the ED.

Patients and Methods

The Shock and Trauma Center at Inba-Hitec Medical Center of Nippon Medical School, corresponding to a Level 1 trauma center in the U.S., was designated as the base hospital of the doctor-helicopter system. During the 24 months from October 2001 through September 2003, the system's personnel carried out 848 flights. Altogether, 771 patients were transported directly from the scene, while 83 flights were interfacility transfers. From among the 771 patients examined at the scene by our specially trained staff doctors aboard the helicopter, severe trauma victims with Injury Severity Score [9] above 15 were chosen for analysis. Patient data included age, gender, mechanism of injury, ISS, Revised Trauma Score [10], and the type of treatment provided at the trauma scene. In particular, RTS at the time the flight doctor evaluated the patient at the scene, and RTS at the time of arrival at the ED were collected, respectively. This permitted two estimates of probability of survival [11], before and after treatment by doctor-helicopter, based on the two RTSs, ISS, and patient age. Comparison between the two PS scores was used to evaluate the effectiveness of the doctor-helicopter system.

All results are expressed as mean ± SD. PS values were analyzed for statistical significance by the Wilcoxon signed-rank test. Results associated with P values below 0.05 were considered significant.

PS = probability of survival
ISS = Injury Severity Score
ED = Emergency Department

EMS = emergency medical services
RTS = Revised Trauma Score

Results

Of 771 trauma victims, 444 were treated at the scene by doctor-helicopter staff during the 24 month study period. The characteristics of these patients treated by the doctor-helicopter system are shown in Table 1. The mean time at the scene and the mean transport time were 17.1 ± 13.8 and 9.5 ± 2.9 minutes respectively. Of the 420 patients (94.6%) admitted to the hospital, 167 (37.6%) had an ISS below 9 and did not require specific interventions. Sixteen patients had cardiopulmonary arrest on arrival at the ED. Twenty-three patients died of severe head injury, 9 of prolonged hemorrhagic shock, and 1 of septic shock.

The study group comprised 151 patients with an ISS above 15, excluding those with cardiopulmonary arrest at the scene. The mean age of these patients was 48.5 ± 23.9 years and the ISS 23.3 ± 7.6. Interventions carried out at the prehospital stage were rapid fluid resuscitation in 148 cases, tracheal intubation in 25 cases (including one cricothyroidotomy), and tube thoracotomy in 8 cases. Mean RTS and PS values compared between the prehospital setting and on arrival at the ED are shown in Table 2.

Among the 151 patients, 32 had hemodynamic instability with systolic blood pressure below 90 mmHg caused by hemorrhagic shock in 29 cases and obstructive shock in 3 cases. All of these patients underwent rapid fluid resuscitation at the scene, while nine required tracheal intubation and five required tube thoracotomy. Although 24 patients survived because of successful resuscitation during prehospital and ED management, 4 others died of uncontrollable hemorrhagic shock – 1 from thoracic aortic disruption and 3 from associated severe brain injury [Table 3]. In these 32 patients with hemodynamic instability, RTS and PS values on arrival at the ED were improved compared to those at the prehospital setting; the difference was significant [Table 4]. On arrival at the hospital, 18 patients underwent early surgical and/or transcatheter intervention for life-threatening injuries (operation in 16 and transcatheter arterial embolization in 7). One patient with severe hypoxia caused by a massive lung contusion required percutaneous cardiopulmonary support. There were five patients with unexpected survival whose PS values prior to prehospital care were 0.086, 0.139, 0.145, 0.170, and 0.187. Twenty-four of 32 patients with hemodynamic instability are still alive and without post-traumatic complication 2 years after sustaining injuries.

Table 1. Characteristics of 444 trauma patients treated by the doctor-helicopter system

Age (yrs)	43.3 ± 23.0 (range 0–94)
Gender (% women)	28.4%
Mechanism of injury (%)	
Motor vehicle accident	238 (53.6)
Fall	107 (24.1)
Farm and industrial	42 (9.5)
Assault	2 (2.7)
Other	43 (9.7)
ISS	13.6 ± 12.3

Continuous variables are shown as mean ± SD; categorical variables as number of patients (%).

