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Clinical Article

The Effectiveness Evaluation of Helicopter Ambulance Transport among Neurotrauma Patients in Korea

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Objective : Helicopter ambulance transport (HAT) is a highly resource-intensive facility that is a well-established part of the trauma transport system in many developed countries. Here, we review the benefit of HAT for neurosurgical patients in Korea.
Methods : This retrospective study followed neurotrauma patients who were transferred by HAT to a single emergency trauma center over a period of 2 years. The clinical benefits of HAT were measured according to the necessity of emergency surgical intervention and the differences in the time taken to transport patients by ground ambulance transport (GAT) and HAT.
Results : Ninety-nine patients were transferred to a single university hospital using HAT, of whom 32 were taken to the neurosurgery department. Of these 32 patients, 10 (31.3%) needed neurosurgical intervention, 14 (43.8%) needed non-neurosurgical intervention, 3 (9.4%) required both, and 11 (34.4%) did not require any intervention. The transfer time was faster using HAT than the estimated time needed for GAT, although for a relatively close distance (<50 km) without ground obstacles (mountain or sea) HAT did not improve transfer time. The cost comparison showed that HAT was more expensive than GAT (3,292,000 vs. 84,000 KRW, $p<0.001$).
Conclusion : In this Korean-based study, we found that HAT has a clinical benefit for neurotrauma cases involving a transfer from a distant site or an isolated area. A more precise triage for using HAT should be considered to prevent overuse of this expensive transport method.

Key Words : Helicopter ambulance transport · Aeromedical evacuation · Neurotrauma · Clinical benefit · Korea.

INTRODUCTION

As the proverb goes, time is gold in an emergent medical situation. Thus, helicopter ambulance transport (HAT) is an established component of many health systems, particularly in high-income countries[2,14], and it has also become one of the important transport methods for emergency patients in Korea. Generally, it is assumed that HAT provides a faster transfer time, thereby allowing a more rapid intervention at the accepting institution compared to ground transportation. Further advantages include an ability to take off and land almost anywhere, move in any axis, and fly very slow and hover in one place. Thus, HAT would be expected to improve the chances of survival for neurotrauma patients in a primary setting. However, whether this is actually the case remains controversial. Some authors have suggested that HAT may improve trauma patient outcome in comparison to ground ambulance transport (GAT)[16-18], but other studies found only a limited benefit of HAT[18,20]. The majority of these studies were conducted in and focused on wide territory countries, and there is little known of the benefit of HAT in narrow territory countries. Furthermore, the neurosurgical advantage provided by HAT remains unproven. Here, we have retrospectively reviewed the actual practice patterns, utilization, and outcomes of neurosurgical patients transferred by HAT in Korea.

MATERIALS AND METHODS

We reviewed all cases in which patients were transported by helicopter to a single medical emergency center between March 2011 and February 2013. The inclusion criteria were transfer from the scene of the incident via helicopter followed by either neurosurgical consultation or admission upon arrival. In addition, we required the primary diagnosis to be neurotrauma. Major exclusion criteria included transport to any area of the

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hospital other than the emergency department. All data from electronic medical records were collected for exact determination of patient outcome measures. This retrospective study was conducted after approval of the institutional review board of Ajou University Medical Center (AJIRB-MED-MDB-13-257).

The HAT system for Ajou University Medical Center is described below (Fig. 1). As a first step, the national emergency rescue team (119 paramedics) is dispatched to the scene of the incident. The paramedic then determines whether HAT is required. After this, the National Emergency Management Agency contacts the on-call staff in the trauma center of Ajou Medical Center, who confirm the use of HAT. At this time, the helicopter departs for the scene via the medical center to pick up the trauma team (which does not include the neurosurgeon). If the trauma occurs on an island or mountain, the helicopter goes straight to the scene without stopping at the medical center. The helicopter transport system for the Ajou University Medical Center covers an area with a radius of nearly 250 km, including Gyeonggi-do, Chungcheong-do, Gangwon-do, and the Yellow Sea islands (Fig. 2).

The data for patients transferred by HAT were obtained from the electronic medical record by a trained nurse. These data included demographic data, neurosurgical status and diagnosis at arrival and discharge, the general type of care on arrival, medical management during hospitalization, and any delays to neurosurgical procedure or surgery. The type of care on arrival was categorized to general ward, intensive care unit (ICU), or palliative care. The emergency operations were classified into neurosurgical, non-neurosurgical, or a combination of both. Injury severity score was used to measure the general injury severity and Glasgow Coma Scale (GCS) was used to measure neurological status[5]. Brain injury severity was defined as a mild brain injury with a GCS score>12, moderate with 8<GCS score≤12, or severe with GCS score≤8. The clinical outcomes were estimated using the Glasgow Outcome Scale (GOS) at the point of discharge and 6 months later.

