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The characteristics and clinical outcomes of trauma patients transferred by a physician-staffed helicopter emergency medical service in Korea: a retrospective study

Myung Jin Jang, MD[1], Woo Sung Choi, MD[2], Jung Nam Lee, MD[1,3], Won Bin Park, MD[2]

[1]Department of Trauma Surgery, Gachon University Gil Medical Center, Incheon, Korea
[2]Department of Emergency Medicine, Gachon University Gil Medical Center, Incheon, Korea
[3]Department of Trauma Surgery, Gachon University College of Medicine, Incheon, Korea

Purpose: Helicopter transport with medical teams has been proven to be effective, with improvements in patient survival rates. This study compared and analyzed the clinical characteristics and treatment outcomes of trauma patients transported by doctor helicopters according to whether patients were transferred after a clinical evaluation or without a clinical evaluation.

Methods: This study retrospectively reviewed data from the Korean Trauma Data Bank of trauma patients who arrived at a regional trauma center through doctor helicopters from January 1, 2014, to December 31, 2022. The patients were divided into two groups: doctor helicopter transport before evaluation (DHTBE) and doctor helicopter transport after evaluation (DHTAE). These groups were compared.

Results: The study population included 351 cases. At the time of arrival at the trauma center, the systolic blood pressure was significantly lower in the DHTAE group than in the DHTBE group (P=0.018). The Injury Severity Score was significantly higher in the DHTAE group (P<0.001), and the accident to trauma center arrival time was significantly shorter in the DHTBE group (P<0.001). Mortality did not show a statistically significant between-group difference (P=0.094). Surgical cases in the DHTAE group had a longer time from the accident scene to trauma center arrival (P=0.002). The time from the accident to the operation room or from the accident to angioembolization showed no statistically significant differences.

Conclusions: DHTAE was associated with significantly longer transport times to the trauma center, as well as nonstatistically significant trends for delays in receiving surgery and procedures, as well as higher mortality. If severe trauma is suspected, air transport to a trauma center should be requested immediately after a simple screening test (e.g., mechanism of injury, Glasgow Coma Scale, or Focused Assessment with Sonography in Trauma), which may help reduce the time to definitive treatment.

Keywords: Wounds and injuries; Transportation; Air ambulances; Trauma centers

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Correspondence to
Jung Nam Lee, MD, PhD
Department of Trauma Surgery,
Gachon University Gil Medical Center,
21 Namdong-daero 774beon-gil,
Namdong-gu, Incheon 21565, Korea
Tel: +82-32-460-3010
Email: jnlee@gilhospital.com

Won Bin Park, MD
Department of Emergency Medicine,
Gachon University Gil Medical Center,
21 Namdong-daero 774beon-gil,
Namdong-gu, Incheon 21565, Korea
Tel: +82-32-460-3015
Email: gil11686@gilhospital.com

INTRODUCTION

Background

Trauma is the fourth leading cause of death in Korea, following cancer, diseases of the circulatory system, and diseases of the respiratory system. It is also the leading cause of death in individuals under the age of 40 years [1]. The socioeconomic losses resulting from trauma are escalating annually, with costs reaching as high as 13.7 trillion KRW, highlighting the importance of effective treatment of trauma patients [2].

The preventable death rate refers to the probability of a trauma patient surviving if they receive timely and appropriate treatment at a suitable medical facility. In Korea, the preventable trauma death rate was 35.2% as of 2013, which was substantially higher than the rates of 10% to 15% reported in the United States and Japan during the same period [3]. In an effort to address this issue, Korea launched a trauma specialization project in 2009 and, by 2022, had established 17 regional trauma centers aimed at reducing the preventable death rate and providing optimal care for patients with severe trauma [4]. The creation of these regional trauma centers has contributed to a reduction in the preventable death rate to as low as 15.9% [5]. However, the rate of preventable deaths occurring before hospital admission remains significantly high [6]. Consequently, prehospital care is essential in further decreasing these rates. In Korea, the deployment of the physician-staffed helicopter emergency medical system—also known as "doctor helicopters"—in 2011 has greatly improved the speed and efficiency of emergency treatment and transport for trauma cases [7].

