Journal of Rural Medicine

Original article

Intentional transit practice through a nearby hospital for remote area emergencies provides earlier primary care than helicopter emergency medical services alone in rural emergencies: a single-center, observational study

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Abstract

Objective: Providing emergency care to serious patients in rural areas remains challenging. Intentional transit practice involves transporting a serious patient to a nearby hospital while requesting the Helicopter Emergency Medical Services (HEMS). This study aims to evaluate its effectiveness on earlier primary medical interventions and the decision of the destination hospital.

Patient and Methods: We conducted a single-center, retrospective observational study at a HEMS base hospital in a rural area of Japan. The study participants included patients who underwent the intentional transit practice between April 2012 and March 2019. We compared actual times to estimated times for each case treated with the HEMS alone (HEMS-alone model). Outcomes were the time from ambulance call to reaching the physician (physician reaching time), arrival at the final destination facility (destination hospital arrival time), and helicopter waiting time at the landing zone (helicopter waiting time). Subgroup analyses by region and an analysis of the relationship between diagnostic tests performed at the transit hospital and the type of destination facility were performed.

Results: Eighty-seven patients were eligible for analysis. Compared to the HEMS-alone model, the intentional transit practice reduced the physician reaching time (median [interquartile] min) (26 [21–32] vs. 37 [29–47], $P<0.0001$) while increasing the destination hospital arrival time and the helicopter waiting time (71 [58–93] vs. 65 [59–80], $P=0.03$; 24 [18–34] vs. 19 [18–21], $P<0.0001$; respectively). Subgroup analysis showed a consistent result for physician reaching time but heterogeneity in the other time courses by region. Diagnostic tests were related to transportation to facilities other than the HEMS base hospital.

Conclusion: The intentional transit practice is beneficial for providing primary care earlier than the HEMS alone and for transport to more specific facilities. However, it delays arrival at the destination facility and increases helicopter waiting time.

Key words: emergencies, rural hospitals, emergency helicopters, healthcare delivery

(J Rural Med 2025; 20(2): 92–101)

Received: August 21, 2024
Accepted: November 28, 2024
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Introduction

Medical disparities exist in emergency care between rural and urban areas. Centralization of the local emergency care system aids in the reduction in mortality rates for certain injuries and illnesses[1]; however, this is a disadvantage for those with acute diseases in the surrounding areas[2, 3]. Access to trauma centers from rural areas is limited[4, 5], resulting in higher mortality of patients in rural areas than in urban areas[6–8]. Even for diseases that require emergency treatment, such as stroke or myocardial infarction, the like-

lihood of receiving more advanced treatment is low in rural areas[9–12].

The physician-staffed Helicopter Emergency Medical Services (HEMS), a system in which emergency physicians travel by helicopters to provide acute care in pre-hospital settings[13], is widely used in many countries[14]. The HEMS provides several pre-hospital medical interventions, more stable transport, and rapid transport for critically ill patients to advanced medical facilities, resulting in low mortality rates for severe trauma[15–19]. Reduced transport time to advanced medical facilities and improved mortality rates are especially expected in rural areas[20, 21]. In Japan, the HEMS was introduced in 2001[22], and 57 systems were in operation as of February 2024. In the Japanese HEMS system, the fire department recognizes an injured or sick person indicative of the HEMS and requests the HEMS. In areas where medical resources are limited, determining whether transport to a local medical facility is sufficient for an injured or sick person is challenging based solely on the information received and observations made by the emergency medical technician. These areas are often located far from the HEMS base hospitals and require considerable time for arrival. Therefore, transporting the patient to a nearby hospital, rather than waiting for HEMS arrival, would result in earlier primary medical intervention.

In the Miyazaki Prefecture, a novel activity has been implemented in which the HEMS is requested in addition to temporary transport to a local hospital until the HEMS arrives (herein, intentional transit practice). In this activity, the medical staff of the local hospital provide initial care to temporarily transported patients and collaborate with the HEMS physicians who arrive later. This activity aims to achieve earlier primary medical intervention through temporary transport as well as the benefits of the HEMS. Furthermore, it provides a more accurate diagnosis and subsequent decision regarding the destination facility by performing diagnostic tests at the temporarily transported facility, which cannot be performed by the HEMS activity alone. However, the effectiveness of this activity has not yet been evaluated.

Therefore, we conducted a novel single-center, retrospective study to evaluate the effectiveness of this activity on earlier primary medical interventions and the decision of the destination hospital. We showed the activities performed by the intentional transit practice—including time course and treatment details—created a HEMS-alone model from them, and compared it with the actual case.

