

ORIGINAL RESEARCH

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# Effect of prehospital notification on acute stroke care: a multicenter study

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## Abstract

**Background:** The sooner thrombolytic therapy is given to acute ischemic stroke patients, the better the outcome. Prehospital notification may shorten the time between hospital arrival and brain computed tomography (door-to-CT) and the door-to-needle (DTN) time. This study investigated the effect of prehospital notification on acute stroke care in an urban city in Taiwan.

**Methods:** This retrospective observational study utilized a prospectively collected dataset from patients treated at 9 hospitals and the emergency medical service (EMS) system in Taipei City from September 1, 2012 to December 31, 2014. During the study period, prehospital notification was performed by emergency medical technicians if the patient met the following criteria: (1) positive Cincinnati Prehospital Stroke Scale (CPSS), (2) symptom onset within 3 h, and (3) a sugar pinprick test result  $\geq 60$  mg/dL. The demographics, final diagnoses, and data associated with stroke for all patients in the prenotification group and for patients diagnosed with acute stroke within 3 h of symptoms onset were prospectively recorded in the stroke registry. The primary outcome was door-to-CT time and the secondary outcome was DTN time. The sensitivity and positive predictive value (PPV) of prehospital notifications and the association between the volume of patients receiving thrombolytic therapy at individual hospitals and DTN time were also evaluated.

**Results:** There were 928 patients who presented  $\leq 3$  h from stroke onset. Among them, 727 (78.3 %) patients were in the prenotification group; of these, more were male, smokers, and presented with severe symptoms, and fewer had a history of prior stroke or cardiac diseases compared to patients in the non-prenotification group. The median door-to-CT time was significantly shorter in the prenotification group than among the non-prenotification group (13 versus 19 min,  $p < 0.001$ ). Prenotification was associated with shorter DTN time (63 versus 68 min,  $p = 0.138$ ). The sensitivity and PPV of prenotification of stroke were 78.3 % and 78.2 %, respectively. The DTN time demonstrated a significant and highly negative association with the volume of patients receiving thrombolytic therapy (Spearman's correlation coefficient  $-0.90$ ,  $p < 0.001$ ).

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**Discussion:** In our study, we found prehospital notification was associated with faster door-to-CT scan and shorter DTN time in patients presenting within 3 hours of symptom onset. Such a close collaboration between hospitals and the EMS system gives citizens an in-time emergency care network. Our study revealed that, like in other countries, prehospital notification for stroke patients improved in-hospital stroke care in Taiwan. Our study showed that the sensitivity and PPV of prenotification decisions according to our CPSS-based criteria was comparable with those in other studies. Our study also found that DTN time was shorter in the hospital that treated a greater volume of patients with thrombolytic therapy. A multicenter collaboration program is needed to help those hospitals with relatively lower stroke patient volume to set up interventions that have been proven to improve stroke care.

**Conclusions:** Prehospital notification of stroke can significantly shorten door-to-CT time and improve acute stroke care in Taiwan.

**Keywords:** Prehospital notification, Stroke, Emergency medical service, Thrombolytic therapy

## Background

Stroke is the third leading cause of death and major disability in adults worldwide [1–3]. Intravenous tissue plasminogen activator (tPA) has been shown to be beneficial for patients with acute ischemic stroke, but it can only be given within 3–4.5 h of stroke onset [4, 5]. Studies have shown that the sooner that thrombolytic therapy is given to stroke patients, the better the functional outcome and the lower the complication rate [6–8]. Therefore, more efforts are needed to shorten the time between the onset of stroke symptoms and the initiation of thrombolytic therapy. The American Heart Association (AHA) and the American Stroke Association (ASA) guidelines recommend that emergency medical service (EMS) systems should be utilized once stroke is suspected, because EMS personnel can provide optimal prehospital stroke care and can transport patients to stroke centers [9]. Other research has outlined some parameters for measuring the quality of EMS systems and hospitals for stroke care. It was also suggested that these quality parameters ought to be used to continuously monitor prehospital and in-hospital activities [9, 10].