The estimate transport time by GAT for each patient was calculated by Google Maps software (Google Inc., Mountain View, CA, USA) in order to compare these with time required for transfer by HAT. Google Maps software is a fee-free website without limitation of usage, and it also provides information about average traffic conditions at the time of each transport. Although it does not provide an exact estimate of journey time, it has been used in several previous studies to compare journey times[10,19]. The estimated journey time from Baengnyeongdo (an island) was calculated as the sum of ground and sea journey times. The time required for HAT was checked using the emergency medical chart. It is impossible to make an exact cost comparison of the different modes of transport, because the cost of HAT is not charged to the patient in Korea. However, to compare the cost-effectiveness of both transportation methods, we computed their approximate cost. The cost of ground transportation was based on the standard rate of a private medical transport company according to distance, and the helicopter transport cost was estimated by the number of transport hours according to the National Emergency Management Agency. All costs in USD were converted to KRW, and statistical analysis was performed using SPSS version 19.0 (SPSS Inc., Chicago, IL, USA). The Student's t-test was used to compare the benefits of both transportation methods. Differences were regarded as significant if $p<0.05$.

RESULTS

In total, 99 patients were transferred by helicopter to a single university medical center over a 2-year period. Among them, 32 patients were admitted to the neurosurgical department (Table 1). All patients underwent one-way helicopter transport. The mean patient age was 44.2 years (range, 11–73 years), and 27 (84.4%) of the patients were male. Of the 32 patients referred to the neurosurgical department, most (34.4%) were diagnosed as having cerebral contusion (Table 2). Following their arrival, 3 patients (9.4%) died, 3 patients (9.4%) were admitted to the general ward, and 26 patients (81.3%) were initially triaged to ICU or taken directly to the operating room (Fig. 3A).

Generally, transfer distance was proportional to transfer time.

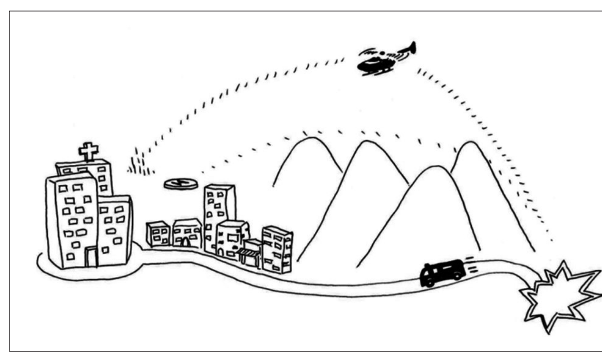

Fig. 1. Pictorial representation of helicopter and ground ambulance transport.

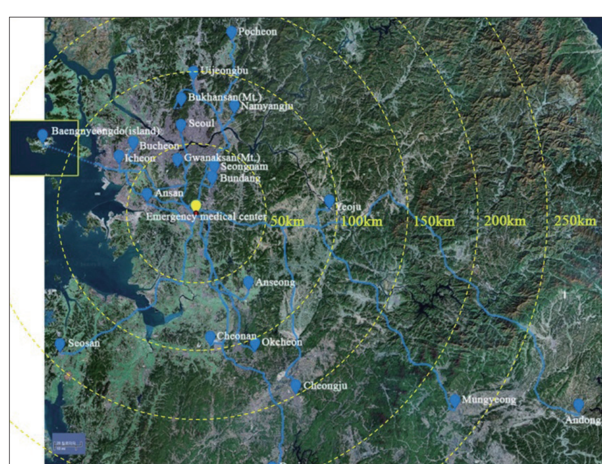

Fig. 2. Geographical distribution of helicopter ambulance transport patients and estimated route taken by the ground ambulance transport.