Helicopter transport with onboard medical teams has been demonstrated to be effective in several previous studies [8–10], and it has been reported to be cost-effective, with improvements in patient survival rates [11,12]. In Korea, there have been a limited number of studies on the use of medical team-assisted helicopter transport for trauma patients. These studies have primarily focused on assessing the effectiveness of helicopter transport, with or without medical teams, or comparing it to ground transport [8,13]. However, there has not yet been a study comparing the outcomes of transporting trauma patients by helicopter from a nearby hospital after an initial injury assessment and subsequent transfer, as opposed to on-site transportation or providing only initial treatment without a clinical evaluation before transferring the patient to a regional trauma center for definitive care.

Objectives

The purpose of this study was to compare and analyze the clinical characteristics and treatment outcomes of trauma patients transported by doctor helicopters according to whether they were transferred after a clinical evaluation or without a clinical evaluation.

METHODS

Ethics statement

We conducted this study in compliance with the principles of the Declaration of Helsinki. The study protocol was reviewed and approved by the Institutional Review Board of Gachon University Gil Medical Center (No. GDIRB2023-180). The requirement for informed consent was waived due to the retrospective nature of the study.

Study subjects and period

This study is a retrospective analysis conducted using data from the Korea Trauma Data Bank to examine the clinical characteristics and outcomes of trauma patients transported by doctor helicopters to a single regional trauma center at Gachon University Gil Medical Center (Incheon, Korea), a 1,500-bed tertiary general hospital, between January 1, 2014, and December 31, 2022. The exclusion criteria for the study population comprised patients who died upon arrival at the emergency department, those who were transferred to other hospitals after an initial assessment in the emergency room, cases where the type of aircraft used for transport was unknown, and patients transferred more than 24 hours after sustaining their injuries.

Study design

All patients included in the study were divided into two groups: doctor helicopter transport before evaluation (DHTBE; n = 168), which consisted of patients transferred directly from the accident scene or transferred only after receiving initial emergency treatment without clinical evaluation, and doctor helicopter transport after evaluation (DHTAE; n = 183), which consisted of patients who had received initial emergency treatment and clinical evaluation at a medical institution before being transferred.

The following clinical characteristics were compared between the DHTBE and DHTAE groups: the patient's age, sex, injury mechanism, time of the accident, systolic blood pressure upon arrival at the regional trauma center, Glasgow Coma Scale (GCS), Revised Trauma Score (RTS), Injury Severity Score (ISS), Trauma and Injury Severity Score (TRISS), time from the accident to regional trauma center arrival, Abbreviated Injury Scale (AIS), and mortality. The mechanisms of injury were categorized as motor vehicle accidents (MVAs), bicycle, motorcycle, pedestrian, falls, slips, being struck by an object, penetrating injuries, and others. Emergency management following arrival at the regional trauma center was also compared between the DHTBE and DHTAE groups. Factors such as transfusion, surgical management, angioembolization, time from the accident to the operating room, time from the accident to the angiography, and mortality were considered. An analysis was conducted to evaluate factors independently associated with mortality.

Statistical analysis

Continuous variables were presented as either the median and interquartile range (IQR) or the mean and standard deviation. Categorical variables were presented as counts and percentages (%) unless otherwise specified. Univariate analysis was conducted using the Mann-Whitney U-test or t-test for continuous variables, and the chi-square test or Fisher exact test for categorical variables. To evaluate factors independently associated with mortality, multivariate backward logistic regression analysis was utilized, incorporating covariates such as age, sex, timing of air transport (before or after evaluation), injury mechanism, systolic blood pressure, ISS, transfusion, and head AIS. Data were analyzed using IBM SPSS ver. 25.0 (IBM Corp). A P-value of <0.05 was considered to indicate statistical significance.

RESULTS

The clinical characteristics of the study population

From January 1, 2014, to December 31, 2022, a total of 551 trauma patients were transported by air. After excluding 89 patients who did not meet the inclusion criteria and 111 patients who were not transported by doctor helicopters, 351 patients who arrived via doctor helicopters were included in the study population. These 351 patients were divided into the DHTBE group (n = 168) and the DHTAE group (n = 183) (Fig. 1).

