Implementation of a Stroke Alert Protocol in the Emergency Department: A Pilot Study

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Context: Although tissue plasminogen activator (tPA) is an effective treatment for stroke patients, it typically must be administered within 3 hours of symptom onset to substantially reduce morbidity and mortality. Because of this limited treatment window, it is essential for healthcare professionals to properly identify and quickly triage stroke patients.

Objective: To determine if implementation of a stroke alert protocol coupled with a limited education program will reduce arrival time to computed tomography scan time and treatment time for stroke patients in the emergency department (ED).

Methods: This prospective pilot study took place at Geisinger Medical Center in Danville, Pennsylvania, and included a formal stroke protocol based partly on The Joint Commission’s stroke center recommendations. The major feature was integration of various hospital departments to quickly and accurately identify and triage stroke patients; included was a limited education program for residents and attending staff. Patients who presented between November 1, 2007, to October 31, 2008, comprised the study group (ie, after protocol implementation). A retrospective analysis of patient records from November 1, 2006, to October 31, 2007, for stroke morbidity, mortality, and tPA administration was employed as a control group (ie, prior to protocol implementation). Inclusion criteria consisted of patients aged 18 years or older who arrived at the ED with stroke-like symptoms. Exclusion criteria consisted of previous hemorrhagic stroke, seizure at stroke onset, internal bleeding, intracranial hemorrhage, recent surgery, platelet count of less than $100 \times 10^3 / \mu L$, untreated blood pressure greater than 185/110 mm Hg, symptoms lasting for longer than 6 hours, and vascular malformation. Patients with a history of ischemic stroke were included in the study.

Results: The study included a total of 233 stroke patients, 132 of whom presented to the ED prior to stroke protocol implementation and 101 of whom presented after stroke protocol implementation. For patients who arrived at the ED within 3 hours from symptom onset, median time to completion of a computed tomography (CT) scan was reduced from 65.5 minutes (interquartile range, 41.0-101.0) prior to the new protocol to 54.0 minutes (interquartile range, 25.0-54.0) after implementation ($P<.004$). Regarding patients who arrived in the ED 3 to 6 hours after symptom onset, median time from ED arrival to CT time decreased from 94.5 minutes (interquartile range, 68.0-136.0) before the new protocol to 48.5 minutes (interquartile range, 33.0-89.0) following implementation ($P<.002$). Of the 79 patients who arrived at the ED within 3 hours of symptom onset in the year after protocol implementation, 12 were treated with tPA, compared to 4 out of 86 treated in the year prior to protocol implementation. Mean time from ED arrival to tPA treatment was reduced from 85.5 minutes in the preprotocol group to 48.9 minutes in the postprotocol group.

Conclusion: By coupling a formal stroke protocol with a limited education program, door-to-treatment time of stroke patients was reduced.


According to the American Stroke Association (ASA), stroke (all types) is the third leading cause of death in the United States. Tissue plasminogen activator (tPA) has been an effective treatment for patients with stroke; one study indicated that recanalization of blood vessels can occur in up to 50% of patients treated with tPA. However, tPA typically be administered in the proper setting within 3 hours of symptom onset. Even when patients arrive at the hospital in time, only about 4% of patients actually receive tPA. Healthcare professionals’ ability to quickly and accurately identify patients at risk for having a stroke and to recognize stroke-type symptoms is important for safe and effective treatment. Stroke protocols in which stroke patients can be identified and triaged quickly may substantially reduce morbidity and mortality rates for this condition.
In 1995, the US Food and Drug Administration (FDA) approved intravenous (IV) administration of tPA as a treatment option for stroke. While previous treatments such as heparin had been shown to be ineffective, tPA was found to reduce morbidity and mortality in patients with stroke. The FDA’s data indicated that when IV tPA was administered within the first 3 hours of stroke onset, outcomes improved. If strict guidelines for IV tPA, including a 3-hour window for administration, are not followed, intracerebral hemorrhage risk increases. New treatment options in neurointervention can expand the treatment window for acute stroke beyond 3 hours. For example, intraarterial tPA delivered by catheter injection can extend the timeframe for tPA administration to 6 hours within stroke onset.