Prehospital notification by EMS personnel can mobilize the resources of the receiving hospital before patient arrival and has been shown to speed up in-hospital management for stroke patients, such as medical assessment, brain imaging, and laboratory studies [11–21]. Nevertheless, there have been no studies that have evaluated the effect of prehospital notification on acute stroke care in Taiwan. In addition, there is some discrepancy in studies describing the association between prehospital notification and door-to-needle (DTN) time [12–14, 16, 17, 19]. Therefore, the aim of our study was to evaluate the effect of prehospital notification on in-hospital timeliness of care for stroke patients in Taipei, a metropolitan city of Taiwan.

## Methods

### Setting

Data was collected from patients treated at nine acute care hospitals in Taipei City with the cooperation of the local EMS system. These participating hospitals receive about 55 % of the 80,000 to 90,000 patients served by the EMS system in Taipei City annually, and these hospitals routinely provide thrombolytic therapy for stroke patients. The Fire Department of Taipei City is responsible for the EMS system. In the catchment area of the participating hospitals, the EMS system is a two-tier system consisting of 41 basic life support units and 4 advanced life support (ALS) units. In these units, there were 591 emergency medical technicians (EMTs) qualified as EMT-Intermediate who had received 280 h of training, and 84 paramedics who had completed 1280 h of training during the study period. No strict rule was implemented to ask the dispatcher to dispatch an ALS unit for patients with a suspected stroke, except when the patients were identified as having a critical condition. Most patients suspected as stroke were served by EMT-Intermediates. A close collaboration between hospitals and the EMS system when providing stroke patient care had not been well established in Taipei until recent years. Since 2011, the EMS system have used new prenotification criteria, which include: (1) a positive finding on the Cincinnati Prehospital Stroke Scale (CPSS); (2) symptom onset within 3 h; and (3) a blood glucose level  $\geq 60$  mg/dL via a pinprick test. One patient has a positive finding on the CPSS if any one of the following abnormalities is shown: facial palsy, arm weakness, and speech abnormalities. The method to perform the CPSS was the same as those in the original study [22]. These criteria were adopted and modified based on other prehospital stroke scales found in the literature, such as the CPSS, the Los Angeles prehospital stroke screen (LAPSS), the Ontario prehospital stroke screening tool (OPSS), and the Melbourne Ambulance

Stroke Screen (MASS) [22–25], and have been validated in a previous study [26]. If EMTs at the scene suspected that a patient was having a stroke, the patient would be examined to see whether he/she met the criteria. If the patient met the new prenotification criteria, the EMT would perform prehospital notification on the way to the receiving hospital. Then, the patient would be sent to the hospital as soon as possible. After receiving the prehospital notification, the personnel at the emergency department (ED) activated standard in-hospital protocols before the patient arrived. All protocols in participating hospitals attempted to establish a fast-track so that a prenotified patient took first priority for medical assessment by emergency physicians, brain imaging, and laboratory studies. However, there were some differences among the protocols; for example, in some hospitals, neurologists were consulted after intracranial hemorrhage was ruled out, but they were consulted before brain image examinations in others.

Before the prenotification criteria were utilized, all of the EMTs participated in a stroke education program, including symptom identification and care skills, in different time frames. During the 2-h education course, EMTs were taught how to perform the CPSS and check blood glucose level by pinprick test on presumed stroke patients. We taught the same method to perform CPSS from the original study [22]. In addition, the skills of querying the time of symptom onset were also taught and practiced in the course.

Although we encouraged EMTs to utilize the prenotification criteria for all patients whose complaints included any of the warning signs of stroke, as recommended by the AHA guidelines [9], it was up to the EMT's discretion whether the prenotification criteria were used for any particular patient.

#### **Study population and data collection**

The study period was from September 1, 2012 to December 31, 2014. The inclusion criteria for study subjects were as follows: (1) patients over age 20 with discharge diagnoses of stroke or transient ischemic attack (TIA) and arriving at the ED within 3 h of symptom onset ( $\leq 3$  h) via EMS; (2) patients receiving prenotification without having discharge diagnoses of stroke or TIA  $\leq 3$  h. Patients without prehospital or in-hospital data were excluded from our study.

