Original Article

Relationship between Emergency Department Crowding and Delay in Acute Stroke Management: A Prospective Observational Study

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Objective: Patients with acute stroke should be treated promptly using fast-track management to decrease morbidity and mortality; however, emergency department [ED] crowding may delay treatment. The authors ascertained the efficiency of acute stroke fast-track management by measuring the correlation between ED crowding (occupancy rate) and time from door to computed tomography [CT] scan.

Materials and Methods: The present report was a prospective observational study including patients with acute stroke symptoms within 4.5 hours after onset, whom were treated by following the acute stroke fast-track management. The occupancy rate was used to represent ED crowding. The correlation between occupancy rate and timing for each step (time to neurologist/radiologist notification, CT scan, blood laboratory report, or needle) was analyzed using Spearman's correlation coefficients.

Results: Among the 94 patients studied, the medians of the door to CT scan, door to blood laboratory report, and door to fibrinolytic drug administration times were 22 minutes (16 to 27.25), 73.5 minutes (63 to 89.25), and 75 minutes (57.5 to 89.5), respectively. The median occupancy rate was 70% (50 to 100). There was no significant correlation between occupancy rate and door to CT scan time (r = 0.184, p = 0.076) or door to fibrinolytic drug administration (r = 0.272, p = 0.233). However, there was a significant, weak positive correlation between ED crowding and door to blood laboratory report time (r = 0.400, p<0.001).

Conclusion: ED crowding was not correlated with door to CT scan time. However, it was correlated with time to blood laboratory report, which might affect acute stroke management.

Keywords: Emergency department, Crowding, Delay, Stroke care

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Acute stroke management requires timely treatment to salvage the penumbral area from ischemia. Recanalization of the occluded artery is the only treatment that effectively decreases morbidity and mortality. The acute stroke fast-track protocol advocated by the American Stroke Association and the American Heart Association[1-3] recommends that stroke team notification, computed tomography [CT] scan completion, CT interpretation, and administration of thrombolytics should occur within 10, 25, 45, and 60 minutes, respectively, in eligible patients with suspected stroke admitted to emergency departments [ED]. Thus, rapid, timely treatment is the key element in time-dependent stroke care.

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ED crowding is becoming a major worldwide issue. Much recent research has shown that ED crowding affects healthcare quality by delaying treatments[4], for example, increased time to antibiotics administration in pneumonia[5-7] or increased adverse cardiovascular outcomes in patients with chest pain[8]. Such delays result in increasing morbidity and mortality among emergency patients[9,10]. The authors doubted that ED crowding could reduce the quality of stroke management. Although Chatterjee et al[11] reported that ED crowding was not associated with delay in patients potentially eligible for thrombolysis, that study employed retrospective methodology. The authors conducted a prospective observational study to measure the correlation between ED crowding and care timing in acute stroke management.

Materials and Methods

Between February and July 2012, the authors

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performed a prospective observational study in ED at Siriraj Hospital, Bangkok, Thailand, which is a university hospital in a metropolitan area that receives 200,000 ED visits annually and has 2,500 inpatient beds, including a 17-bed stroke unit. The investigators included patients aged older than 18 years hospitalized with suspected acute stroke within 4.5 hours after onset and treated following the acute stroke fast-track guidelines. The patients for whom doctors activated the stroke team from other departments or were transferred from other hospitals were excluded.

When the patients met the inclusion criteria, the ED physician immediately initiated the acute stroke fast-track protocol by contacting the call center to activate the acute stroke team, which consisted of neurologists and radiologists. The ED physician obtained informed consent from the patients or their families, and then the neurologists assessed the patients in the ED immediately after the protocol was activated. When the ED physician had contacted the radiologists, the patients were sent for CT scans. The CT scanner is one floor below the ED, requiring elevator transport. The combination of medical history, physical exam, and imaging results were used for patient evaluation, and the neurologist decided whether to give thrombolysis. If appropriated, fibrinolytic drugs were given in the ED as early as possible. All patients with acute stroke in the present study received standard ED care and disposition to definite care later. During a pre-study orientation, the participating ED physicians recorded all appropriate data, including baseline characteristics, actual times of important protocol events (i.e., times of stroke onset, ED arrival, stroke team activation, CT scanning, blood laboratory report generation, thrombolysis administration, and disposition), lab results, definite diagnosis, whether or not thrombolysis was received, disposition, and overall number of patients in ED at the time of treatment (to calculate occupancy rate, which our internal data shown was highly reliable and valid tool to detect ED crowding in the hospital setting[12]). Then, the protocol timing data were calculated to ascertain their correlation with occupancy rate, as described above.