Patients and Methods

Miyazaki Prefecture

Miyazaki—a regional prefecture in southwestern Japan—is approximately 7,735 km^2 in size, with a population of 1.1 million. The distance from north to south is approximately 160 km, with the eastern side being coastal and the western side mountainous. One HEMS is in operation in this prefecture. The HEMS base hospital, the University of the Miyazaki Hospital, is a tertiary-care hospital located in the capital city, slightly south of the center of the prefecture. The southernmost point of the prefecture is the Kushima region (Southern area), the westernmost is the Nishimoro region (Western area), and the northernmost is the Nishiusuki region (Northern area) (Figure 1); the flight times from the HEMS base hospital to these regions are approximately 15, 13, and 30 minutes, respectively. The main hospitals in these districts are not equipped to treat critical emergency injuries and illnesses, such as brain diseases and cardiac emergencies; therefore, patients with these conditions should be transported out of the district.

General HEMS practice and the intentional transit practice

After an emergency call is received by the fire department, the ambulance team heads to the scene. If the HEMS is determined to be applicable based on the information in the call and evaluation by the emergency medical technician, the HEMS base hospital will be requested to dispatch the HEMS. The request criteria for the Miyazaki HEMS include the following: (i) a patient is, or is suspected to be, critically injured or critically ill; (ii) to shorten an extended ground transportation time for severely ill patients; or

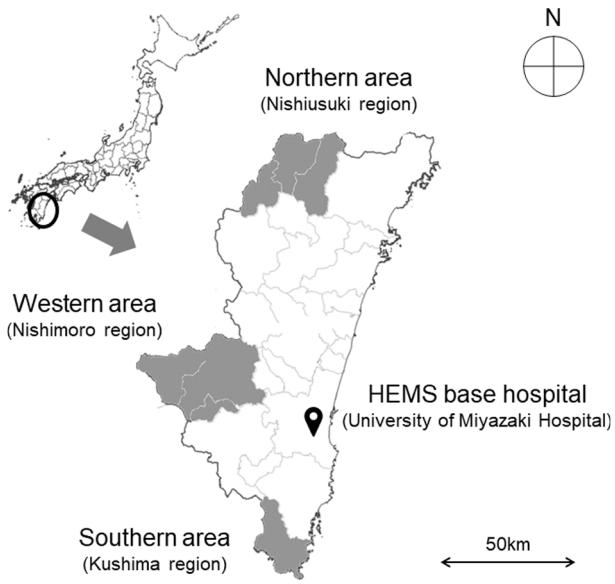

Figure 1 Map of the Miyazaki Prefecture.
The base hospital of the Helicopter Emergency Medical Service in Miyazaki is located in the Southeast area of the Miyazaki Prefecture. HEMS: helicopter emergency medical service.

(iii) emergency physicians' diagnosis and/or treatment are required at the scene[23]. After receiving a request from the fire department, the HEMS dispatches medical personnel, including an emergency physician, from the base hospital.

In general, the fire department designates a landing zone for the helicopter, where the HEMS medical crew meets the ambulance team with the patient on board. Following the examination and provision of emergency care, the HEMS medical crew determines the destination facility, and the patient is transported by air or ground (Figure 2A).

The intentional transit practice is similar to the HEMS-alone activity until the HEMS is requested; however, the ambulance team temporarily transports the patient to a hospital near the landing zone (herein, transit hospital) until the HEMS arrives, and a physician at the hospital provides primary care. Two methods exist for the HEMS medical crew to meet the patients: the HEMS medical crew joins the care at the transit hospital (Figure 2B), or the HEMS medical crew meets the patient transported by a physician at the transit hospital at the landing zone (Figure 2C). The decision regarding the destination facility is made by the HEMS physicians and the physician at the transit hospital based on the findings of the examination.

These practices differ from those for interfacility transportation. In general, or in the intentional transit practice, the fire department requests the HEMS to provide advanced pre-hospital care to patients at the scene. In the case of interfacility transportation, a hospital requests a HEMS from the fire department to transport a patient in the hospital to another hospital.

Study design

This single-center, retrospective, observational study was conducted at the Department of Emergency and Critical Care Center at the University of Miyazaki Hospital. The inclusion criteria were patients treated by the Miyazaki HEMS between April 2012 and March 2019 who were temporarily transported to a nearby hospital prior to HEMS arrival. Eligible cases were extracted from the Miyazaki HEMS and medical records to identify those in which temporary transport was provided. In the primary analysis, the exclusion criteria were cases in which the time course and treatment details were unknown or unavailable, whereas, in the subgroup analysis, cases in areas with fewer than five temporary transports per fire department were excluded.

Items of interest

The following information was extracted from the medical records: date and time of temporary transport, patient age, sex, traumatic or non-traumatic emergency illness, requesting fire department, transit hospital, examination, medical care administered by the temporary care facility and/or HEMS physician, type of final destination medical facility, and whether secondary transport followed. The time of each activity in the fire department and the HEMS was extracted by referring to the medical records and the HEMS database.