The Taipei EMS stroke registry was established to measure, track, and improve stroke care beginning in September 2012. All 9 participating hospitals joined the registry. Trained hospital staff prospectively identified stroke patients over age 20 who arrived at the ED within 3 h of symptom onset via EMS, as well as all patients arriving with prehospital notification. Staff then collected data on demographics and prehospital

and in-hospital quality indicators and management using a standardized, web-based data collection tool.

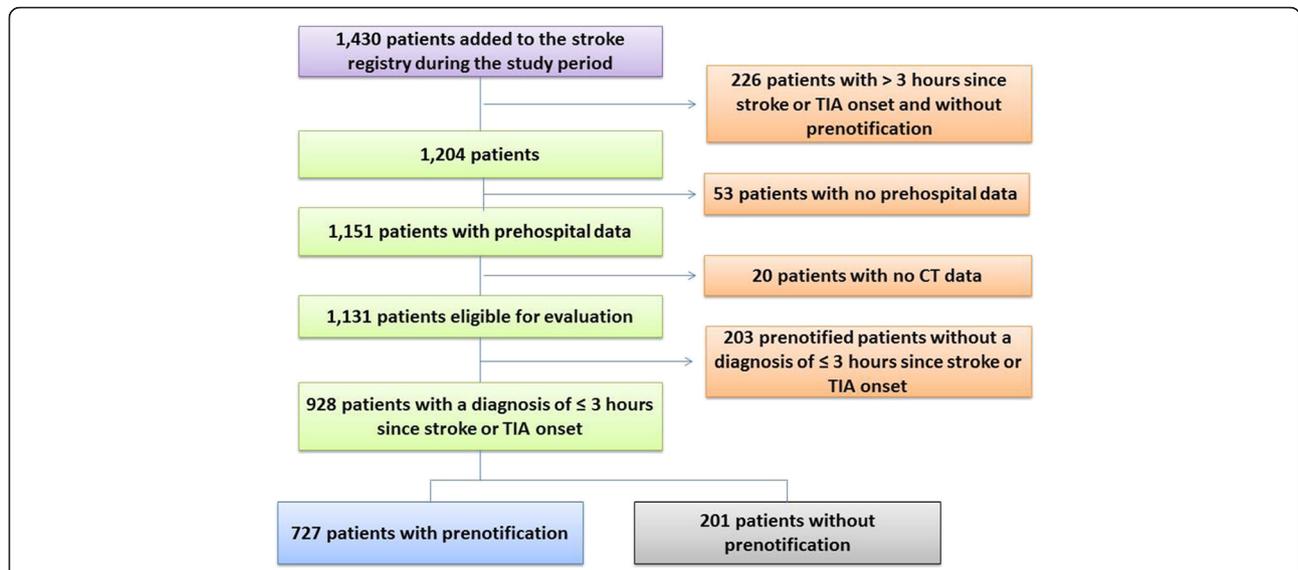
We extracted the registry data during the study period. The extracted data had been processed before we acquired it from the dataset, and thus the identity of each patient could not be identified. From the web-based registry, we collected data regarding age, sex, underlying diseases, scores on the National Institutes of Health Stroke Scale upon ED arrival, prehospital and in-hospital management time, and reasons why thrombolytic therapy was not given.

#### **Study outcomes and variables**

Our primary outcome was door-to-computed tomography (door-to-CT) time. The door-to-CT time was defined as the period from ED arrival to time of CT completion. The time of CT completion was obtained from the film printout or the digital image of the radiology report. The reason why we chose the door-to-CT time as our primary outcome was that there were few differences in management protocols before patients received CT examinations among hospitals; thus, it eased the effect of the different protocols from different hospitals. The secondary outcome was DTN time. The DTN time was defined as the time interval between ED arrival and time that the patient received their first bolus of tPA. The total prehospital management time included the period of time from the receipt of the call by EMS to the patient's arrival at the hospital. In addition, we also evaluated the positive predictive value (PPV) and sensitivity of the prenotification calls and tried to understand the reasons why thrombolytic therapy was not given to patients presenting  $\leq 3$  h after stroke onset. The association between the volume of patients receiving thrombolytic therapy and DTN time in individual hospitals was also evaluated. The study received approval from the institutional review board of National Taiwan University Hospital.

