JCN Open Access ORIGINAL ARTICLE

pISSN 1738-6586 / eISSN 2005-5013 / J Clin Neurol 2023;19(2):125-130 / https://doi.org/10.3988/jcn.2022.0158

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Interactive Direct Interhospital Transfer Network System for Acute Stroke in South Korea

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Background and Purpose Interhospital transfer is an essential practical component of regional stroke care systems. To establish an effective stroke transfer network in South Korea, an interactive transfer system was constructed, and its workflow metrics were observed.

Methods In March 2019, a direct transfer system between primary stroke hospitals (PSHs) and comprehensive regional stroke centers (CSCs) was established to standardize the clinical pathway of imaging, recanalization therapy, transfer decisions, and exclusive transfer linkage systems in the two types of centers. In an active case, the time metrics from arrival at PSH ("door") to imaging was measured, and intravenous thrombolysis (IVT) and endovascular treatment (EVT) were used to assess the differences in clinical situations.

Results The direct transfer system was used by 27 patients. They stayed at the PSH for a median duration of 72 min (interquartile range [IQR], 38–114 min), with a median times of 15 and 58 min for imaging and subsequent processing, respectively. The door-to-needle median times of subjects treated with IVT at PSHs (n=5) and CSCs (n=2) were 21 min (IQR, 20.0–22.0 min) and 137.5 min (IQR, 125.3–149.8 min), respectively. EVT was performed on seven subjects (25.9%) at CSCs, which took a median duration of 175 min; 77 min at the PSH, 48 min for transportation, and 50 min at the CSC. Before EVT, bridging IVT at the PSH did not significantly affect the door-to-puncture time (127 min vs. 143.5 min, p=0.86).

Conclusions The direct and interactive transfer system is feasible in real-world practice in South Korea and presents merits in reducing the treatment delay by sharing information during transfer.

Keywords stroke; transfer; transportation; thrombolytic therapy; mechanical thrombolysis.

Received April 19, 2022
Revised July 30, 2022
Accepted July 30, 2022

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INTRODUCTION

In the stroke care system, an interhospital transfer allow more-intensive care to be provided to critically ill patients with stroke, postintravenous thrombolysis (IVT) care, or surgical treatment in time.[1,2] With the recent advancements in endovascular treatment (EVT),[3-7] the focus of the transfer system has shifted to increasing accessibility to EVT during the therapeutic time window while still retaining its former roles.

Similar to the upgrades of transfer systems in many other countries, various hospitals that participate in the stroke care system in South Korea have attempted to modify the transfer process so that individual hospitals provide early treatment according to their capacities and transfer selected cases for further treatment.[8-10] This process requires comprehensive cooperation strategies among the regional health care stakeholders. However, the previous procedures are still used with passive modifications, which lead to difficulties in transfer agreements and time delays.[8,11,12]

In real-world practice, there is increasing evidence for the time effect on acute stroke, thereby increase attention on the entire transfer process, especially the clinical process in primary hospitals, contact protocols for transfer, and transportation services.[13-15] However, even though approximately 20% of patients with stroke are transferred within 1 day,[16] there have been few attempts to develop an effective transfer system.

To improve the current transfer process for patients with stroke, a pilot project was conducted to link primary stroke hospital (PSHs) in rural areas to comprehensive regional stroke centers (CSCs), and to establish an interactive and direct transfer system. This operates through a 24/7 direct-call system between physicians at the PSHs and stroke specialists at the CSCs, who made individual decisions for every case, such as bypass the unnecessary pathway for EVT, and emergent neuroradiological and neurosurgical treatments. This study observed the transfer cases and measured the time metrics, noting the time-consuming steps of the transfer process, which would be critical in improving the subsequent steps.

METHODS

Study subjects and data collection

The study was conducted at a PSH located 43 km from a CSC in Icheon, Gyeonggi-do, South Korea in 2020, which included approximately 230,000 residents. Since 2019, the PSH has renovated its stroke care system to set up a clinical pathway (CP) with a focus on IVT in the emergency room and provide key stroke treatment in the newly operating stroke unit. It also created a direct transfer system with the CSC, which aimed to succeed in conducting EVT and supporting any other stroke treatments that occurred in the PSH (Fig. 1). Based on the formal agreements, a hotline telephone line, transfer protocol, and feedback system were established.