HEMS-alone model

We created HEMS-alone models for each case using actual times of intentional transit practice and times of simi-

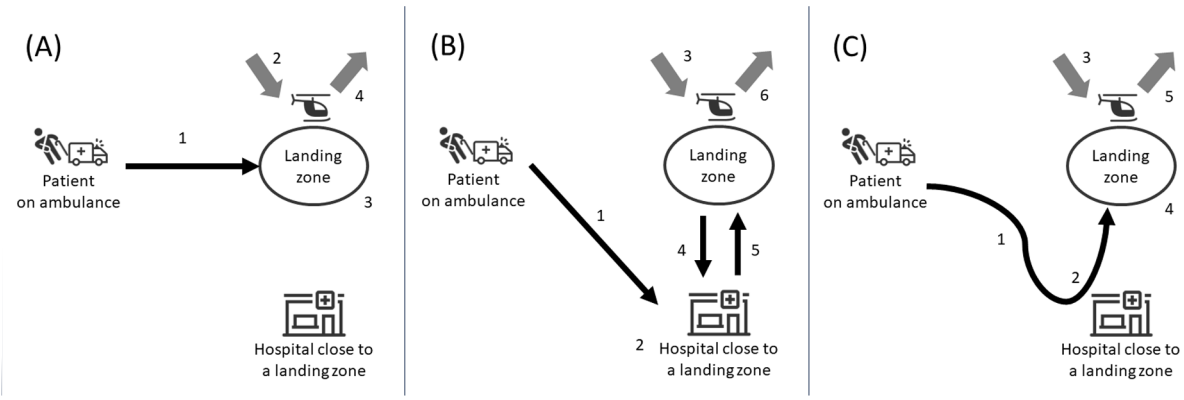

Figure 2 Schematic diagrams of the general practice of the HEMS and the intentional transit practice.
(A) General practice of HEMS activity. An ambulance transports a patient to a landing zone (1). HEMS lands at the landing zone (2) and meets, examines, and treats the patient (3). Finally, HEMS transports the patient (4). (B) The intentional transit practice. An ambulance transports a patient to a hospital close to the landing zone (1). The physician examines and treats the patient at the hospital (2). After HEMS landing (3), HEMS medical crew goes to the hospital and participates in the treatment of the patient (4). HEMS medical crew brings the patient to the landing zone (5) and destination hospital (6). (C) Another intentional transit practice. An ambulance transports a patient to a hospital close to the landing zone (1). The physician examines and treats the patient at the hospital and brings the patient to the landing zone (2). After HEMS landing (3), HEMS medical crew examines and treats the patient (4) HEMS medical crew brings the patient to a destination hospital (5). HEMS: helicopter emergency medical service.

lar non-intentional transit HEMS activity cases during the same periods. In this HEMS-alone model, we assumed that patients receive the same treatment at the landing zone and are transported to the same final destination facility as in the intentional transit practice. The time courses for the flights to the landing zone are identical to those for the intentional transit cases. The time spent at the landing zone was determined by averaging the time courses for similar injury types, HEMS-provided treatments, and destination types in the non-intentional transit cases during the same period. For the transport time, the same transport time was used as in the intentional transit practice. In cases where the patient remained at the transit hospital, the travel time of the HEMS medical crew from the landing zone to the transit hospital was considered as the transport time.

Outcome measures

The primary outcome was the time from when the emergency call was placed to a physician (physician at a transit hospital or HEMS physician) reaching the patient (physician reaching time) compared to the time in the HEMS-alone model. The physician reaching time was defined as the time from the emergency call to patient arrival at the transit hospital in the intentional transit practice and the time from the emergency call to helicopter landing in the HEMS-alone model. Secondary outcomes were the time from the emergency call to the arrival of the patient at the destination hospital (destination hospital arrival time) and the time from helicopter landing to helicopter take-off at the landing zone (helicopter waiting time). These items were analyzed in subgroups by region.

Additionally, we examined the relationship between diagnostic tests performed at transit hospitals and destination facility category (HEMS base hospital vs. other hospitals).

Statistical analyses

Continuous variables were tested for normality using the Shapiro–Wilk test for both the intentional transit practice and the HEMS-alone model. Normally distributed items were represented by means (standard deviation [SD]), and items including non-normally distributed items were represented by medians (Interquartile range [IQR], 25–75%); however, when non-normally distributed variables were included in the comparison group, they were represented by medians (IQR). Continuous variables were compared using a paired *t*-test between normally distributed variables and a Wilcoxon signed-rank test for non-normally distributed variables. For tests involving three or more groups, tests between normal distributions were performed using analysis of variance, and comparisons between groups were performed using Dunnett's multiple comparison test. Items involving non-normal distributions were analyzed using the Kruskal–Wallis test, and each group was compared using Dunn's multiple comparison test. For nominal variables, the χ^2 test was conducted; however, Fisher's exact test was performed if there were more than 20% of cells in the contingency table with expected values less than 5. Statistical analyses were performed using Prism 9 (GraphPad Software, LCC, CA, USA). The level of significance was set at 5%.