The DHTBE had a statistically lower average age than the DHTAE group (59.5 years [IQR, 51.0–69.0 years] vs. 62.1 years [IQR, 53.0–76.0 years]; but there was no statistically significant difference in the sex distribution between the two groups (male sex, 75.6% vs. 77.6%, P = 0.658). The most common mechanism of injury was falls in both groups (24.4% vs. 25.1%), and there was no significant difference between the two groups (P = 0.874). However, in the DHTAE group, injuries caused by MVAs were more frequent (11.9% vs. 23.0%, P = 0.007), while in the DHTBE group, injuries caused by being struck by objects were statistically significantly more common than in the DHTAE group (23.8% vs. 8.7%, P < 0.001).

At the time of arrival at the trauma center, the systolic blood pressure of the DHTAE group was statistically significantly lower than that of the DHTBE (137.5 mmHg [IQR, 119.8–161.0 mmHg] vs. 128.9 mmHg [IQR, 108.0–154.5 mmHg], P = 0.018). However, there were no significant differences between the two groups in terms of the initial GCS and RTS. The ISS was significantly higher in the DHTAE group (12.3 [IQR, 4.0–17.8] vs. 19.1 [IQR, 9.0–25.0], P < 0.001) and the proportion of severely injured trauma patients with an ISS exceeding 15 was also significantly higher in the DHTAE group (36.3% vs. 60.7%, P < 0.001). However, the accident to trauma center arrival time was significantly shorter in the DHTBE group (135.6 minutes [IQR, 81.0–178.8 minutes] vs. 214.5 minutes [IQR, 120.0–221.0 minutes], P < 0.001). Mortality did not show a statistically significant difference between the two groups (7.7% vs. 12.6%, P = 0.094) (Table 1).

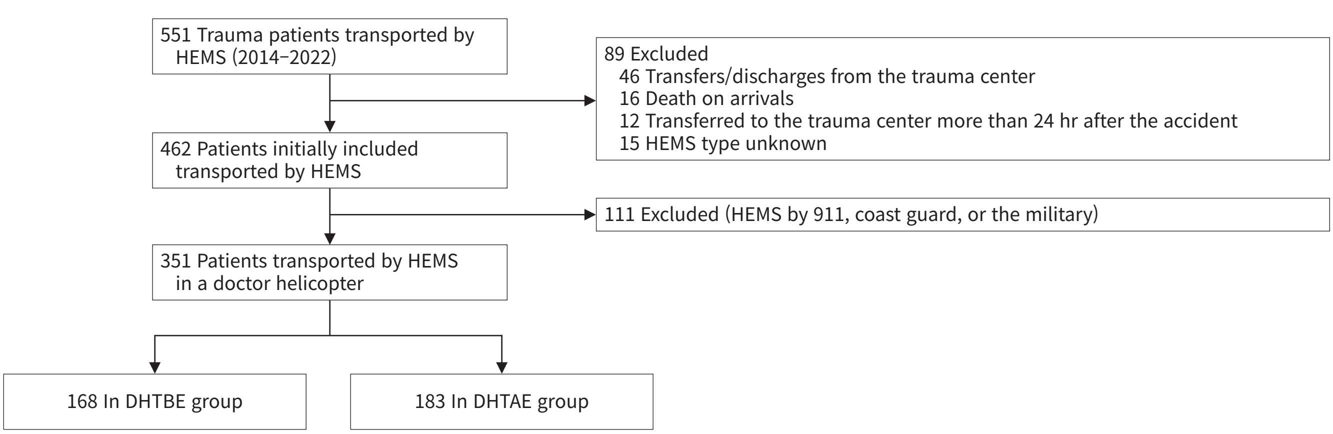

Fig. 1. Selection process flowchart for trauma cases transported by doctor helicopters. HEMS, helicopter emergency medical services; DHTBE, doctor helicopter transport before evaluation; DHTAE, doctor helicopter transport after evaluation.

