

The Neurological Emergency Room and Prehospital Stroke Alert: The Whole Is Greater Than the Sum of Its Parts

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BACKGROUND: Emergency medical services (EMS) prenotification to hospitals regarding the arrival of patients who have had a stroke is recommended to facilitate the workup once the patient arrives. Most hospitals have the patient enter the emergency department (ED) before obtaining a head computed tomography (CT) scan. At Capital Health, prehospital stroke-alert patients are delivered directly to CT and met by a neurological emergency team. The goal of bypassing the ED is to reduce the time to treatment.

OBJECTIVE: To evaluate (1) door-to-CT and door-to-needle time in patients with an acute stroke who arrive as prehospital stroke alerts and (2) the accuracy of EMS assessment.

METHODS: A prospective database of all prehospital stroke alert patients was kept and data retrospectively reviewed for patients who were seen between July 2012 and July 2013.

RESULTS: Between July 2012 and July 2013, 141 prehospital stroke alerts were called to our emergency department, and the patients were stable enough to bypass the ED and go directly to CT. EMS assessment of stroke was accurate 66% of the time, and the diagnosis was neurological 89% of the time. The average time between patient arrival and acquisition of CT imaging was 11.8 minutes. Twenty-six of the 141 patients (18%) received intravenous tissue plasminogen activator. The median time from arrival to intravenous tissue plasminogen activator bolus was 44 minutes.

CONCLUSION: Trained EMS responders are able to correctly identify patients who are experiencing neurological/neurosurgical emergencies and deliver patients to our comprehensive stroke center in a timely fashion after prenotification. The prehospital stroke alert protocol bypasses the ED, allowing the patient to be met in CT by the neurological ED team, which has proven to decrease door-to-CT and door-to-needle times from our historical means.

KEY WORDS: Emergency medical services, Intravenous tissue plasminogen activator, Prehospital notification, Stroke, Thrombolysis

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Administration of intravenous (IV) tissue plasminogen activator (tPA) is currently recommended in select patients with

ischemic stroke within 4.5 hours of symptom onset. Improved functional outcomes have been shown up to 1 year in patients who received IV tPA for stroke.^{1–4} Recommendations from the Brain Attack Coalition suggest that “door-to-needle” time, or time from arrival to the emergency department (ED) to the administration of intravenous recombinant tissue-type plasminogen activator alteplase (IV tPA) be 60 minutes or less. Despite the documented benefits of IV tPA and the recommendations for rapid administration, delivery remains low at 3% to 5% in

ABBREVIATIONS: ASLS, Advanced Stroke Life Support; DTN, door-to-needle; ED, emergency department; EMS, emergency medical services; EMT, emergency medical technician; IV, intravenous; MEND, Miami Emergency Neurological Deficit; PHSA, prehospital stroke alert; tPA, tissue plasminogen activator

potentially eligible patients for multiple reasons.⁵ One reason is the timing between onset of symptoms and delivery to the ED. Emergency medical services (EMS) play a crucial role in the initial assessment and stabilization of stroke patients and alerting the accepting EDs. Current American Heart Association/American Stroke Association guidelines recommend prehospital notification by EMS with patients suspected to have strokes to facilitate the necessary laboratory tests, imaging, and treatment once the patient arrives.⁶ Previous studies have shown that EMS prehospital notification significantly reduces all stroke time targets except door-to-IV tPA administration or door-to-needle (DTN) time.⁷ However, most hospitals who use a prenotification system have the patient arrive in the ED before obtaining a noncontrast head CT.⁷ Our study goes a step further by bypassing the ED and delivering patients directly to CT with the goal of reducing DTN time in eligible patients. In addition to our unique prehospital stroke alert (PHSA) protocol, Capital Health has the nation's first known neurological ED.⁸ Our neurological emergency team meets the patient in CT, quickly assesses the patient, and then the CT is done immediately. Bypassing the ED in conjunction with the expertise of our neurological ED has been implemented to reduce the time for the necessary workup and delivery of IV tPA.