Table 1. The location of cases requiring helicopter ambulance transport

Location	No. of cases	Distance (km)	Mean helicopter transfer time (min)	Expected ground transfer time (min)	Obstacles
Bundang	1	20	18	30	-
Seongnam	1	24	36	42	-
Ansan	2	24	48 (35–60)	47	-
Seoul	1	42	33	60	-
Icheon	2	50	30 (30–30)	60	-
Anseong	5	51	50 (27–73)	60	-
Okcheon	1	51	74	60	-
Bucheon	1	53	40	70	-
Namyangju	1	54	25	70	-
Cheonan	1	64	30	70	-
Uijeongbu	1	68	75	90	-
Yeoju	2	79	33	64	-
Pocheon	1	88	60	119	-
Seosan	2	96	36 (24–47)	100	-
Gwanaksan (Mt.)	1	35	56	57	Mountain
Bukhansan (Mt.)	2	76	95 (91–104)	109	Mountain
Cheongju	1	106	36	100	-
Daejeon	1	130	52	110	-
Mungyeong	2	157	25 (15–34)	110	-
Baengnyeongdo (Island)	2	227 (60+167)*	84 (80–88)	420 (80+360)†	Yellow sea
Andong	1	227	23	185	-

*Total distance is sum of ground (60 km) and sea (167 km) distance, †Total expected ground transfer time is sum of ground (80 min) and sea (360 min) transfer time

Table 2. The main neurosurgical diagnosis and neurosurgical operation for patients transferred by helicopter ambulance

Main neurosurgical diagnosis	No. of cases (%)	Neurosurgical operation (No. of cases)	Operation percentage (%)
Cerebral contusion	10 (31.3)	None	0
Skull fracture	4 (12.5)	FCCD reconstruction (2)	50
Epidural hematoma	3 (9.4)	C/E/H/R (1) C/O/H/R (2)	100
Subdural hematoma	4 (12.5)	ICP monitoring (1) C/E/H/R (1)	50
Intracerebral hemorrhage	2 (6.3)	EVD insertion (1)	50
Traumatic subarachnoid hemorrhage	2 (6.3)	ICP monitoring (1)	50
Spinal fracture	4 (12.5)	None	0
Traumatic cervical disc disease	3 (9.4)	C-AIF (1)	33

FCCD : fracture compound comminuted depressed, C/E/H/R : craniectomy and hematoma removal, C/O/H/R : craniotomy and hematoma removal, ICP : intracranial pressure, EVD : external ventricular drainage, C-AIF : cervical anterior interbody fusion

For transfer from the trauma scene to the hospital, the longest time taken was 104 minutes and the shortest time taken was 8 minutes. The mean helicopter transport time was 45.6 minutes. On arrival, 15 patients (46.9%) had a GCS score of ≥13, and 8 patients (25.0%) had a GCS score of ≤8. Thus, more than half of the patients were found to have suffered a mild head injury (Fig. 3B). Overall, 21 patients (65.6%) underwent at least one invasive procedure. Among them, 10 patients (31.3%) needed neurosurgical intervention, 14 patients (43.8%) needed non-neurosurgical intervention, 3 patients (9.4%) needed both, and the remaining 11 (34.4%) patients did not require surgical intervention (Fig. 3C). The 10 neurosurgical operations included fracture compound comminuted depressed reconstruction, craniectomy and hematoma removal, craniotomy and hematoma removal, intracranial pressure monitoring, external ventricular drainage, and cervical anterior interbody fusion. The median time from trauma to neurosurgery was 6.15 hours, and varied with the diagnosis. Craniotomy and hematoma removal were associated with the shortest interval to operation (median 4.2 hours, n=2) while intracranial pressure monitoring involved the longest interval to operation.

A comparison of the estimated GAT transfer time and the recorded HAT transfer time is summarized in Table 1. The mean estimated GAT time was 98.8 minutes (range, 30–420 minutes),

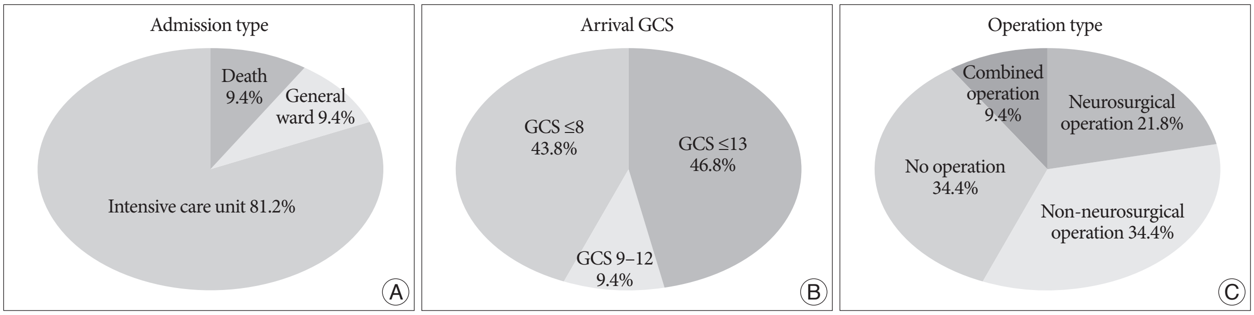

Fig. 3. There characteristics of patients who were transferred using helicopter ambulance transport. A : Admission type. B : GCS on admission. C : Operation type of each patient. GCS : Glasgow Coma Scale.