During the past several years, research into best practices and outcomes has led to the formation of guidelines for the management of stroke. The ASA and The Joint Commission (formerly the Joint Commission on the Accreditation of Healthcare Organizations) have developed guidelines for ischemic stroke and hemorrhagic stroke. In addition, some hospitals have successfully developed and implemented protocols for the administration of tPA within 3 hours of symptom onset. Douglas et al described how the application of criteria recommended by the Brain Attack Coalition led to increased tPA use at 34 academic medical centers. However, while stroke protocols have been shown to be effective in the treatment of stroke patients, risks such as hemorrhage continue to be safety concerns.

Rural hospitals have had a more difficult time than urban hospitals adapting to the new stroke guidelines because of a lack of resources including personnel, facilities, and diagnostic imaging equipment. As a result, hospitals have implemented alternative processes to treat stroke patients. For example, one hospital used a process known as “drip-and-ship,” in which IV tPA is started in the field or at an outside facility before the patient is transported to a tertiary care center. This process poses a possible dilemma because field personnel do not necessarily have the appropriate certification or sufficient experience to make critical decisions regarding the treatment of stroke patients. Therefore, other innovative procedures have been developed such as stroke telephone networks. These networks allow field personnel to talk to stroke neurologists at tertiary care centers to prevent problems in potential stroke patients (eg, giving tPA when not appropriate).

As previously mentioned, it is important for physicians, nurses, and other healthcare providers to know major warning signs for stroke (eg, weakness, numbness, changes in speech) because the treatment window for stroke patients is limited. Although recent educational campaigns for the public have resulted in better stroke recognition and quicker treatment of patients to date, educational programs for healthcare professionals have not been used widely to help alleviate the healthcare professionals’ underrecognition of stroke symptoms. The development of a stroke protocol that includes a program to educate staff about stroke warning signs and required treatment could greatly improve the treatment of stroke patients and, thus, save more lives. Our goal was to develop a system that—in addition to educating staff about stroke and the stroke protocol—would integrate several departments, streamline patient flow, and expedite imaging and laboratory studies. Educational tools to facilitate this process also needed to be developed. It was essential that the stroke protocol stemmed from evidence-based guidelines and published research.

Geisinger Medical Center in Danville, Pennsylvania, was an appropriate medical site to test such a comprehensive program because, on average, the center admits more than 600 stroke patients per year. It is also a rural tertiary care center. At the time we began the present study, the medical center did not have a protocol in place to effectively triage stroke patients in the emergency department (ED). We predicted that development of a standardized stroke protocol designed to streamline and improve processing through the ED and to educate staff about stroke symptoms prior to its implementation would improve the timeliness of patient care.

Methods
This clinical prospective pilot study was conducted at Geisinger Medical Center in Danville, Pennsylvania. Approval was received from the medical center’s Institutional Review Board. Patients who presented between November 1, 2007, to October 31, 2008, comprised the study group (ie, after protocol implementation). A retrospective analysis of patient records from November 1, 2006, to October 31, 2007, for stroke morbidity, mortality, and tPA administration was employed as a control group (ie, prior to protocol implementation). Inclusion criteria consisted of patients aged 18 years or older who arrived at the ED with stroke-like symptoms including (but not limited to) weakness, numbness, and problems with speech. Exclusion criteria consisted of history of hemorrhagic stroke, seizure at stroke onset, internal bleeding, intracranial hemorrhage, recent surgery, platelet count of less than 100 × 10^3/µL, untreated blood pressure greater than 185/110 mm Hg, symptoms lasting for longer than 6 hours, and vascular malformation. Patients with a history of ischemic stroke were included in the study.

Education Program
Physicians and nursing staff directly involved in treating stroke patients underwent a limited education program consisting of a newly created Microsoft Office PowerPoint (Microsoft Corporation, Redmond, Washington) slide presentation created by one of the authors (C.H.) and a video from the ASA. The slide presentation and video contained information on warning signs and symptoms of stroke such as facial droop, numbness, and weakness. Several sessions were made available for
participants to review. The number of staff members who participated in the sessions was less than desired; approximately 20 healthcare professionals attended, and fewer than that were actually measured. However, staff members from each department involved were thoroughly briefed on the training by their respective administrators. Given this briefing and the pilot nature of the study, it was decided to commence the protocol.