The authors also identified secondary factors affecting delayed time to CT scanning, defined as a time interval greater than 25 minutes according to the standard protocol from the American Stroke Association and the American Heart Association[1-3]. The authors recorded factors such as intubation before the patients underwent CT scans and communication problems. Communication problems were defined by failure to contact the call center using all phone numbers or failure to contact the radiologist more than once.

The ethical considerations of the present study were approved by the Siriraj Review Board.

Statistical analysis

Previous data indicated that the correlation coefficient between occupancy rate and door to CT scan time was ±0.8. The authors used a rule of thumb to interpret the magnitude of the absolute value of the correlation coefficient: 0.00 to 0.30, 0.30 to 0.50, 0.50 to 0.70, 0.70 to 0.90, and 0.90 to 1.00, indicate negligible, weak, moderate, strong, and very strong correlations, respectively. A correlation of 0.6 indicated a moderately strong relationship[13]. The number of enrolled patients was 94.

Continuous, normally distributed variables were presented as mean ± SD. Frequency and percentage were used to describe categorical variables. Non-parametric time intervals were presented as median and interquartile range [IQR]. For non-normal data distributions, Spearman's correlation coefficient was used to assess the correlation between occupancy rate and delay at each time interval.

To identify the factors affecting delay in time to treatment, the Fisher's exact test and Mann-Whitney U test were used for categorical and continuous variables, respectively. A *p*-value smaller than 0.05 was defined as statistically significant. SPSS version 17 was used for statistical analysis.

Result

Baseline characteristics

Ninety-four patients were enrolled. Their baseline characteristics are shown in Table 1. Their mean age was 66 years, and 50% were men. The most common comorbidity was hypertension (57.4%). Of all the participants, 69 (73.4%), 32 (34%), and 20 (21.3%) presented with hemiparesis, facial palsy, and dysarthria, respectively. Of the 94 patients, 14 (14.9%) were intubated in the ED before being sent for CT scanning. CT scans were performed on 65 patients (69%) within 25 minutes of arrival. Among the 52 patients diagnosed with acute ischemic stroke, 21 (22.3%) received fibrinolytic therapy. Only five (23.8%) of the patients received fibrinolytic therapy within 60 minutes. The median ED occupancy rate was 70% (IQR 50 to 100).

Time intervals in acute stroke management

All calculated time intervals in acute stroke

Table 1. Baseline characteristics

Variable	n (%)
Age (years), mean ± standard deviation	66±15
Sex	
Male	47 (50.0)
Comorbidity	
Hypertension	54 (57.4)
Diabetes mellitus	19 (20.2)
Prior stroke	17 (18.1)
Dyslipidemia	12 (12.8)
Atrial fibrillation	8 (8.5)
Coronary artery disease	8 (8.5)
Valvular heart disease	4 (4.3)
Chronic liver disease	3 (3.2)
Anticoagulant	11 (11.7)
Presentation	
Hemiparesis	69 (73.4)
Facial palsy	32 (34.0)
Dysarthria	20 (21.3)
Numbness	9 (9.6)
Dysconjugate eye movement	8 (8.5)
Seizure	2 (2.1)
Glasgow Coma Scale, median (interquartile range)	15 (10 to 15)
Intubation	14 (14.9)
Final diagnosis	
Ischemic stroke	52 (55.3)
Hemorrhagic stroke	25 (26.6)
Transient ischemic attack	4 (4.3)
Others	13 (13.8)
Receiving fibrinolytic therapy	21 (22.3)

Table 2. Time intervals in acute stroke management

Interval	Time (minute) median (interquartile range)
Symptom onset to ED arrival (door)	110 (11 to 270)
Door to neurologist notification	6 (4 to 10)
Door to radiologist notification	7 (4 to 10)
Door to computed tomography scan	22 (16 to 27.25)
Door to blood test results reported	73.5 (63 to 89.25)
Door to rt-PA	75 (57.5 to 89.5)

ED = emergency department

management are shown in Table 2. The median intervals were from ED arrival (door) to the ED physician's activation of the neurologist 6 minutes (IQR 4 to 10), door to CT scan 22 minutes (IQR 16 to 27.25), door to laboratory report 73.5 minutes (IQR 63 to 89.25), and door to needle time 75 minutes (IQR 57.5 to 89.5).

Correlation between ED crowding and time intervals

There was no significant association between occupancy rate and door to CT scan time (r = 0.184, $p = 0.076$) or door to needle time (r = 0.272, $p = 0.233$). However, there was a significant, correlation between occupancy rate and door to laboratory report time (r = 0.400, $p<0.001$) (Table 3).