The CP in the PSH permitted flexible imaging modalities according to the expertise and decisions of the attending physicians. It conducted CT protocol with a high priority and set up MRI protocol by the physicians' decision. In both processes, they consisted of multiphasic CT angiography and CT perfu-

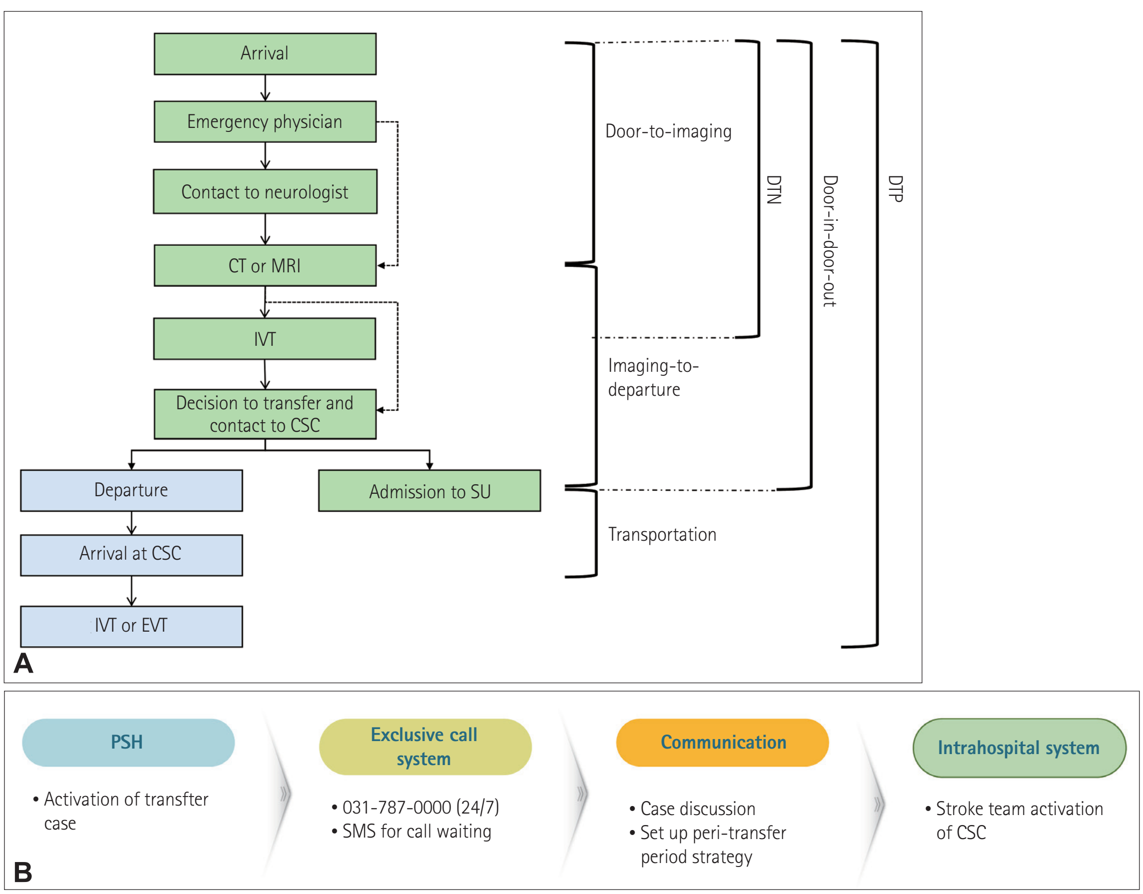

Fig. 1. CP of a PSH (A) and a direct contact system (B). The intrahospital process was conducted according to its CP. It generally followed routine steps (solid arrow) with the adoption of alternative pathways (dotted arrow) in the absence of a neurologist or during the weekend. In active cases, the direct contact system was operated using an exclusive phone line and the subsequent strategies were decided. CP, clinical pathway; CSC, comprehensive regional stroke center; DTN, door-to-needle; DTP, door-to-puncture, EVT, endovascular treatment; IVT, intravenous thrombolysis; SMS, short message service; SU, stroke unit; PSH, primary stroke hospital.

sion or diffusion-weighted imaging and MR angiography. When the attending physician wanted, it also allowed to perform the non-contrast CT protocol and transfer with the consultation. When any decisions on IVT, post-IVT management, EVT, neurosurgery or intensive care, or other related matters were required, direct contact was initiated with a stroke neurologist at the CSC and subsequent steps in both hospitals were decided. Using the hotline system, physicians directly discuss each clinical vignette and appropriate therapeutic plans, including a rapid transfer, immediate treatment at PSH, and post-transfer treatment.