**Stroke Alert Protocol**

In conjunction with the education program, the medical center formulated and implemented a formal protocol for improving the identification of and treatment process for stroke patients (Appendix). This protocol was based partly on The Joint Commission’s stroke center recommendations. Physicians and staff from several departments (ie, laboratory, radiology, emergency medicine, and neurology) were integrated to facilitate this flow protocol.

In accordance with the protocol, patients in the ED who were suspected of having a stroke were examined immediately. Once stroke-like symptoms were confirmed and the time of stroke onset was determined, other departments were notified that a stroke patient was in the ED to ensure the availability of equipment (ie, CT scanner) and the timeliness of tests. Although the National Institutes of Health stroke scale and pocket cards were distributed, the protocol did not require use of these tools. The patient was assigned a nurse and placed in a room. Appropriate laboratory tests, including coagulation screens such as prothrombin time, partial thromboplastin time, and blood platelet count, were drawn and sent immediately (stat) to the laboratory. The patient was sent to the radiology department for a CT scan so that any risk of hemorrhage could be identified. The neurology department was also consulted immediately so that staff could be bedside within minutes to help with the decision-making process. Contraindications for IV tPA administration were addressed through patient questioning, laboratory testing, and appropriate imaging. Subsequently, a decision was made whether to administer IV tPA and patients were admitted for further workup or treatment as necessary.

An online database developed and maintained by the ASA called “Get with the Guidelines” tracked patient variables including time of arrival to ED (ED arrival time), time from ED arrival and the completion of a computed tomography scan (CT time), time between ED arrival to initiation of treatment (treatment time), and the number of patients who were administered IV tPA. The database included patient identifiers such as the date that the patient presented to the ED. However, only de-identified patient information was analyzed.

**Statistical Analysis**

The goal of statistical analysis was to determine whether there was a statistically significant reduction in ED arrival time to CT time for stroke patients after the stroke protocol was implemented in November 2007. The preprotocol and postprotocol patient groups were compared according to the following categories: presentation time in relation to symptom onset (ie, within 3 hours or 3-6 hours from onset of symptoms), time of day of presentation (ie, patients who presented during standard workday hours [between 8:00 AM and 5:00 PM]), and patient sex, age, and race (Table 1). P values for categorical variables were obtained from $\chi^2$ and Fisher exact tests; P values for age were determined by t tests. All tests were 2-sided. P values less than .05 were considered statistically significant. Median time differences were tested using the nonparametric Wilcoxon test. In addition, Type III F tests were used to determine adjusted P values for protocol status by median times. A regression model (the time was the dependent variable and was

<table>
<thead>
<tr>
<th>Table 1. Characteristics of Patients in the Emergency Department Suspected of Having a Stroke (N=233)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable</td>
</tr>
<tr>
<td>n=86</td>
</tr>
<tr>
<td>Presented &lt;3 h From Symptom Onset</td>
</tr>
<tr>
<td>□ Mean (SD) Age, y</td>
</tr>
<tr>
<td>□ Sex</td>
</tr>
<tr>
<td>– Men</td>
</tr>
<tr>
<td>– Women</td>
</tr>
<tr>
<td>□ White</td>
</tr>
<tr>
<td>□ Workday presentation (Monday-Friday, 8:00 AM to 5:00 PM)</td>
</tr>
<tr>
<td>n=46</td>
</tr>
<tr>
<td>Presented 3-6 h From Symptom Onset</td>
</tr>
<tr>
<td>□ Mean (SD) Age, y</td>
</tr>
<tr>
<td>□ Sex</td>
</tr>
<tr>
<td>– Men</td>
</tr>
<tr>
<td>– Women</td>
</tr>
<tr>
<td>□ White</td>
</tr>
<tr>
<td>□ Workday presentation (Monday-Friday, 8:00 AM to 5:00 PM)</td>
</tr>
</tbody>
</table>

* Data presented as No. (%) unless otherwise noted.
† P values derived from $\chi^2$ or Fisher exact tests, except for age, which was derived from 2-sample t tests.
log-transformed to correct for nonnormality) was fitted with covariates (eg, age, gender, time of day) in the model and the adjusted $P$ value obtained for protocol status.