whilst the mean HAT time was significantly faster at 45.6 minutes (range, 15–104 minutes; $p<0.001$). However, 13 cases (41%) involved an estimated GAT time of less than 1 hour. The journey time with respect to distance (using cutoffs of 50, 70, and 100 km) and obstacles (mountain or sea) was similar for journeys of less than 50 km, but significantly shorter for longer journeys by HAT compared to GAT (Fig. 4). The cost comparison showed that HAT was more expensive than GAT (3292000 vs. 84000 KRW, $p<0.001$). Twenty-five patients (78%) were discharged from the neurosurgical department, of whom 13 patients (40%) stayed in hospital for rehabilitation and 12 patients (38%) went home. The remaining 7 patients (22%), all of whom had a GOS score of 1, died. At discharge, 13 patients (41%) had a GOS score of between 2 and 4 (requiring rehabilitation) and 12 patients (38%) had a GOS score of 5. Six months later, 7 patients (21%) had a GOS score of 1, and 8 patients (25%) had a GOS score between 2 and 4, and 17 patients (53%) had a GOS score of 5.

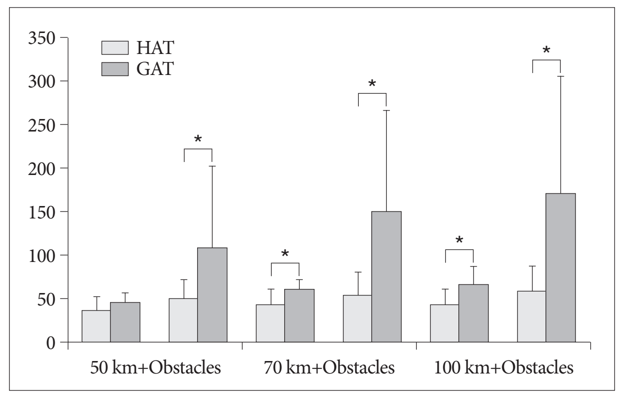

Fig. 4. Comparison of transport time between helicopter ambulance transport (HAT) and ground ambulance transport (GAT) according to the distance and geographic obstacles. *$p<0.05$ for the HAT time compared with that of GAT transfer time.

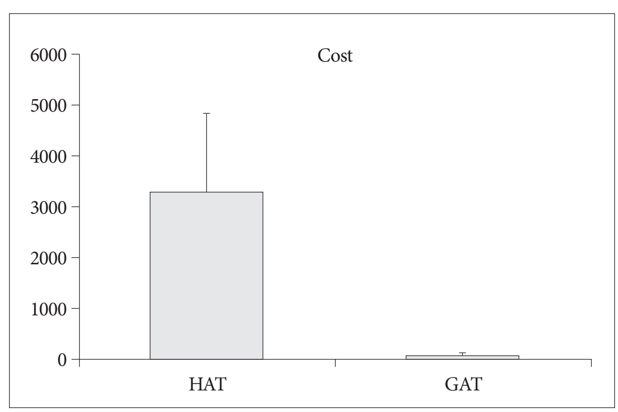

Fig. 5. Cost comparison of helicopter ambulance transport (HAT) and ground ambulance transport (GAT) (KRW, $p<0.001$)

DISCUSSION

Recently, HAT has been prominent in a variety of neurosurgical emergencies, and the necessity for a higher level of care is the commonly cited justification[1,12,20]. In general, it is assumed that helicopter transport reduces transfer time relative to a ground ambulance, and thus reduces risk exposure times. Furthermore, a helicopter can take off and land almost anywhere, can move in any axis, and can fly very slow and hover in one place[9]. However, helicopter transport needs a very high level of staff training, for example, safety training, evacuation procedure for the aircraft, and basic on-board communication skills. It is also a concern that helicopter vibration could potentially exacerbate bleeding and pain from fracture sites. The most important disadvantage though is the very high cost, and cost effectiveness is one of most important but also the most controversial issues in this area[11,20].