Results

We identified 110 cases of intentional transit practices during the observation period (Figure 3). This accounted for 6.5% of the HEMS requests, excluding inter-facility transfers, with a gradual upward trend from year to year (Figure 4). Among them, 23 cases were excluded (two cases of multiple victims and 21 cases with missing or unavailable data), leaving 87 cases eligible for analysis (Figure 3). There were 53 (61%) men, 33 cases (38%) with trauma, and the median (IQR) age was 68 (54–81) years. The southern region was the most common region, with 47 (54%), followed by the Northern and Western areas with similar percentages (Table 1).

A total of 83 (95%) patients were transported to a transit hospital before the helicopter landed. In the transit hospital, 84 (97%) patients underwent medical procedures, with

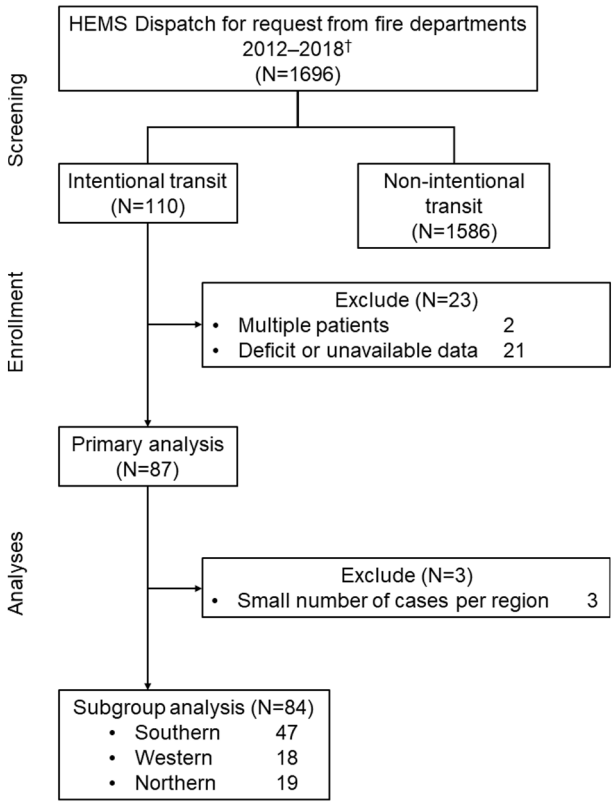

Figure 3 Study diagram.
†Fiscal year. HEMS: helicopter emergency medical service.

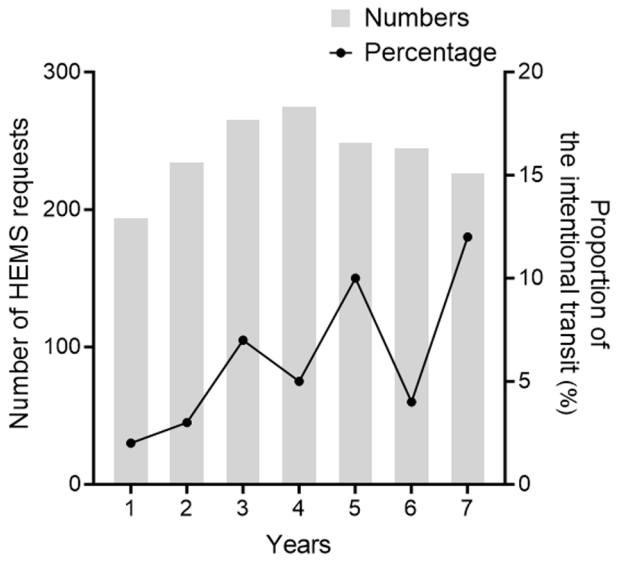

Figure 4 Annual numbers and proportions of the intentional transit practice.
The numbers represent requests for HEMS dispatch to victims at the scene (requests for interfacility transport were not counted). The proportions indicate those of the intentional transit practices to the requests for dispatch to victims at the scene. HEMS: helicopter emergency medical service.

the most common procedure being the insertion of venous catheters in 82 (94%), followed by CT imaging in 34 (39%) patients. The HEMS medical crew members were present in the hospital in 63 (72%) cases. The HEMS medical crew performed additional medical procedures in 68 (78%), administered drugs in 38 (44%), and performed ultrasound examinations in 36 (41%) patients. The final destination facility was the HEMS base hospital in 38 cases (44%), the transit hospital in 11 cases (13%), and other hospitals in 38 cases (44%). Regarding the relationship between the diagnostic tests performed at the transit hospital and the final destination hospital, at least one test was associated with more transfers other than to the HEMS base hospital (P=0.0056), and CT imaging was associated with more transfers other than to the HEMS base hospital (P=0.0037) (Table 2).