**Results**

The patient sample consisted of a total of 233 stroke patients, 132 of whom presented to the ED from November 1, 2006, to October 31, 2007 (prior to stroke protocol implementation), and 101 of whom presented from November 1, 2007, to October 31, 2008 (after stroke protocol implementation) (Table 1 and Figure).

No statistically significant differences existed between the 2 groups with regard to any patient variables (Table 2). For those patients who arrived in the ED within 3 hours of symptom onset, the median ED arrival time to CT time was reduced from 65.5 minutes prior to protocol implementation (interquartile range, 41.0-101.0) to 54.0 minutes after protocol implementation (interquartile range, 33.1-55.3) ($P<.004$) (Table 2). For those who arrived in the ED 3 to 6 hours after symptom onset, the median ED arrival time to CT time was decreased from 94.5 minutes prior to protocol implementation (interquartile range, 68.0-136.0) to 48.5 minutes after protocol implementation (interquartile range, 33.0-89.0) ($P<.002$) (Table 2).

For patients who arrived at the ED within 3 hours of symptom onset, the number of patients treated with IV tPA increased from 4 in the year prior to implementation of the stroke protocol to 12 during the 12 months after the protocol was put in place (Table 3). In addition, median ED arrival time to treatment time decreased from 85.5 minutes preprotocol to 48.9 minutes postprotocol for this patient group. Reasons patients did not qualify for the administration of tPA included being on anticoagulant medications at the time of presentation and having a history of hemorrhagic stroke. Patients who received intraarterial tPA were not tracked with the present study.

**Comment**

After initiation of the present education program and stroke flow protocol at Geisinger Medical Center, a dramatic reduction in both ED arrival time to CT time and ED arrival time to treatment time occurred. The findings with the lowest $P$ value were the ED arrival time to CT time, which yielded $P$ values of .004 and .002 in the groups who presented to the ED less than 3 hours and 3 to 6 hours from symptom onset, respectively. The amount of time required to obtain a CT scan in the ED was reduced by approximately 50% after implementation of the stroke protocol. This reduction in turnaround time for CT scans is important when determining if a patient could benefit from tPA; the faster a CT scan can be obtained, the quicker that decisions about intravenous or intraarterial tPA can be made.

In addition to a reduction in ED arrival time to CT time, the number of patients treated with IV tPA increased after implementation of the stroke protocol. Although an increase in tPA treatments in itself can improve morbidity and mortality, this objective was not part of the present study.

To improve stroke care, other barriers that can adversely affect how stroke patients are cared for before they arrive at the ED need to be overcome. The first barrier is a lack of public awareness of stroke-like symptoms. When patients become symptomatic, it is essential that they immediately call 911 or go to the hospital. However, at Geisinger Medical Center, the
of educating all emergency personnel who may potentially be first responders—including emergency medical services staff working for various ambulance companies, fire fighters from different fire departments, and police officers—is daunting for a hospital. Therefore, this type of project is better suited for a larger entity such as a county or state government that can possibly integrate an educational process into licensing requirements for these personnel.

The third barrier is secondary stroke prevention. After patients who have a stroke are discharged from the hospital, they have up to a 20% chance of having another stroke, many of which occur within the first 90 days after discharge. For this reason, a stroke education program for patients who have recently had a stroke is needed. A patient-oriented stroke education program can be initiated while stroke patients are in the hospital prior to discharge and can address topics including risk factor modification, dietary changes, medication review, and overall lifestyle modification. These topics could be reinforced with additional individual or group sessions after the patient leaves the hospital.