This retrospective study identified a consecutive series of patients with stroke transferred between March 2019 and January 2020. By reviewing the electronic medical records and stroke registry, we collected data on age; sex; stroke risk factors such as hypertension, diabetes mellitus, dyslipidemia, atrial fibrillation, current smoking, and baseline National Institutes of Health Stroke Scale (NIHSS) score; stroke onset time; and acute revascularization therapies for IVT and EVT. We also surveyed the time indicators of door-in (arrival at PSH), imaging, transfer decision, and door-out (departure from PSH) of the PSH, and transportation, arrival at CSC, and acute treatment times at the CSC. In IVT and EVT cases, the door-in times of the PSH to needle (DTN) and puncture (DTP) were calculated.

Approval of study protocols and exemption of consent

The Institutional Review Board of the Seoul National University Bundang Hospital (IRB No. B-2205-755-102) approved the study protocol. The requirement for informed consent was waived considering the retrospective design of the study and the minimal risk and harm imposed on the enrolled subjects. All data were anonymized and de-identified prior to the analysis.

Statistical analysis

We estimated and summarized the time metrics of door-in, imaging, transfer decision, door-out, transportation at the PSH, and door-in and recanalization therapies at the CSC. Those who received IVT, DTN, and their processes were estimated and compared using IVT at the PSH (drip-and-ship) and CSC (ship-and-drip). The time metrics comprising the DTP of EVT were assessed according to its workflow. The DTP was compared between patients with and without bridging IVT. All analyses were performed using SPSS software (version 25.0 for Window; IBM Corp., Armonk, NY, USA). Significance was set at $p<0.05$.

RESULTS

Baseline characteristics of the fast-track system

Among 161 patients with stroke who initially arrived at the PSH, 27 (16.8%) who had transferred to a CSC via a direct transfer system were enrolled. The median baseline NIHSS score was 4 (interquartile range [IQR], 1.5–14.5) and the transfers took a median of 136 min (IQR, 63–264) after stroke onset (Table 1).

At the PSH, the door-in and door-out (DIDO) process took a median of 72 min (IQR, 38–114 min), which consisted of door-to-imaging (median, 15 min; IQR, 11–23 min), and imaging-to-departure (median, 58 min; IQR, 28–79 min) (Fig. 2). In the transfer processes, the transfer decision took an estimated median of 33 min (IQR, 27–38 min) after imaging and then a median of 24 min (IQR, 20–34 min) before departure. The median transportation time was 45 min (IQR, 40–51 min).

IVT: drip-and-ship and ship-and-drip models

Among the transferred subjects, IVT was administered at the PSH (drip-and-ship, *n*=5) and CSC (ship-and-drip, *n*=2) (Supplementary Table 1, in the online-only Data Supplement). The DTN with drip-and-ship took a median of 21 min (IQR, 20–22 min), which was profoundly different from the median of 137.5 min (IQR, 125.3–149.8 min) for ship-and-drip (Fig. 3). The median DIDO process with drip-and-ship was 85 min (IQR, 57–132 min), which did not differ significantly from the median of 78.5 min (IQR, 62.8–94.3 min) for ship-and-drip. The median transportation times of the two IVT models were 48 min (IQR, 43–52 min) and 40 min (IQR, 39.5–40.5 min), respectively.

EVT

EVT was performed on seven subjects (25.9%) (Supplemen-

Table 1. Baseline demographics and clinical characteristics of transferred patients (*n*=27)

Characteristic	Value
Sex, male	18 (66.7)
Onset to arrival, min	136 (63–264)
Age, years	65.9±16.8
Atrial fibrillation	6 (22.2)
Hypertension	15 (55.6)
Diabetes mellitus	8 (29.6)
Hyperlipidemia	9 (33.3)
Good premorbid status, mRS score=0–2	24 (88.9)
NIHSS baseline score	4 (1.5–14.5)

Data are *n* (%), median (interquartile range), or mean±standard-deviation values.
mRS, modified Rankin Scale; NIHSS, National Institutes of Health Stroke Scale.