Compared to the HEMS-alone model, the intentional transit practice reduces the physician reaching time (intentional transition practice vs. HEMS-alone model) (26 [21–32] vs. 37 [29–47] min, P<0.0001), while it extends the destination hospital arrival time (71 [58–93] vs. 65 [59–80] min, P=0.03) and the helicopter waiting time (24 [18–34] vs. 19 [18–21] min, P<0.0001) (Figure 5).

Subgroup analysis was performed in the Southern, Northern, and Western areas, excluding the three areas where the number of cases per region is low (Figure 3). Regarding the elapsed time among the three areas (Table 3), there was no time difference from the emergency call to the HEMS request or from the HEMS request to helicopter dispatch; however, the time from dispatch to landing differed among the three areas (P<0.0001), with the Northern area exhibiting the longest time. Additionally, the time from helicopter landing to patient contact by the HEMS medical crew varied among the three areas, with the Northern area having the longest time. In most cases in the Northern area, the HEMS physician reaches the patient at the transit hospital. The time from emergency call to patient arrival at the transit hospital also varied among the three areas (P=0.03), with the Northern area being significantly longer than the Western area (P=0.02)—but not significantly longer than the Southern area. Air transportation was performed in 41 cases (87%) of the Southern, 15 (83%) in the Western, and 17 (89%) in the Northern areas. Although there was little difference in the overall transport time (P=0.13), transport time to the HEMS base hospital significantly differed among the three areas (P<0.0001), and transport time to other hospitals was significantly longer in the Northern area than in the Southern area (P=0.03).

Compared to that of the HEMS-alone model, physician reaching time was significantly shorter in the intentional transit practice in all areas (intentional transit practice vs. HEMS-alone model) (Southern area, 26 [21–32] vs. 33 [28–39] min, P<0.0001; Northern area, 29 [25–34] vs. 49 [44–55] min, P<0.0001; Western area, 21 [18–29] vs. 29 [27–40] min, P<0.0001). Destination hospital arrival time was significantly longer only in the Northern area (99 [93–121] vs. 83 [76–91] min, P=0.011), but not in the other areas. Helicopter waiting time of the intentional transit practice was longer in the Southern area (22 [17–26] vs. 19 [18–22] min, P=0.05) and in the Northern area (36 [34–40] vs. 19 [18–21] min, P<0.0001) than the HEMS-alone model, but not different in the Western area (Figure 6).

Discussion

This single-center, retrospective study showed that the intentional transit practice reduced physician reaching time, whereas destination hospital arrival time and helicopter waiting time were extended compared to the HEMS-alone model. Additionally, examinations at the transit hospital were associated with increased transportation to non-HEMS-based hospitals. In 87% of the cases, patients were transported by the HEMS; however, there were no secondary transport cases among patients transported from the landing zone or retained at the transit hospital.

This study's results suggest that the intentional transit practice is advantageous in earlier primary medical interventions. Many cases requiring the HEMS are emergent and require early primary medical intervention[17]. Compared to the HEMS-alone model, the intentional transit practice reduced the physician reaching time by a median of –10

Table 1 Demographics of the participate cases

Demographics		(N=87)
Age (years)	Median (IQR)	68 (54–81)
Sex male		53 (61)
Trauma		33 (38)
Cardiovascular disease		16 (18)
Stroke		16 (18)
Cardiopulmonary arrest		3 (3)
Others		19 (22)
Area		
Southern		47 (54)
Western		18 (21)
Northern		19 (22)
Others		3 (3)
Patient arrive at transit hospital before the helicopter landing		83 (95)
Place where the HEMS medical crew reached the patient		
At landing point		24 (28)
In hospital		63 (72)
Medical interventions and examinations at transit hospital		84 (97)
Insertion intravenous line (total)		82 (94)
(1 route)		80 (92)
(2 routes)		2 (2)
Tracheal intubation		8 (9)
Blood gas analysis		12 (14)
Electrocardiogram		18 (21)
Ultrasound		7 (8)
X-rays		6 (7)
Computed tomography		34 (39)
Magnetic resonance imaging		3 (3)
Gastrointestinal endoscopy		0 (0)
Administration of medications		12 (14)
Additional interventions and examinations by HEMS medical crew		
Insertion intravenous line (1 route)		16 (18)
1 route in total		5 (6)
2 routes in total		11 (13)
Tracheal intubation		10 (11)
Ultrasound		36 (41)
Administration of medications		38 (44)
Tube thoracotomy		1 (1)
Resuscitative thoracotomy		1 (1)
Destination hospital		
HEMS base hospital		38 (44)
transit hospital		11 (13)
Others		38 (44)
Secondary transportation		0 (0)

Number (%) are expressed unless otherwise indicated. IQR: interquartile range; HEMS: helicopter emergency medical services.

minutes. The most common procedure performed at transit hospitals is the insertion of intravenous catheters, facilitating fluid infusion and administration of medications. Since the success rate of intravenous catheter insertion is low in pre-hospital settings[24, 25], obtaining an intravenous catheter in a hospital would be an advantage of intentional transit practice for procedural success.