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Table 1. Baseline characteristics of doctor helicopter transportation patients (n=351)

Variable	Doctor helicopter transportation		P-value
	Before evaluation (n=168)	After evaluation (n=183)	
Age (yr)	55.9 (51.0–69.0)	62.1 (53.0–76.0)	0.035
Male sex	127 (75.6)	142 (77.6)	0.658
Injury mechanism			
Motor vehicle accident	20 (11.9)	42 (23.0)	0.007
Bicycle	8 (4.8)	6 (3.3)	0.478
Motorcycle	17 (10.1)	22 (12.0)	0.571
Pedestrian	10 (6.0)	12 (6.6)	0.815
Falls	41 (24.4)	46 (25.1)	0.874
Slip down	19 (11.3)	22 (12.0)	0.836
Struck by object	40 (23.8)	16 (8.7)	<0.001
Penetrating	6 (3.6)	4 (2.2)	0.436
Others	5 (3.0)	6 (3.3)	0.402
Unknown	2 (1.2)	7 (3.8)	0.119
Systolic blood pressure (mmHg)	137.5 (119.8–161.0)	128.9 (108.0–154.5)	0.018
<90	13 (34.2)	25 (65.8)	0.072
Glasgow Coma Scale score	13.9 (15.0–15.0)	14.0 (14.0–15.0)	0.795
Revised Trauma Score	7.5 (7.8–7.8)	7.5 (7.8–7.8)	0.806
Injury Severity Score	12.3 (4.0–17.8)	19.1 (9.0–25.0)	<0.001
>16	61 (36.3)	111 (60.7)	< 0.001
Trauma and Injury Severity Score	0.9 (0.9–1.0)	0.9 (0.9–1.0)	0.362
Accident to trauma center arrival[a)] (min)	135.6 (81.0–178.8)	214.5 (120.0–221.0)	<0.001
Mortality	13 (7.7)	23 (12.6)	0.094

Values are presented as median (interquartile range) or number (%).
[a)]Time taken from the scene of the accident to the medical facility.

Comparison of injury regions

In the analysis of injury regions using the AIS, the DHTAE group had significantly more severe injuries than the DHTBE group in both the head and neck region (2.9 [IQR, 2.0–4.0] vs. 3.7 [IQR, 3.0–5.0], P<0.001) and the abdominal region (2.3 [IQR, 2.0–3.0] vs. 2.8 [IQR, 2.0–3.0], P=0.013) (Table 2).

Emergency surgery or procedures after arriving at the regional trauma center

Among the study population, 64 patients underwent emergency surgery after arriving at the trauma center, with brain surgery, including craniectomy and craniotomy, being the most common at 21 cases (32.8%). Extremity surgery, including amputation and external fixation, accounted for 14 cases (21.9%), while abdominal surgery due to intra-abdominal organ injury was performed in 13 cases (20.3%). Among patients who underwent emergency surgery after arriving at the trauma center, the proportion of patients who received emergency surgery was statistically significantly higher in the DHTAE group than in the DHTBE group (13.7% vs. 22.4%, P=0.035). In the DHTAE group, abdominal surgery was significantly more common than in the DHTBE group (1.2% vs. 6.0%, P=0.017), while there was no significant difference in the proportion of patients who underwent brain surgeries (4.2% vs. 7.7%, P=0.169).

Emergency vascular embolization was performed in 20 cases. Pelvic vessel embolization due to pelvic bone fractures was the most common, with 11 cases (55.0%), followed by splenic embolization with six cases (30.0%). There was no significant difference in the proportion of patients who received angioembolization between the two groups (3.6% vs. 7.7%, P=0.100), nor was there a significant difference in the anatomical regions where the procedures were performed.

In a comparison of the timelines of the two groups of patients who underwent surgery, the time from the accident scene to arrival at the trauma center was significantly longer in the DHTAE group than in the DHTBE group (112.7 minutes [IQR, 77.0–133.0 minutes] vs. 184.5 minutes [IQR, 120.0–237.5 minutes], P=0.002). Additionally, the time from the accident to the operating room was longer in the DHTAE group than in the DHTBE group, although this difference was not statistically significant (269.0 minutes [IQR, 190.0–306.0 minutes] vs. 297.5 minutes [IQR, 199.8–388.8 minutes], P=0.363).