#### **Statistical analysis**

The chi-square test, Student's *t*-test, and Wilcoxon rank-sum test were used to compare the differences between variables for patients with and without prehospital notification. The PPV, sensitivity of prenotification, and 95 % confidence intervals (CIs) were calculated. Spearman's rank correlation coefficient was used to evaluate the association between median DTN time and the volume of patients receiving thrombolytic therapy in individual hospitals. SAS software (Version 9.2, SAS Institute Inc., Cary, NC) was used for statistical analyses. A two-tailed *p*-value less than 0.05 was defined as statistically significant.



**Fig. 1** Flowchart of participants included in the study. TIA: transient ischemic stroke

**Results**

During the study period, there were 1,430 records entered into the registry. There were no patients aged less than 20 years old in the records. We excluded patients who presented > 3 h after stroke or TIA and did not arrive at the hospital with prenotification ( $n = 226$ ), whose records did not include prehospital data ( $n = 53$ ), and whose records did not include documented CT time ( $n = 20$ ). After these exclusions, there were 1,131

patients who were included in the results (Fig. 1). The rate of data missing was 6.1 % (73/1204). Among them, 203 prenotified patients had other discharge diagnoses other than ischemic stroke, hemorrhagic stroke, and TIA within 3 h of symptom onset. Therefore, there were 928 patients presenting  $\leq 3$  h after symptom onset and diagnosed with stroke or TIA in our study.

Of the 928 patients who presented  $\leq 3$  h after symptom onset and who were diagnosed with stroke or TIA,

**Table 1** Demographics of patients with and without prenotification

	Prenotification ( $n = 727$ )	No prenotification ( $n = 201$ )	<i>p</i> -value
Male	469 (64.5 %)	104 (51.7 %)	0.001
Mean age, years	69.0 $\pm$ 15.1	70.6 $\pm$ 16.2	0.204
Past history			
Prior ischemic stroke	112 (15.4 %)	39 (19.4 %)	0.174
Hypertension	426 (58.6 %)	113 (56.2 %)	0.545
Hypercholesterolemia	72 (9.9 %)	33 (12.4 %)	0.001
Cardiac disease	167 (23.0 %)	69 (34.3 %)	0.001
Chronic renal disease	11 (1.5 %)	6 (3.0 %)	0.229
Diabetes mellitus	140 (19.3 %)	46 (22.9 %)	0.255
Malignancy	35 (4.8 %)	12 (6.0 %)	0.508
Alcohol intake in last 2 years	32 (4.4 %)	8 (4.0 %)	0.795
Smoking in last 2 years	78 (10.7 %)	15 (7.5 %)	0.172
Median NIHSS score	16 (9–22)	12.5 (8–18)	0.081
Stroke type			
Hemorrhagic stroke	250 (34.4 %)	66 (32.8 %)	<0.001
Ischemic stroke	433 (59.6 %)	105 (52.2 %)	
Transient ischemic attack	44 (6.1 %)	30 (14.9 %)	

Values are a number (percentage) or mean  $\pm$  standard deviation

**Table 2** Prehospital and in-hospital management time for patients with and without prenotification

	Prenotification (n = 727)	No prenotification (n = 201)	p-value
Total prehospital time, median	22.5 (18.5–26.0)	22 (17.5–26.5)	0.433
Door to CT time, median	13 (10.0–18.0)	19 (13.0–34.0)	<0.001
Door to CT time ≤ 25 min	660 (90.8 %)	125 (62.2 %)	<0.001
Door to needle time, median	63 (49.0–79.0)	68 (54.0–86.0)	0.138
Door to needle time ≤ 60 min	65 (45.1 %)	7 (28.0 %)	0.110
Administering thrombolytic therapy	144 (19.8 %)	25 (12.4 %)	0.017

Values are a number (percentage) or median (upper quartile, lower quartile)

727 patients received prenotification, while the others did not. The characteristics of these patients are shown in Table 1. The prenotification group included more males, more recent smokers, and fewer patients with underlying diseases such as prior ischemic stroke, hypercholesterolemia, and cardiac diseases in comparison with the no-prenotification group. The prenotification group also had a higher stroke severity. In terms of the primary outcome, the prenotification group had a significantly shorter door-to-CT time than the no-prenotification group (13 versus 19 min,  $p < 0.001$ ) (Table 2). In regards to the secondary outcome, the prenotification group was associated with a shorter DTN time (63 versus 68 min,  $p = 0.138$ ) and a higher percentage of DTN time ≤ 60 min (45.1 % versus 28.0 %,  $p = 0.110$ ). Both groups had similar times in regards to total prehospital management time.