Diagnostic tests conducted in transit hospitals influenced the decision of the final destination facilities. CT imaging was performed in approximately 40% of the cases. In primary care and emergency medicine, CT enables physicians to definitively diagnose and manage diseases[26, 27]. Thus,

Table 2 Relationship between diagnostic tests at transit hospital and the destination facility

	Overall (N=87)	HEMS base hospital (N=38)	Other hospital (N=49)	*P*-values†
Diagnostic tests (any test)	58 (67)	19 (50)	39 (80)	0.006**
Blood gas analysis	12 (14)	6 (16)	6 (12)	0.76
Electrocardiogram	18 (21)	5 (13)	13 (27)	0.18
Ultrasound	7 (8)	5 (13)	2 (4)	0.23
X-rays	6 (7)	4 (11)	2 (4)	0.40
CT	34 (39)	8 (21)	26 (53)	0.004**
MRI	3 (3)	1 (3)	2 (4)	>0.99

†Fisher's exact test. Number (%) are expressed unless otherwise indicated. **P<0.01. HEMS: helicopter emergency medical services; CT: computed tomography; MRI: magnetic resonance imaging.

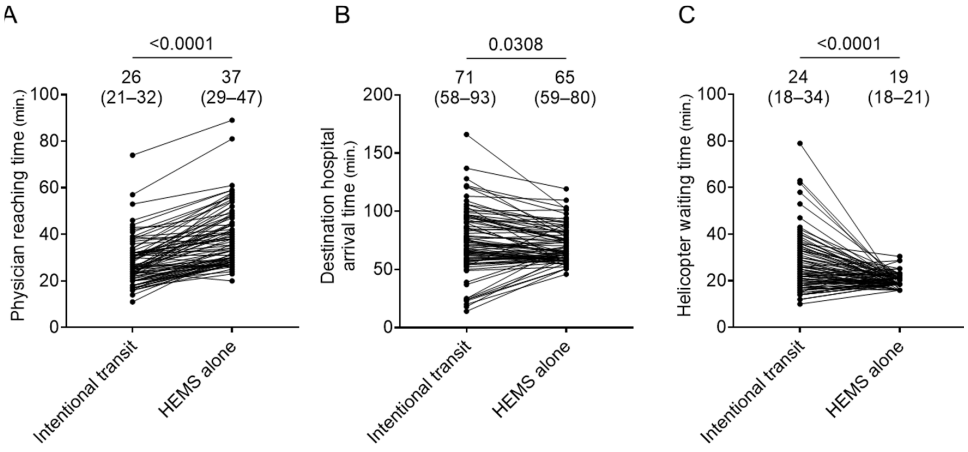

Figure 5 Outcomes of the primary analysis.
Physician reaching time (A), destination hospital arrival time (B), and helicopter waiting time (C). Variables are presented as median (interquartile range). HEMS: helicopter emergency medical service.

performing CT imaging at the transit hospital is useful in earlier and specific planning for patient management. This benefit would be amplified in the care of patients requiring urgent treatment, such as those with severe trauma, stroke, and cardiovascular diseases, because there is a limited capability to treat these patients in rural areas[9–12]. In addition to these merits, the HEMS physicians support the evaluation of CT imaging results in the intentional transit practice. This support results in a higher rate of transportation to facilities other than the HEMS base hospital or staying at the transit hospital. These transports and stays were not related to secondary transportation. Therefore, the intentional transit practice has the advantage of optimizing patient distribution based on a more accurate diagnosis through diagnostic tests at the transit hospitals and the support of HEMS physicians.

Disadvantages of the intentional transit practice include extended destination hospital arrival time and helicopter waiting time. Other emergent cases coinciding with the intentional transit practice are no longer expected to receive the HEMS because the intentional transit practice occurs at the edges of the prefecture and requires an extended duration for each mission. The subgroup analysis indicated that the destination hospital arrival time and helicopter waiting time in the Western area did not extend in comparison with the HEMS-alone activity. In this area, the time between the helicopter landing and the HEMS physician reaching the patient was the minimum, even in cases where the HEMS physician reached the patient in the transit hospital. These results indicate that reducing the travel time between the landing zone and the transit hospital is critical to reducing the destination hospital arrival time and helicopter waiting time. Additionally, the time wasted at a local hospital owing to unnecessary diagnostic tests and/or waiting time should be avoided, although diagnostic tests at a transit hospital are useful. In this context, intentional transit practices are more advantageous than HEMS-alone activities or interfacility transport because of the involvement and direction of the HEMS physicians during the initial stages of emergency care.