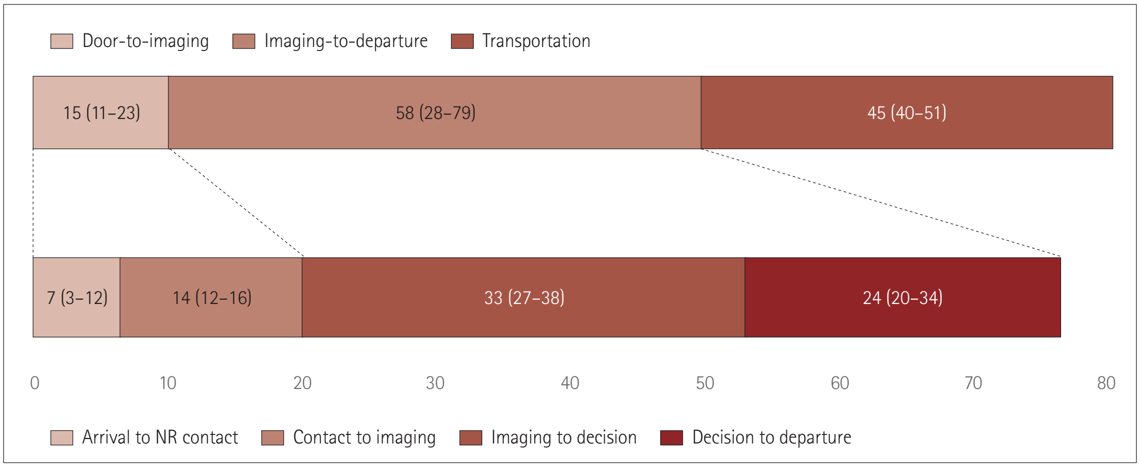

Fig. 2. Time metrics from arrival (door-in) to transportation of transferred subjects (n=27). The time metrics were measured for door-to-imaging, imaging-to-departure, and transportation. Cases of contact with a neurologist required the detailed time metrics of arrival to NR contact, contact to imaging, imaging to transfer decision, and decision to actual transfer. NR, neurological.

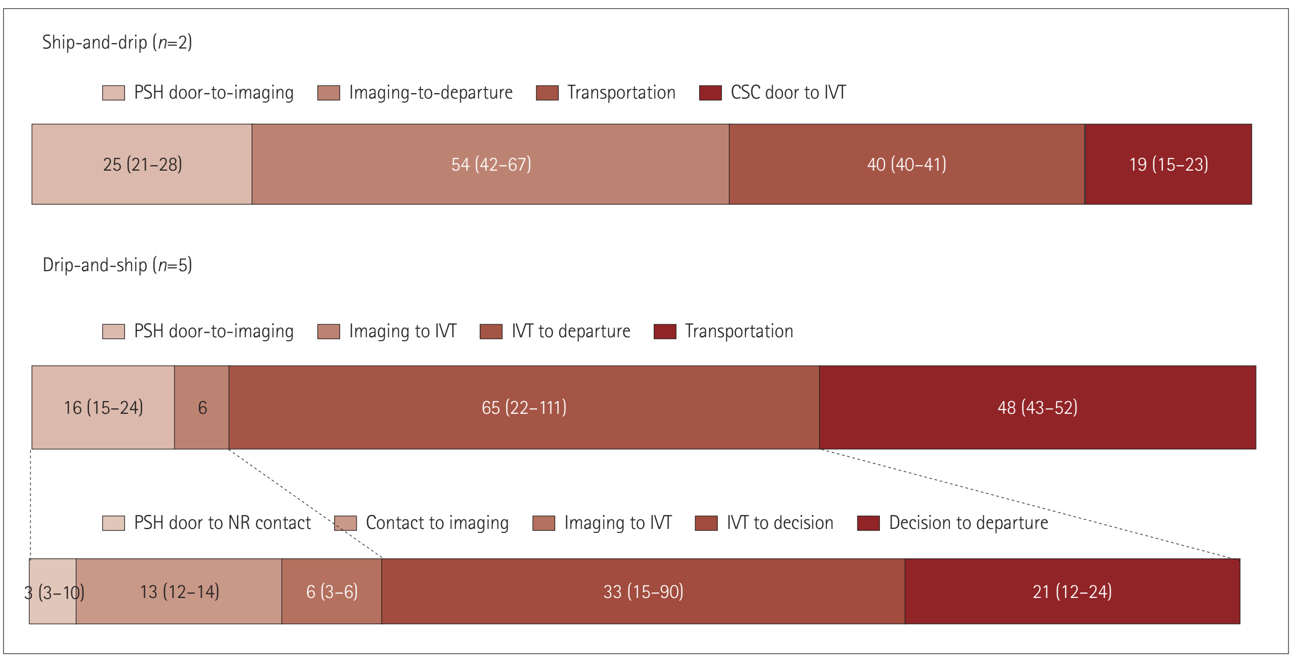

Fig. 3. Comparison of DTN between drip-and-ship (lower panel) and ship-and-drip (upper panel) models. The DTN of drip-and-ship had a median time of 21 min, while ship-and-drip had a median time of 137.5 min for imaging and transfer decision at the PSH, transportation, and the subsequent processes at the CSC. CSC, comprehensive regional stroke center; DTN, door-to-needle; IVT, intravenous thrombolysis; NR, neurological; PSH, primary stroke hospital.

tary Table 2, in the online-only Data Supplement). The median DTP was 179.0 min (IQR, 156.5–225.5 min), which consisted of 77.0 min (IQR, 57.0–108.5 min) at the PSH, 48.0 min (IQR, 44.0–50.5 min) for transportation, and 50.0 min (IQR, 44.0–63.0 min) from arrival at the CSC to the groin puncture.