Our retrospective analysis showed that many patients transferred via HAT owing to trauma and needing neurosurgical care underwent surgery in a high level emergency center. There were some clinical benefits in selected cases. The patients with "highly critical" diagnoses, such as epidural hematoma, require an early emergency operation. We found that the mean time from trauma to arrival in the operation room was 6.15 hours, and the shortest time was 4.2 hours (craniotomy & hematoma removal in epidural hematoma patients). An early operation in cases of epidural hematoma removal led to a better outcome, and delay correspondingly was associated with a poor outcome[3,10].

However, many of these patients did not undergo an invasive procedure, most probably having cerebral contusion. Mild traumatic brain injury can be managed effectively when a surgical lesion is not initially present[4]. In severe traumatic injured patients who did not require emergent hematoma evacuation we placed the intracranial pressure monitoring device after follow up CT scan after 4–6 hours, so they did not need immediate surgical procedure. The GCS score for 46.8% of these patients was more than 13. The GCS is routinely used in the acute care setting after traumatic brain injury to guide decision in triage, on the basis of its ability to predict morbidity and mortality[5-7,21].

It is widely assumed that HAT is more rapid than ground transport, and, therefore, it uses up less trauma-golden time. As a result, the estimated difference in time between HAT and GAT should be clinically meaningful. The key points of our study were that the referring facilities were all located in South Korea and that there were no adverse events during HAT. The mean HAT transfer time was 45.6 minutes, and over the same distance, the mean estimated ground transport time using Google Maps software was 98.8 minutes, meaning that HAT was on average 2.33 minutes faster. However, the estimated GAT time was less than 1 hour for 15 patients (46.9%) in this study. Furthermore, in a previous study, hospitals that did not have access to HAT also did not have an increased transport time or mortality rate for trauma patients[13]. We also need to consider that HAT is very expensive. The cost of HAT during the period of our study was estimated by the National Emergency Management, Gyeonggi, to be 3,084,812 (706,000–6,625,000) KRW. Patients in South Korea do not have to pay for HAT, and the cost is consequently born by the country, despite the clinical benefit being unproven[3,8,19].

As discussed above, a reduced transport time using HAT did result in a clinical benefit in cases where the injury occurred more than 50 km from the hospital or there were intervening geographical obstacles such as a mountain or the sea. However, many other cases failed to show any advantage from HAT. For example, some cases involving spinal fractures in this study did not require surgery (only 1 patient was taken for an emergency operation for cervical anterior interbody fusion among a total 3 cases involving spinal fracture). During HAT, helicopter vibration is dangerous for spinal fracture patients[8]. It is also noteworthy that contusion was the most common trauma in our study (n=10, 31.3%), but none of these patients needed neurosurgery. Thus, in some cases, there appears to be little clinical benefit from the reduction in transfer time provided by costly helicopter transport[19].

The GOS remains the most widely used method of analyzing outcome in severely head-injured patients[15]. In our study, 7 patients (21%) had a GOS score of 1, all of whom died. We think that these deaths were a result of the initial trauma and would not have been affected by the transfer time. Furthermore, the HAT service is always staffed by an emergency medical service dispatcher or a trauma surgeon or nurse, and at the scene, the triage is always divided between them. Many of the HAT patient's triages were found to be inappropriate in previous studies[11,20]. Therefore, we suggest that new criteria for the use of HAT be developed.

Our study has several limitations. First, only a limited number of hospitals in Korea have recently gained access to HAT. Thus, this study was an initial experience of a single institution, and consequently, the sample size was relatively small. Second, this study could not take into account the weather and traffic conditions owing to a lack of information, although both could greatly affect the transfer time. Furthermore, the scene of the accident and transport between hospitals is not classified. Despite these limitations, this is the first study to evaluate the efficacy of HAT in Korea. Our findings suggest that HAT might be beneficial in some emergency cases such as long distance transfer or geographical obstacles (mountains or sea). However, the use of HAT represents an unnecessary financial burden in cases where it provides no clinical benefit. In the near future, a well-designed study with more cases is required to re-examine the benefit of HAT in patients with a neurological emergency status.

CONCLUSION

HAT is significantly faster than GAT, and has some clinical benefit in selected cases. Determining the precise indication of its use remains a challenge. Our findings suggest that some patients did not benefit from HAT transfer, as evidenced by the lack any necessity for neurosurgical intervention and equivalent estimated GAT times. We think that clear criteria for HAT are needed considering its high cost, and that neurosurgeons should be involved in the decision process of HAT for proper triage.

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