Table 3 Time courses, overall and subgroup by region

		Overall (N=87)	Southern (N=47)	Western (N=18)	Northern (N=19)	*P*-values[†]	Multiple comparisons[¶] *P*-values for Southern vs. Western	*P*-values for Southern vs. Northern	*P*-values for Western vs. Northern
Times spent in HEMS activity									
Request for HEMS–dispatch		5 (4–6)	5 (4–6)	5 (4–6)	5 (4–5)	0.79	>0.99	>0.99	>0.99
Dispatch–landing		15 (14–21)	14(14–16)	13 (12–14)	30 (27–32)	**<0.001**	**0.002**	**<0.001**	**<0.001**
Landing–HEMS physician reaching to the patient		3 (2–5)	3 (2–5)	2 (2–3)	6 (5–8)	**<0.001**	0.10	**<0.001**	**<0.001**
HEMS reach the patients at a landing point	n (%)	24 (28)	18 (38)	3 (17)	1 (5)				
		2 (2–3)	2 (2–3)	2 (1–4)	2	0.93	>0.99	>0.99	>0.99
HEMS reach the patients at a hospital	n (%)	63 (72)	29 (62)	15 (83)	18 (95)				
		4 (2–6)	5 (3–5)	2 (2–3)	6 (5–8)	**<0.001**	**0.02**	**0.01**	**<0.001**
Times spent in Fire department/ambulance activity									
Request for ambulance–request for HEMS		13 (9–20)	13 (9–20)	12 (11–18)	13 (9–17)	>0.99	>0.99	>0.99	>0.99
Request for ambulance–arrival at transit hospital (Physician Reaching Time)		26 (21–32)	26 (21–32)	22 (18–30)	29 (25–34)	**0.02**	0.21	0.46	**0.02**
Transportation time[§]			14 (8–15)	13 (12–14)	15 (12–26)	0.12	>0.99	0.16	0.29
HEMS base hospital	n (%)	38 (44)	19 (40)	13 (72)	5 (26)				
		14 (13–16)	15 (14–15)	13 (12–14)	29 (27–31)	**<0.001**	**0.006**	**0.03**	**<0.001**
Other hospital	n (%)	38 (44)	22 (47)	2 (11)	12 (63)				
		10 (8–14)	9 (7–11)	12 (9–14)	13 (11–16)	**0.03**	>0.99	**0.03**	>0.99

[†]Kruskal–Wallis test was performed to test the difference of variance among Southern, Western, and Northern; [¶]Dunn's multiple comparisons test; [§]Values are only from cases where transport occurred after care at the transit hospital. Median (IQR) minutes are expressed for each time value unless otherwise indicated. *P*-values in bold indicate statistical significance. IQR: interquartile range; HEMS: helicopter emergency medical service.

This study has a few limitations. First, the study design—a single-center, retrospective study—has selection bias. Additionally, we employed the HEMS-alone model, which was generated from the times of other HEMS cases, to compare the times. This comparison includes the vulnerability of the model development. Direct comparisons between cases of the intentional transit practice and those of the non-intentional transit practice cases are inappropriate because of several variables that influence the time course of the HEMS, including the category and severity of the illness/injury and the location of the patient. Nonetheless, the reduced physician reaching time, longer destination hospital arrival time, and longer helicopter waiting time in the intentional transit practice than in the HEMS-alone practice would be reasonable.

Conclusion

The intentional transit practice has benefits for earlier primary medical intervention and specific care planning. However, it is associated with longer destination hospital arrival time and helicopter waiting time.

Conflict of interest: All authors declare no conflicts of interest.

Funding information: This study did not receive any financial support.

Ethical considerations: Information about the implementation of this study was disclosed on the Website of the University of Miyazaki Hospital for a certain period, and offers regarding non-participation in this study were accepted (opt-out). This study was conducted in accordance with the Declaration of Helsinki and approved by the Institutional Review Board of the University of Miyazaki Hospital (Research No. O-0701).

Consent for publication: All authors have approved the manuscript and consented to its publication.

Data availability: The datasets generated and/or analyzed during the current study are not publicly available due to our study protocol approved by institutional review board.