Bridging IVT was administered to three subjects, in whom DTP did not differ significantly from those without bridging IVT (median, 179.0 min [IQR, 161.0–204.0 min] vs. 194.0 min [IQR, 161.8–234.3 min], p=0.86). At the PSH, DIDO with and without bridging IVT had median times of 85.0 min (IQR, 63.5–108.5 min) and 74.5 min (IQR, 62.5–109.3 min), respectively.

DISCUSSION

This is the first report that we know of on how fast and direct interhospital transfer systems work in a real clinical environment, and which has provided time metric information throughout the process between PSHs and CSCs in South Korea.

Even though a rapid diagnostic workup and transfer decision is key for the interhospital transfer of patients with stroke,[13] the actual data for primary hospitals or clinics were not well known. Recent national surveillance data reflect the complexity of stroke care networks. In brief, patients with stroke initially visit thousands of hospitals and merge into one-fourth the number of stroke centers within 1 day. Since there has been no organized transfer system, each transfer requires the repetition of time-consuming activities such as searching, inquiring, and contacting with a transfer hospital.

In this context, our study attempted to establish an effective direct fast-track system between PSHs and CSCs. Several emergency physicians and daytime neurologists in regional rural community hospitals could also effectively operate the stroke care system and use the direct transfer system according to their needs.[8] Importantly, our study has confirmed the critical role of the PSH, which contributed enormously to a difference of approximately 100 min in DTN compared with the drip-and-ship model.[17] This center adopted a well-organized system to suit its own circumstances and presented a remarkable median DTN of only 21 min.[18]

Our study found the departure delay from PSH after the transfer decisions to be approximately 25 min, which included paperwork, payment, waiting for an ambulance, and image copying. This would be a target to monitor and improve by applying deferred payments and an automatic imaging transportation system.

The fast-track system can improve the imaging-to-decision time (by approximately 30 min); given that this process includes image reviewing, acute resuscitation management, and tissue plasminogen activator infusion, it might be difficult to further reduce this time. However, predetermined imaging protocols can help with the repeated imaging times.[19] In the era of EVT, multiphase computed tomography angiography and/or perfusion computed tomography (or magnetic resonance imaging) seemed necessary in rural PSHs for selecting eligible patients and decreasing unnecessary transfers.

According to the Clinical Research Collaboration for Stroke in Korea report in 2018, the median DTP was 105 min (IQR, 81–136 min) in 15 stroke centers nationwide.[17] Even though our study had selected a population that were transferred before EVT, it found a median DTP of 175 min and suggests that it could be applied to several other regions or hospital networks.

As found in previous studies, transferred subjects had a lower probability of favorable outcomes compared with patients directly admitted to an intervention center.[13-15] However, interhospital transfer may be necessary in several areas, such as large rural areas, as presented in our study. Transportation from that area took about 1 hour, while the other three-quarters of cases could be managed in the local stroke hospitals. It would therefore be better to organize the regional stroke care system according to the local circumstances and to adopt and maintain an effective transfer system.[20,21] In such a situation, measuring important and applicable parameters would be the first step in ameliorating the current problems.

This study had certain limitations. No data were available before applying the direct transfer system because the PSH had no exact record of the hospital each patient was transferred from. Second, several ship-and-drip cases were presented. In South Korea, telemedicine is not well established, and the emergency physicians faced practical difficulties in the use of tissue plasminogen activator.[22,23] Considering this, the fast-track system could be used as an alternative and supplementary method.

In conclusion, this study was the first to evaluate time metrics among patients with acute ischemic stroke transferred to EVT-capable hospitals from the perspective of a rural hospital. The time metrics involved in stroke transfer have been assessed, which has yielded key process data.

Supplementary Materials

The online-only Data Supplement is available with this article at https://doi.org/10.3988/jcn.2022.0158.

Availability of Data and Material

The datasets generated or analyzed during the study are available from the corresponding author on reasonable request.

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Conflicts of Interest

The authors have no potential conflicts of interest to disclose.

Funding Statement

This research was supported by a fund(2020-ER6303-00) by Research of Korea Centers for Disease Control and Prevention.

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