Table 2. RTS and PS for 151 patients with ISS above 15, excluding those with cardiopulmonary arrest at the scene

	Before prehospital treatment	On ED arrival	*P*
Revised Trauma Score	6.16 ± 1.65	6.57 ± 1.63	<0.0001
Probability of survival	0.78 ± 0.27	0.82 ± 0.25	<0.0001

Values are mean ± SD

Discussion

Japanese fire departments, police departments, Self-Defense Forces, and private businesses make considerable use of helicopters, but these aircraft have scarcely been used for emergency medical services. In the Hanshin-Awaji earthquake on 17 January 1995, many people with life-threatening injuries such as crush syndrome were transported by conventional ambulances to the appropriate hospital, which was located far from the disaster site. During the 24 hours following onset of the earthquake only one patient was evacuated by helicopter. Many Japanese, including emergency medical technicians and doctors, have not recognized the value of helicopters for transporting emergency patients. Operational costs for helicopters are extremely high, and the noise produced by these aircraft is unacceptable to the population that lives near the landing site. Despite these negative factors, helicopters have been deployed by others for the transport of trauma victims. As early as the 1970s, the Maryland Institute of Emergency Medical Service System created such a modality [1]. As a national project for the Japanese EMS system under the direction of the Ministry of Health, Labour and Welfare, we are currently establishing a doctor-helicopter system modeled after certain air ambulance systems in the United States [1], ADAC in Germany [12], REGA in Switzerland [13,14], and the London HEMS in the UK [2]. This system provides an "on-site ED" capable of providing advanced prehospital treatment for the severely ill or injured patient.

The system is alerted by direct telephone call from EMS providers at the scene. Our flight crews include one trauma surgeon and one flight nurse who are airborne within 3 minutes of the call; the helicopter touches down at the designated temporary heliport nearest the scene. Approximately 500 sites have been selected as temporary heliports in Chiba Prefecture, including public parks, athletic fields, and school yards. Medical intervention during transportation by helicopter is a challenging problem: limited space, noise from the helicopter, and limited medical resources interfere with emergency and even routine treatment that would be performed routinely in the ED setting. Therefore, the physician and flight nurse carry out airway management, fluid resuscitation, administration of drugs, and some surgical management inside an ambulance parked at the temporary heliport. The victim is then transported by helicopter to the ED of the trauma center.

Unfortunately, Japanese emergency medical technicians are

Table 3. Characteristics of 32 hemodynamically unstable patients*

Patient no.	Injuries	Age (yrs)	ISS	SBP (mmHg)	Management at the scene**	Surgery or IVR	Outcome
1	Liver, gallbladder and colon injury	48	16	50	FR	Laparotomy, TAE	Died
2	Pelvic fx	62	26	52	FR	TAE, EF	Alive
3	Head injury, flail chest, hemothorax	79	34	80	FR		Alive
4	Thigh amputation	51	16	60	FR	Stump plasty	Alive
5	Skull fx, pelvic fx, tibial fx	73	20	60	FR, intubation	TAE	Died
6	Hemothorax, rib fx, femoral fx	39	19	80	FR	ORIF	Alive
7	Humeras fx, biliateral tibial fx	33	17	88	FR	ORIF	Alive
8	Cardiac rupture, liver laceration	57	42	50	FR, tube thoracotomy	DCS, TAE	Alive
9	Pelvic fx, femoral fx	37	21	82	FR	TAE, EF	Alive
10	Tension pneumothorax, splenic laceration, renal laceration, pelvic fx	22	45	50	FR, tube thoracotomy	DCS, EF	Alive
11	Open pelvic fx	35	35	50	FR	EF	Alive
12	Rib fx, humeral fx, femoral fx	75	19	60	FR	ORIF	Alive
13	Hemothorax	55	18	52	FR		Alive
14	Tension pneumothorax, hemothorax, C7-Th1 fx	6	24	80	FR, tube thoracotomy		Alive
15	Aortic disruption, bilateral tibial fx	43	34	50	FR, intubation	ERT	Died
16	Lung contusion, flail chest, liver laceration	80	50	88	FR	DCS	Died
17	Lung contusion, rib fx, humeral fx, femoral fx	84	29	88	FR	ORIF	Alive
18	Head injury, skull fx, facial fx, rib fx, sternal fx, ulnal fx	76	22	66	FR, intubation		Died
19	Head injury, pneumothorax, femoral fx, tibial fx	24	17	88	FR	ORIF	Alive
20	Small bowel perforation, mesenteric injury	65	21	80	FR	Laparotomy	Alive
21	Flail chest, lung contusion, liver laceration, bilateral femoral fx	67	41	84	FR, intubation	DCS, EF	Alive
22	Head injury, femora fx	81	29	50	FR, intubation		Died
23	Lung contusion, pneumothorax, liver laceration, femoral degloving injury	5	27	60	FR	Repair	Alive
24	Head injury, hemothorax, mesenteric injury, pelvic fx	58	27	50	FR	Laparotomy, TAE, EF	Alive
25	Head injury, flail chest, hemothorax, lung contusion, scapular fx	25	45	80	FR, intubation	PCPS	Alive
26	Head injury, tibial fx	69	18	50	FR	ORIF	Alive
27	Head injury, hemothorax, rib fx	34	50	50	FR, intubation		Died
28	Carotid arterial disruption	39	34	60	FR, intubation	Repair	Died
29	Renal laceration, rib fx	62	20	70	FR	Laparotomy	Alive
30	Hemothorax, pelvic fx, femoral fx	64	25	64	FR, intubation, tube thoracotomy	TAE	Alive
31	Pancreas, duodenum disruption	33	25	70	FR	Laborotomy	Alive
32	Tension pneumothorax	39	26	80	FR, tube thoracotomy		Alive