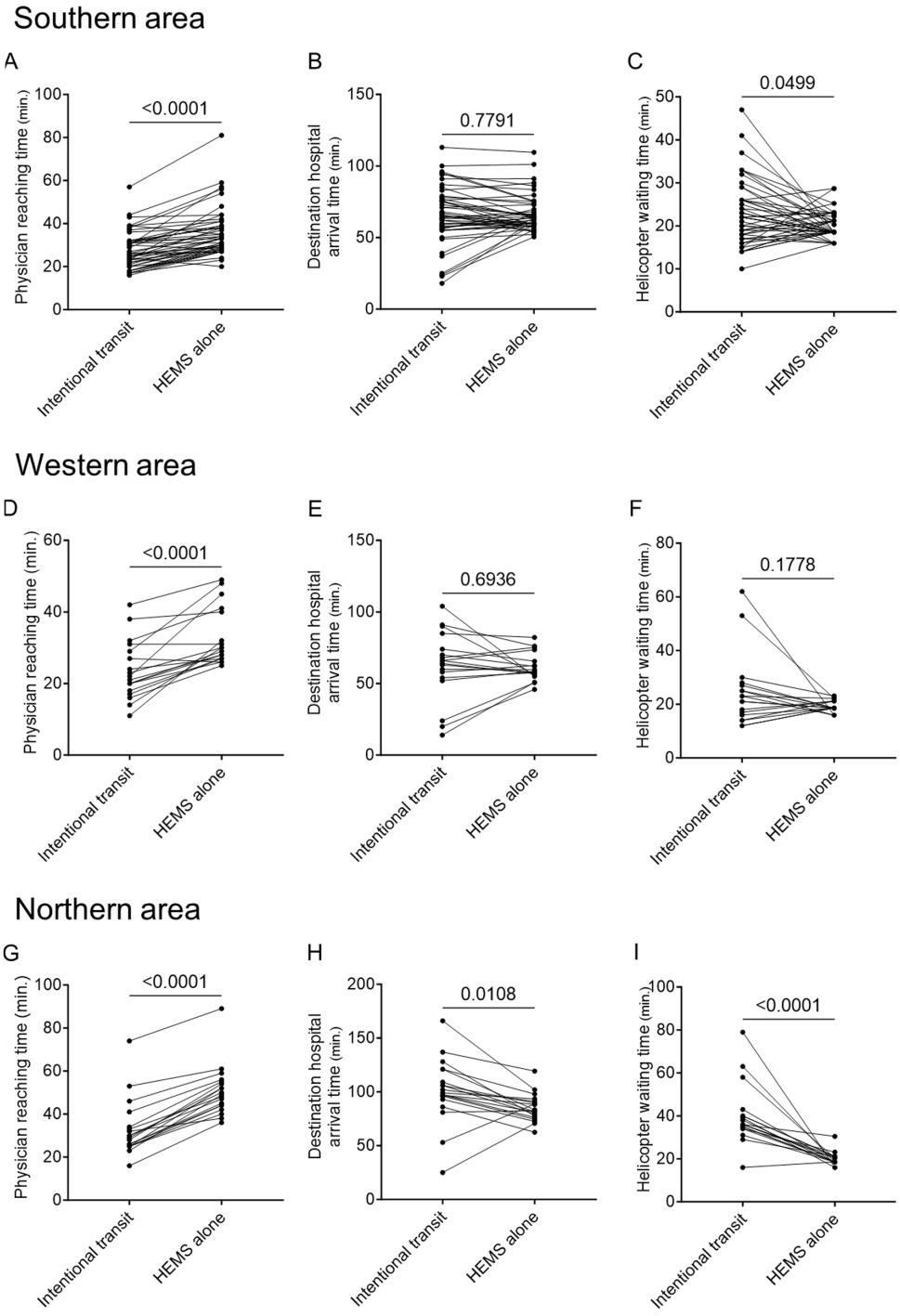

Figure 6 Outcomes of the subgroups analysis.
Physician reaching time (A, D, and G), destination hospital arrival time (B, E, and H), and helicopter waiting time at the landing zone (C, F, and I). HEMS: helicopter emergency medical service.

Author contributions: All the authors have contributed significantly. Katsutoshi Saito, Conceptualization, Methodology, Formal analysis, Investigation, Resources, Data Curation, Validation, Writing-Original Draft, Writing-Review & Editing, Project administration; Tomohiro Abe, Conceptualization, Methodology, Formal analysis, Investigation, Resources, Data Curation, Writing-Original Draft, Writing-Review & Editing, Visualization; Rina Tanohata, Methodology, Resources, Data Curation; Takehiko Nagano, Methodology, Validation, Resources, Data Curation, Validation;

Hidenobu Ochiai, Methodology, Investigation, Validation, Supervision.

Acknowledgements

We would like to express our appreciation to all the staff at University of Miyazaki Hospital and other hospitals for their support.

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