The PPV and sensitivity of the prehospital notification criteria were 78.2 % (727/930, 95 % CI: 75.4–80.8) and 78.3 % (727/928, 95 % CI: 75.5–80.9). Among 203 prenotified patients without diagnoses of stroke or

**Table 3** Other diagnoses (excluding ≤ 3 h acute cerebrovascular disease) among patients with prenotification (n = 203)

Diagnoses	n (%)
>3 hours since stroke onset or TIA <sup>a</sup>	116 (57.1 %)
Seizure	39 (19.2 %)
Hypoglycemia	4 (2.0 %)
Peripheral vertigo or dizziness	2 (1.0 %)
Prior stroke	5 (2.5 %)
Traumatic brain injury	3 (1.5 %)
Syncope	5 (2.5 %)
Intracranial tumor	5 (2.5 %)
Drug or alcohol overdose	3 (1.5 %)
Hepatic encephalopathy	4 (2.0 %)
Serotonin syndrome	1 (0.5 %)
Hydrocephalus	1 (0.5 %)
Aortic dissection	2 (1.0 %)
Weakness due to other medical problems	13 (6.4 %)

<sup>a</sup>TIA: transient ischemic attack

TIA ≤ 3 h after onset, the most common discharge diagnoses were stroke or TIA > 3 h after onset (57.1 %) and seizure (19.2 %) (Table 3). Among the 685 patients who presented ≤ 3 h after stroke onset and did not receive thrombolytic therapy, the most frequent three reasons were: hemorrhagic stroke or hemorrhagic transformation (46.1 %), age greater than 80 years old (22.9 %), and prompt symptom recovery or minor stroke (13.0 %) (Table 4). Ten (1.5 %) patients who were suitable for thrombolytic therapy refused the treatment. The DTN times among participating hospitals were also different, ranging from 51.5 min to 87 min, and the DTN time was significantly and highly negatively associated with the volume of patients receiving thrombolytic therapy (Spearman's correlation coefficient -0.90,  $p < 0.001$ ) (Fig. 2).

## Discussion

In our study, we found prehospital notification was associated with faster door-to-CT scan in patients presenting within 3 h of symptom onset. It saved time from arrival to CT completion and gave both doctors and patients more time to make further evaluations and decisions for a disease with time-limited treatment options. Such a close collaboration between hospitals and EMS systems gives citizens an in-time emergency care network. Our study revealed that, like in other countries [11–18, 21], prenotification for stroke patients improved in-hospital stroke care in Taiwan.

Prenotification was also associated with shorter DTN time in our study. In the literature, prenotification shortened DTN time significantly in some studies [13, 14, 16, 17], but it did not show the same effect in other studies [12, 19]. Such discrepancies regarding the effect of prenotification on DTN time among these studies may be caused by small sample sizes or may be related to the fact that the time that thrombolytic therapy is begun is affected not only by the speed of laboratory studies, imaging studies, and medical evaluation by medical personnel, but also by communication between doctors and patients or family members, and the speed that decisions are reached by doctors, patients, and