Table 2. Abbreviated Injury Scale of doctor helicopter transportation patients (n=351)

Abbreviated Injury Scale	Doctor helicopter transportation		P-value
	Before evaluation (n=168)	After evaluation (n=183)	
Head and neck	2.9 (2.0–4.0)	3.7 (3.0–5.0)	<0.001
≥3	44 (26.2)	102 (55.7)	<0.001
Face	1.7 (1.0–2.0)	1.8 (1.0–2.0)	0.832
≥3	2 (1.2)	3 (1.6)	0.723
Chest	2.8 (3.0–3.0)	2.8 (2.3–30)	0.818
≥3	46 (27.4)	60 (32.8)	0.270
Abdomen	2.3 (2.0–3.0)	2.8 (2.0–3.0)	0.013
≥3	9 (5.4)	34 (18.6)	<0.001
Pelvis and extremities	2.3 (2.0–3.0)	2.5 (2.0–3.0)	0.220
≥3	30 (17.9)	31 (16.9)	0.821
External	1.1 (1.0–1.0)	1.1 (1.0–1.0)	0.845

Values are presented as median (interquartile range) or number (%).

No statistically significant difference was found in the anatomical region of angioembolization between the two groups. In the DHTAE group, the time from the accident to trauma center arrival was longer than in the DHTBE group (173.7 minutes [IQR, 76.5–225.0 minutes] vs. 235.8 minutes [IQR, 118.8–337.5 minutes], P=0.472). The DHTAE group had a longer time from the accident to angioembolization than the DHTBE group, but the difference was not statistically significant (289.8 minutes [IQR, 199.5–387.8 minutes] vs. 310.9 minutes [IQR, 186.0–397.3 minutes], P=0.804) (Table 3).

Treatment outcomes

The logistic regression analysis for associations between each variable and mortality showed significant associations for systolic blood pressure (odds ratio [OR], 0.977; 95% confidence interval [CI], 0.963–0.991; P=0.001), transfusion (OR, 12.328; 95% CI, 4.161–36.529; P<0.001) and head AIS >3 (OR, 17.666; 95% CI, 5.176–60.300; P<0.001). The category of doctor helicopter transport (DHTBE or DHTAE) was not associated with mortality. The multivariate analysis was adjusted for covariates including age, sex, doctor helicopter transport type, injury mechanism, systolic blood pressure, ISS, transfusion, and head AIS (Table 4).

DISCUSSION

This study analyzed the clinical characteristics and treatment outcomes of trauma patients transported to a regional trauma center by doctor helicopters.

Among the 462 cases that met the inclusion criteria of this study, 351 (76.0%) were transported to the hospital by doctor helicopters. This proportion was higher than the 55.6% reported in a previous study by Jung et al. [10], and this difference can be attributed to the presence of doctor helicopters. The ISS was significantly higher in the DHTAE group, reflecting the fact that the DHTAE group included more patients with systolic blood pressure under 90 mmHg and patients who received blood transfusions after arrival. This suggests that the severity of patients' conditions was significantly higher in the DHTAE group. Doctor helicopter transport was provided, and the time from the accident scene to the regional trauma center arrival was approximately 80 minutes longer in the DHTAE group. Furthermore, the mortality rate was not significantly improved in the DHTAE group. Furthermore, considering that the TRISS of this study population showed no significant difference between the two groups [14], the predicted mortality rate between the two groups appeared to be similar, suggesting that an aggressive clinical evaluation of severely injured trauma patients at an emergency medical institution near the trauma scene may not have a significant positive effect on the prognosis.