Factors affecting delayed time to treatment

The significant factor affecting delayed time to CT scan performance was intubation. Six patients (9.2%) were intubated in the group of patients with CT scan time faster than 25 minutes, compared with eight patients (27.5%) in the group with CT scan time longer than 25 minutes ($p = 0.03$) (Table 4).

Discussion

In the present study, the authors evaluated the efficiency of acute stroke fast-track management at the tertiary care unit of a university hospital, by conducting a prospective observational study to measure the correlation between ED crowding and care timing in acute stroke management. There were 94 patients enrolled. The present study focused on door to CT scan time, because CT imaging provided the most important information to distinguish between ischemic and hemorrhagic stroke and facilitates proper treatment. There was no correlation between occupancy rate and door to CT scan time. However, there was a significant correlation between occupancy rate and door to laboratory report time.

Chatterjee et al found no significant relationship between ED crowding and delay in CT timing or thrombolysis at three hours or less after symptom onset, consistent with the present study[11]. However, there

Table 3. Relationship between occupancy rate and time interval in acute stroke management

Interval	Correlation coefficient	*p*-value
Door to neurologist notification	0.026	0.806
Door to radiologist notification	0.039	0.711
Door to computed tomography scan	0.184	0.076
Door to blood test results reported	0.400	<0.001
Door to rt-PA	0.272	0.233

Table 4. Factors affecting delay time to computed tomography [CT] scan

Factors	CT time within 25 minutes (n = 65), n (%)	CT time >25 minutes (n = 29), n (%)	p-value
Intubation before CT scan	6 (9.2)	8 (27.5)	0.03
Communication problem*			
Contact with call center	16 (24.6)	4 (13.7)	0.29
Contact with radiologist	8 (12.3)	2 (6.8)	0.72

* Communication problem was defined by failure to contact call center using all phone numbers or failure to contact radiologist more than once

was a correlation between occupancy rate and door to blood laboratory report time (r = 0.400, p<0.001). Waiting for coagulation results might be the major cause of delay to needle time, as only five (23.8%) patients received thrombolysis within 60 minutes. Previous studies have indicated that point-of-care-testing provided rapid, reliable results compared with central laboratory testing[14,15]. Therefore, using point-of-care coagulation testing during time of ED crowding might decrease delay to thrombolysis[16]. Nevertheless, the present study did not show a significant correlation between occupancy rate and door to needle time (r = 0.272, p = 0.233). The data might be lacking, because small number of patients (21) received fibrinolysis.

According to the American Heart Association guidelines for cardiopulmonary resuscitation and emergency cardiovascular care[17], suspected stroke patients should receive CT scans within 25 minutes. In the present study, 29 patients (31%) did not received CT scans within that period. The significant factor affecting delay in CT scan time in the present study was intubation. However, this procedure was mandatory for patient resuscitation and thus unavoidable delay. Another reason for the delay may be due to the CT scanner's location, that requires elevator transport. A previous study reported that moving the CT scanner to the ED significantly reduced time to CT scan[18]. Moreover, the communication problems could be the cause of some delay time, as shown by a previous study[19]. Surprisingly, such delays did not affect the system, possibly because the authors chose an unsuitable definition of communication problems. Because failure to contact a physician only once indicated a communication problem, such problems did not serve as a distinguish indicator between the two groups (i.e., patients who received CT scans in 25 minutes or less and in more than 25 minutes).

Only 12 patients were transferred to the studied hospital by emergency medical services. Mostly, they came to the hospital by themselves, and the median time between symptom onset and hospital arrival was more than one hour. Barsan et al[20] found that using emergency medical services to reduce time to hospital arrival resulted in decreased door to needle time in patients with stroke. To facilitate the greatest benefits for stroke patients, the public should be educated about signs of cerebral insufficiencies and get immediate treatment, provide adequate prehospital stroke care via emergency medical services, and improve in-hospital stroke care systems.

Limitation

First, the present study was a single-center study, which might make it difficult to apply to other hospitals with different stroke fast-track systems. Second, the number of patients who received thrombolysis was too small to permit multivariate analysis. Finally, the present study did not demonstrate any clinical outcomes. Further studies are needed to assess the effects of ED crowding on adverse events and outcomes of patients with stroke, including medical errors, adverse events, morbidity, and mortality.

Conclusion

In conclusion, ED crowding was not associated with time to CT scan performance in patients treated with acute stroke fast-track management, indicating that the stroke care system is effective even though the ED was overcrowded.

What is already known on this topic?

Rapid, timely treatment is the key element in time-dependent stroke care. ED crowding has become a serious problem worldwide.

What this study adds?

The main factor affecting delay in time to CT scan was emergency intubation. No significant correlation between ED crowding and timing was found in acute stroke fast-track management.

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Potential conflicts of interest

The authors declare no conflict of interest.

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