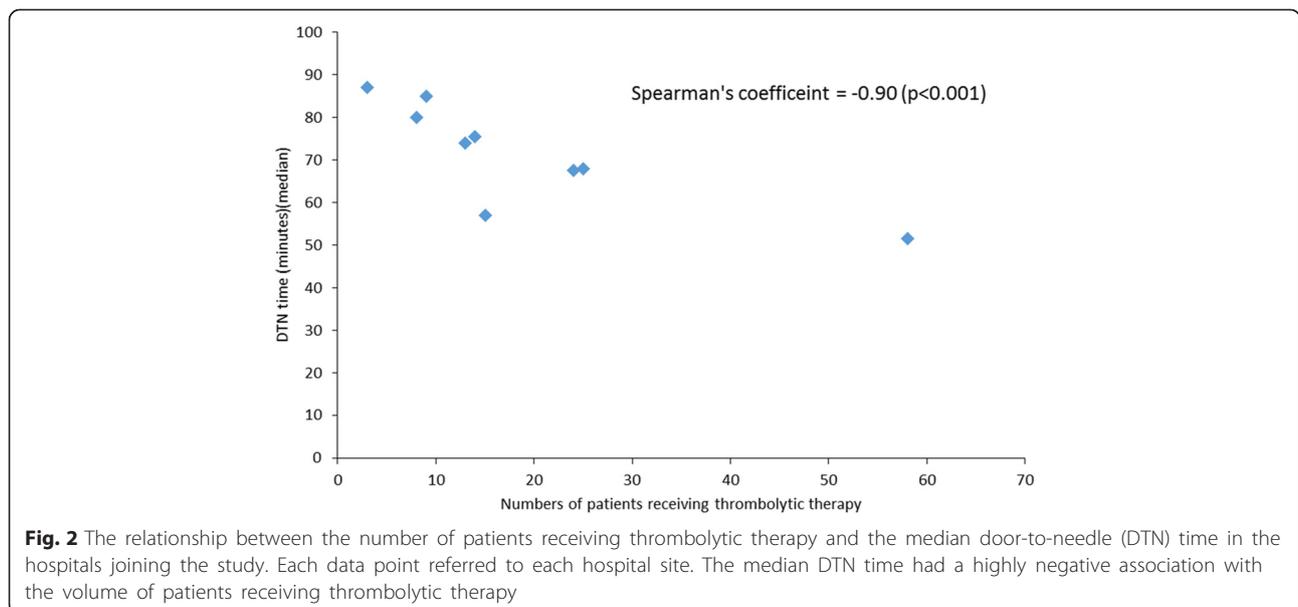
**Table 4** Reasons thrombolytic therapy was not administered to patients presenting within 3 h of stroke onset

Reasons	Prenotification (n = 539)	No prenotification (n = 146)	Total (n = 685)
Hemorrhagic stroke or hemorrhagic transformation	250 (46.4 %)	66 (45.2 %)	316 (46.1 %)
Older than 80 years of age	117 (21.7 %)	40 (27.4 %)	157 (22.9 %)
Rapid recovery or minor symptoms	70 (13.0 %)	19 (13.0 %)	89 (13.0 %)
Very severe symptoms/signs	28 (5.2 %)	9 (6.2 %)	37 (5.4 %)
Stroke or serious head injury within 3 months	11 (2.0 %)	2 (1.4 %)	13 (1.9 %)
Prior stroke accompanied with diabetes mellitus history	7 (1.3 %)	3 (2.1 %)	10 (1.5 %)
Seizure during stroke onset	8 (1.5 %)	2 (1.4 %)	10 (1.5 %)
Patient or family refused therapy	9 (1.7 %)	1 (0.7 %)	10 (1.5 %)
Uncontrolled hypertension	8 (1.5 %)	0 (0 %)	8 (1.2 %)
International normalized ratio >1.7	4 (0.7 %)	3 (2.1 %)	7 (1.0 %)
Known vascular malformation, aneurysm, or brain tumor	7 (1.3 %)	0 (0 %)	7 (1.0 %)
More than 4.5 hours before thrombolytic therapy given	6 (1.1 %)	0 (0 %)	6 (0.9 %)
Other	14 (2.6 %)	1 (0.7 %)	15 (2.2 %)

family members. Poor communication or hesitation to make a decision could delay the initiation of treatment. These unmeasured confounders suggest that the association between prenotification and DTN time is inconclusive. Our results suggest that to further shorten the DTN time in our community, more efforts are needed to improve the process during the period between CT completion and thrombolysis, because more time, which had the potential to be saved, was consumed during this period.