Among the study population, the head and neck region was the most common site of injury with an AIS score of 3 or higher, accounting for 41.6%. This incidence is higher than the 18.0% reported by Weinlich et al. [15] and the 31.8% reported by Hesselfeldt et al. [8]. Consistent with several previous studies [8,15,16], the head and neck region was also the most frequently injured area in the current study. Given these findings, it is recommended that if the mechanism of injury suggests a traumatic brain injury, or if neurological symptoms such as a decreased GCS are observed at the scene or in the emergency department near the trauma site, air transport to a trauma center should be arranged as soon as possible to avoid unnecessary delays.

In the present study, 18.2% of patients underwent surgery, with

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Table 3. Emergency management at the trauma center (n=351)

Variable	Doctor helicopter transportation		P-value
	Before evaluation (n=168)	After evaluation (n=183)	
Transfusion	36 (21.4)	68 (37.2)	0.001
4-hr RBC (U)	5.15±4.1	6.04±7.09	0.551
24-hr RBC (U)	4.25±3.34	3.53±3.47	0.374
Surgical management (n=64)	23 (13.7)	41 (22.4)	0.035
Brain	7 (4.2)	14 (7.7)	0.169
Spine	1 (0.6)	1 (0.5)	0.952
Thorasic	1 (0.6)	1 (0.5)	0.952
Abdomen	2 (1.2)	11 (6.0)	0.017
Vascular	3 (1.8)	6 (3.3)	0.377
Extremity	7 (4.2)	7 (3.8)	0.870
Other	2 (1.2)	1 (0.5)	0.513
Angioembolization (n=20)	6 (3.6)	14 (7.7)	0.100
Spleen	2 (1.2)	4 (2.2)	0.472
Liver	0	1 (0.5)	0.337
Kidney	0	1 (0.5)	0.337
Pelvic	3 (1.8)	8 (4.4)	0.165
Other	1 (0.6)	0	0.296
Accident to trauma center arrival[a)] (min)			
Surgical management group	112.7 (77.0–133.0)	184.5 (120.0–237.5)	0.002
Angioembolization group	173.7 (76.5–225.0)	235.8 (118.8–337.5)	0.472
Accident to operation[b)] or intervention[c)] room (min)			
Surgical management group	269.0 (190.0–306.0)	297.5 (199.8–388.8)	0.363
Angioembolization group	289.8 (199.5–387.8)	310.9 (186.0–397.3)	0.804

Values are presented as number (%), mean±standard deviation, or median (interquartile range).
RBC, red blood cell.
[a)]Time taken from the scene of the accident to the regional trauma center. [b)]Time taken from the scene of the accident to the operation time. [c)]Time taken from the scene of the accident to the angioembolization time.

Table 4. Logistic regression analysis for mortality (n=351)

Variable	Mortality of air transportation patients		P-value
	Unadjusted OR (95% CI)	Adjusted OR (95% CI)	
Age	1.019 (0.997–1.043)	-	0.222
Sex (reference, male)	0.770 (0.355–1.673)	-	0.864
DHTBE (reference, DHTAE)	1.714 (0.838–3.504)	-	0.498
Motor vehicle accident		-	
Bicycle (reference)	0.321 (0.038–2.695)		0.585
Motorcycle (reference)	0.758 (0.259–2.218)		0.841
Pedestrian (reference)	0.926 (0.264–3.242)		0.793
Fall (reference)	0.365 (0.135–0.988)		0.185
Slip down (reference)	0.214 (0.045–1.011)		0.448
Struck by object (reference)	0 (0–0)		0.997
Penetrating (reference)	0 (0–0)		0.999
Systolic blood pressure	0.972 (0.961–0.983)	0.977 (0.963–0.991)	0.001
Injury Severity Score	1.124 (1.083–1.167)	-	0.184
Transfusion (reference, no)	14.425 (4.103–50.711)	12.328 (4.161–36.529)	<0.001
Head AIS ≥3 (reference, <3)	9.718 (2.329–40.544)	17.666 (5.176–60.300)	<0.001

OR, odds ratio; CI, confidence interval; DHTBE, doctor helicopter transportation before evaluation; DHTAE, doctor helicopter transportation after evaluation; AIS, Abbreviated Injury Scale.