It is important to consider some limitations in the present pilot study. For example, our study was conducted at only 1 institution. We plan to expand our study to other sites to determine if the present results can be replicated elsewhere. Expansion of this investigation to other medical centers could potentially have a substantial impact on stroke care and even possibly lead to a reduction in stroke morbidity and mortality. In addition, while provision of a limited education program did increase awareness of an impending stroke protocol, insufficient metrics were employed to determine its effectiveness. Finally, data regarding recurrent strokes were not collected or measured. Future studies on this topic should address these issues.

After completion of this research, a major article was published in the New England Journal of Medicine that stated, in certain cases, tPA can be given up to 4.5 hours from the onset of stroke symptoms. This new information will be taken into consideration as we develop plans to expand this program to other medical sites.

**Table 2.**

<table>
<thead>
<tr>
<th>Patient Group</th>
<th>Protocol Status (median [interquartile range]), min</th>
<th>Before Stroke Protocol</th>
<th>After Stroke Protocol</th>
<th>P Value†</th>
<th>P Value‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patients presenting &lt;3 hours from onset of stroke symptoms</td>
<td>65.5 (41-101)</td>
<td>54.0 (25-81)</td>
<td>.013</td>
<td>.004</td>
<td></td>
</tr>
<tr>
<td>Patients presenting 3-6 hours from onset of stroke symptoms</td>
<td>94.5 (68-136)</td>
<td>48.5 (33-89)</td>
<td>.007</td>
<td>.002</td>
<td></td>
</tr>
</tbody>
</table>

* All times are medians with 25th (Q1) and 75th (Q3) percentiles.
† No adjusting, Kruskall-Wallis test of medians.
‡ Adjusted for age, gender, and time of day in regression model of log (time).

**Table 3.**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Before Stroke Protocol</th>
<th>After Stroke Protocol</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>4</td>
<td>12</td>
<td>+300.0</td>
</tr>
<tr>
<td>Mean Time, min</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emergency department arrival to initial computed tomography scan</td>
<td>62.5</td>
<td>32.6</td>
<td>-47.8</td>
</tr>
<tr>
<td>Computed tomography scan to treatment</td>
<td>23.0</td>
<td>16.3</td>
<td>-29.1</td>
</tr>
<tr>
<td>Emergency department arrival to treatment</td>
<td>85.5</td>
<td>48.9</td>
<td>-42.8</td>
</tr>
</tbody>
</table>

The second barrier is recognition of stroke symptoms by emergency personnel. It is important that stroke symptoms be quickly recognized and patients be brought to the hospital in a timely fashion with steps such as tPA taken en route to the hospital. In this regard, a stroke protocol initiated prior to arrival to the hospital would be beneficial. However, the task...
tially reduced door-to-evaluation and subsequent treatment times of patients suspected of having a stroke. We anticipate that other medical centers would experience similar results if comparable protocols and educational programs are initiated. A stroke program such as the one described can have a major impact in the overall care of stroke patients.

Acknowledgments

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References


Appendix

Handout describing a formal protocol for improving the identification of and treatment process for stroke patients at Geisinger Medical Center in Danville, Pennsylvania. The handout has been altered for graphic enhancement only. Abbreviations: CBC, complete blood count; CT, computed tomography; ED, emergency department; EMS, emergency medical services; ER, emergency room; IV, intravenous; PT/INR, prothrombin time and international normalized ratio; PTT, partial thromboplastin time; tPA, tissue plasminogen activator.

Stroke Alert Protocol Proposal

Patient arrives to ED and found to have stroke symptoms <3 hours.  
EMS brings in stroke patient from the field.

Patient immediately brought back to exam room and stroke patient flow protocol initiated.

Time of onset confirmed by the ER resident/staff. Stroke-like symptoms confirmed.

Code Stroke called and stroke team alerted. Other departments notified including radiology, laboratory, and nursing staff.

Nurse assigned to patient, labs drawn and sent super-stat including PT/INR, PTT, CBC, chemistries, and CT scan without contrast done.

Patient evaluated by stroke team and a decision to initiate tPA is made. If the patient does not qualify for IV tPA, then patient may be a candidate for intraarterial tPA or other intervention at the discretion of the neurologist.