* Hemodynamic instability was defined by systolic blood pressure below 90 mmHg.

** By airborne medical staff.

ISS = Injury Severity Score, SBP = systolic blood pressure, IVR = interventional radiology, fx = fracture, FR = fluid resuscitation, TAE = transarterial embolization, EF = external fixation, ORIF = open reduction and internal fixation, DCS = damage control surgery, ERT = emergency room thoracotomy, PCPS = percutaneous cardiopulmonary support.

Table 4. RTS and PS for 32 hemodynamically unstable patients*

	Before prehospital treatment	On arrival at the ED	*P*
Revised Trauma Score	5.10 ± 1.96	5.88 ± 2.41	0.0015
Probability of survival	0.56 ± 0.38	0.65 ± 0.38	0.0003

* Hemodynamic instability was defined by systolic blood pressure below 90 mmHg.

not trained or allowed to perform the same interventions as paramedics in the USA, such as tracheal intubation, fluid resuscitation, or drug administration. As an alternative, the doctor-helicopter system does allow patient management by a doctor at the scene and in transit to the ED. It is difficult to make an objective assessment of whether this doctor-helicopter system has improved survival rates for severely injured patients, since the situation does not lend itself to prospective randomized studies.

Shatney and colleagues [15] reported that 148 of 947 patients (15.6%) in their study population had an ISS above 15, and only 84 patients (8.9%) required early operation. Seventeen patients (1.8%) underwent immediate surgery for life-threatening injuries. In our study, 155 of 444 patients (34.0%) treated by doctor-helicopter during the investigated period had an ISS above 15. Thirty-two victims (7.2%) received early fluid resuscitation for life-threatening hemorrhagic and/or obstructive shock, while 5 underwent tube thoracotomy and 18 (4.1%) had early surgical and/or transcatheter intervention. In all likelihood their lives were saved because of the doctor-helicopter system. It was evident that we would have 24 long-term survival cases with hemodynamic instability at the scene. Our results suggest that this system functioned at least as well as the helicopter transport described in Shatney's report.

Several articles [3–8] have described the effectiveness of helicopter EMS in the evacuation of trauma victims. In these studies, helicopter transport was judged to be faster than transport by ground ambulance, but their conclusions often focused on time comparisons. Instead, we considered survival. In our 151 cases with high ISS, the mortality rate was limited to 16.6%, but whether our helicopter EMS system contributed to mortality reduction is not certain. Baxt and Moody [16] reported 35% lower mortality using a physician-staffed helicopter than with

nurse/paramedic staffing. Although this was a non-randomized small study, our retrospective data also focused on whether a helicopter EMS including physicians could influence the mortality rate of trauma patients, with survival probability calculations suggesting a possible reduction in mortality. Our study's major limitation was the lack of a control group. However, since the Japanese EMS system does not have the regular doctor-manned ambulances, we could not compare data from before the initiation of the doctor-helicopter system.

The doctor-helicopter system is expected to play an increasingly important role in emergency medical care for Japanese patients who experience life-threatening trauma prior to arrival at appropriate emergency centers. In conclusion, our data showed that this doctor-helicopter system contributes to improve probability of survival of trauma victims on arrival at the ED.

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