brain surgery being the most common at 6.0%, followed by laparotomy for abdominal organ injuries at 3.7%. When comparing the time from the accident scene to the trauma center arrival with the time from the accident scene to the operating room, the DHTAE group arrived at the trauma center approximately 70 minutes later, and the time to surgery was about 30 minutes longer. Harmsen et al. [17] reported that a systematic literature review on prehospital delay and prognosis in trauma patients found that rapid transfer positively impacts the outcomes of head injury and hypotensive patients. Harvin et al. [18] and Clarke et al. [19] have reported an increase in mortality as surgical treatment time is delayed for abdominal injury patients. Harvin et al. [18] also highlighted the importance of reducing transfer times, including air transport, to prevent delays in surgical treatment.

In the present study, among the patients who underwent surgery, there was a significant decrease in the time from the accident to trauma center arrival in the DHTBE group. However, the time from the accident to the operating room did not show a statistically significant decrease in the DHTBE group. This may be because even in the DHTBE group, an assessment of the injury, such as computed tomography (CT) scans or x-rays, must be performed at the trauma center before surgery or procedures can be based on the patient's clinical condition. This likely influenced the lack of significant difference in the time from the accident to definitive management in the current study. Nonetheless, the study population showed a trend toward a shorter time from the accident to definitive treatment in the DHTBE group, suggesting that requesting a doctor helicopter transfer in advance to a trauma center equipped with the necessary human and medical resources could be beneficial for trauma patients.

Based on the results of this and previous studies, it is recommended that, instead of delaying surgical time for time-consuming imaging tests such as CT scans, multiple x-rays, and overly aggressive treatments at initial emergency medical institutions, medical personnel should request doctor helicopter transport to a regional trauma center in advance, following a simple screening test such as extended Focused Assessment with Sonography in Trauma to quickly confirm the presence of abdominal and pericardial fluid. This approach could reduce the patient's time at the scene and shorten the time to surgery [20]. In the group that underwent angioembolization, the times from the accident to trauma center arrival and from the accident to the intervention room showed no statistically significant differences between the DHTBE and DHTAE groups. The suggestions mentioned above could also address this issue.

Vascular embolization was most frequently performed in the pelvic region. Pelvic fractures represent a critical injury that can greatly affect patient survival. As such, prompt resuscitation and the maintenance of pelvic stability are crucial [21–23]. Numerous studies have highlighted the efficacy of pelvic binders in the initial management of pelvic fractures [21–23]. It is important to provide education and training to emergency medical personnel and prehospital care providers on strategies to maintain blood pressure and pelvic stability prior to intervention. This may involve early fluid resuscitation and the application of pelvic binders or other suitable techniques for pelvic stabilization.

Limitations

This study has several potential limitations. First, as a retrospective study, there is a possibility of significant inherent bias. Second, it was not possible to identify all initial emergency treatments administered by the medical institution first visited by the patient or during transport. Consequently, we cannot evaluate the appropriateness of these medical interventions, which may also have influenced patient mortality. Third, this study was conducted at a single center, meaning that our results may not be representative of doctor helicopter transport characteristics more broadly. Further multicenter, large-scale research is needed to better understand the clinical outcomes of doctor helicopter transport in severely injured trauma patients.

Conclusions

DHTAE was associated with significantly longer transport times to the trauma center. It also showed nonsignificant trends for delays in receiving surgery and procedures, as well as higher mortality. If severely injured trauma is suspected, requesting air transport in advance to a trauma center following a simple screening test may help reduce the time to definitive treatment. Further multicenter, large-scale research is needed to evaluate the clinical outcomes of doctor helicopter services in severely injured trauma patients.

ARTICLE INFORMATION

Author contributions

Conceptualization: JNL, WBP; Data curation: MJJ, WSC; Formal analysis: MJJ, WBP; Project administration: JNL, WBP; Methodology: WBP; Visualization: MJJ, WSC; Writing–original draft: MJJ, WSC; Writing–review & editing: all authors. All authors read and approved the final manuscript.

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Conflicts of interest

The authors have no conflicts of interest to declare.

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Data availability

Data analyzed in this study are available from the corresponding author upon reasonable request.

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