Our study demonstrated that the PPV and sensitivity of prenotification decisions were high, both reaching 80 %. In the literature, the PPV of the CPSS ranged from

40 % to 85 %, and the sensitivity ranged between 44 %–95 % [22, 25, 27–32]. The PPV and sensitivity of prenotification decisions according to our CPSS-based criteria was comparable with those in other studies. Although our study showed that prenotification decisions had high PPV and sensitivity, to further improve the accuracy of prenotification decisions, more efforts are needed to develop periodic refresher programs to maintain important skills regarding clarification of the onset time of symptoms, because the most frequent diagnosis for patients with an inaccurate prenotification decision was stroke occurring more than 3 h earlier. In addition, the final diagnosis for about 20 % of patients with an incorrect



**Fig. 2** The relationship between the number of patients receiving thrombolytic therapy and the median door-to-needle (DTN) time in the hospitals joining the study. Each data point referred to each hospital site. The median DTN time had a highly negative association with the volume of patients receiving thrombolytic therapy

prenotification decision was seizure. In the previous validated prehospital stroke screening tools, such as LAPSS, OPSS, MASS and the Recognition of Stroke in the Emergency Room scale, history of seizure or seizure at onset was one of the criteria [23–25, 33]. In order to further improve the PPV of prenotification decisions, it may be useful to add a seizure criterion in order to eliminate patients with seizure at onset and to improve the skills of EMTs to identify seizures.

Our study showed that very few patients eligible for thrombolytic therapy refused the therapy. This suggested that most patients accepted thrombolytic therapy after physicians explained the benefits of the treatment in spite of the risk of intracerebral hemorrhage. This result hints that emergency care staff must pay attention to identify stroke patients and to give appropriate therapy. In addition, the stroke patients included in our study had moderate to severe symptoms, and it was speculated that stroke patients who suffered from minor symptoms might arrive at hospitals by themselves instead of EMS. To increase EMS utilization by stroke patients, more efforts are needed not only to enable the citizens to identify stroke symptoms, but also to emphasize the importance of calling ambulance to the public.

Our study also showed that DTN time was shorter in the hospital that treated a greater volume of patients with thrombolytic therapy. One multicenter study found that the annual volume of patients receiving thrombolysis affected the DTN time much more than the years of treatment [34]. Another study also found that higher annual volume was associated with lower stroke mortality [35]. Therefore, a multicenter collaboration program is needed to help those hospitals with relatively lower stroke patient volume to set up interventions that have been proven to improve stroke care.

There were some limitations to our study. First, our study was performed in a metropolitan city, and the study results might not be generalizable to rural areas. Second, all of the participating hospitals had standard in-hospital protocols for treating stroke patients. The effect of prenotification on stroke care, as demonstrated in our study, might be different in hospitals without such protocols. Nevertheless, our study revealed that prehospital notification was a useful strategy when a close collaboration was developed between well-trained and organized EMS systems and hospitals.

## Conclusions

Prehospital notification shortened door-to-CT time significantly, and was also associated with improved DTN time. EMTs also exhibited good PPV and sensitivity when applying prenotification criteria but also had some room for improvement. Our study showed that prehospital notification is a feasible strategy for better stroke care in Taiwan.

## Abbreviations

tPA: tissue plasminogen activator; AHA: American Heart Association; ASA: American Stroke Association; EMS: emergency medical service; DTN: door-to-needle; CPSS: Cincinnati Prehospital Stroke Scale; LAPSS: Los Angeles prehospital stroke screen; OPSS: Ontario prehospital stroke screening tool; MASS: Melbourne Ambulance Stroke Screen; EMTs: emergency medical technicians; ED: emergency department; PPV: positive predictive value; CI: confidence interval.

## Competing interests

The authors declare that they have no competing interests.

## Authors' contributions

MH, JJ, and MHM conceived the study. MH and ST performed the statistical analyses. All other authors (WC and LT) contributed to the study design, data collection, and data analysis. MH, ST, WC, and JJ wrote the manuscript. All authors contributed substantially to manuscript revision. All authors have read and approved the final manuscript for publication.

## Acknowledgments

We would like to thank the Taipei City Fire Department for their administrative support and implementation of prehospital stroke care in the EMS system. We would also like to thank the medical personnel who are devoted to the best possible stroke care at the participating hospitals.

## Funding

The study was supported by the National Science Council, Taiwan (NSC101-2314-B-002-120-MY3) and the Taiwan Ministry of Science and Technology (MOST 103-2628-B-002-007-MY2 and MOST 104-2314-B-002-032-MY2).

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Received: 6 October 2015 Accepted: 20 April 2016

Published online: 27 April 2016

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