PATIENTS AND METHODS

This is a prospective study evaluating door-to-CT and DTN time in patients who have acute stroke arriving as prehospital stroke alerts. In addition, EMS diagnostic accuracy was also studied. All Capital Health Systems paramedics/emergency medical technicians (EMTs) are certified in Advanced Stroke Life Support (ASLS) and the Miami Emergency Neurological Deficit (MEND) examination. Our own staff provides the education and training for paramedics and EMTs, and Capital Health is an ASLS/MEND training site. Based on our PHSA protocol, when EMS identifies a patient with a potential stroke with a duration of symptoms of 6 hours or less, they notify our neurological ED. In the field, as time permits, paramedics will complete the following: accucheck, estimated weight, MEND, obtain IV access, and 12-lead electrocardiogram. In the meantime, the ED will open the stroke-alert packet with patient identifiers and laboratory tubes and enter the computer orders for head CT scan and laboratory tests. The ED also alerts our call center and identifies the case as a PHSA; the call center sends a blast page to the CT tech, designated neurological ED nurse, ED charge nurse, registration, pharmacy, and the neurological ED physician. Once the patient arrives in CT, EMS hands the patient off to the neurological ED team that is waiting in CT to assess the patient. The ED physician awaits the results of the plain head CT to determine whether IV tPA administration is appropriate and has the expertise to administer tPA independently (Figure 1).

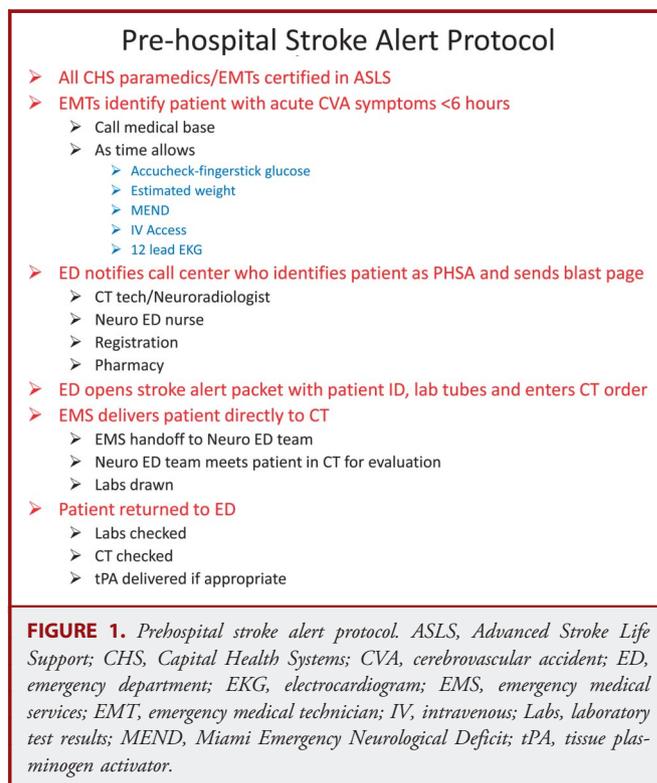
Inclusion criteria for the study included all patients 18 years of age and older identified by EMS as having a possible acute stroke. Patients less than 18 years of age, hemodynamically unstable patients who needed to be assessed first in the ED, and patients not transported by EMS were not eligible for the study.

RESULTS

From July 1, 2012 to July 1, 2013, 170 PHSAs were called to Capital Health Regional Medical Center/Capital Health Hopewell

EDs. Patient age ranged from 20 to 98 years. Eighty-three patients were male and 87 were female. Upon arrival, 29 patients were deemed too unstable to go first to CT, were deemed not to be having a stroke, or were deemed otherwise ineligible for the study. These 29 patients were not included in door-to-CT or DTN time data because they were excluded from the study, but they were included in the analysis of EMS accuracy with stroke diagnosis. The EMS diagnosis of stroke was correct 66% of the time. Stroke was defined as ischemic or hemorrhagic stroke or transient ischemic attack. EMS was correct that the diagnosis was neurological 89% of the time. Nonstroke, neurological diagnoses included seizures (17), encephalitis/encephalopathy (6), complicated migraine (4), subdural hematoma (3), intracranial mass (2), and ulnar neuropathy (1). Nonneurological causes of patients' symptoms included syncope (7), cardiac (7), hypoglycemia (3), labyrinthitis (2), dehydration (2), pneumonia with hypoxia (1), urinary tract infection (1), and inhalation of paint fumes (1).

Between July 2012 and July 2013, a total of 141 patients who were called in as a PHSA bypassed the ED and were worked up as stroke alerts per our protocol. The average time between patient arrival and acquisition of CT imaging was 11.8 minutes. This includes time for assessment by the neurological ED team, blood drawn for laboratory tests, and IV placement when necessary. Our historical mean for door-to-CT time after the neurological ED opened was 35 minutes in 2011, which is a 67% reduction in door-to-CT time from then to now.



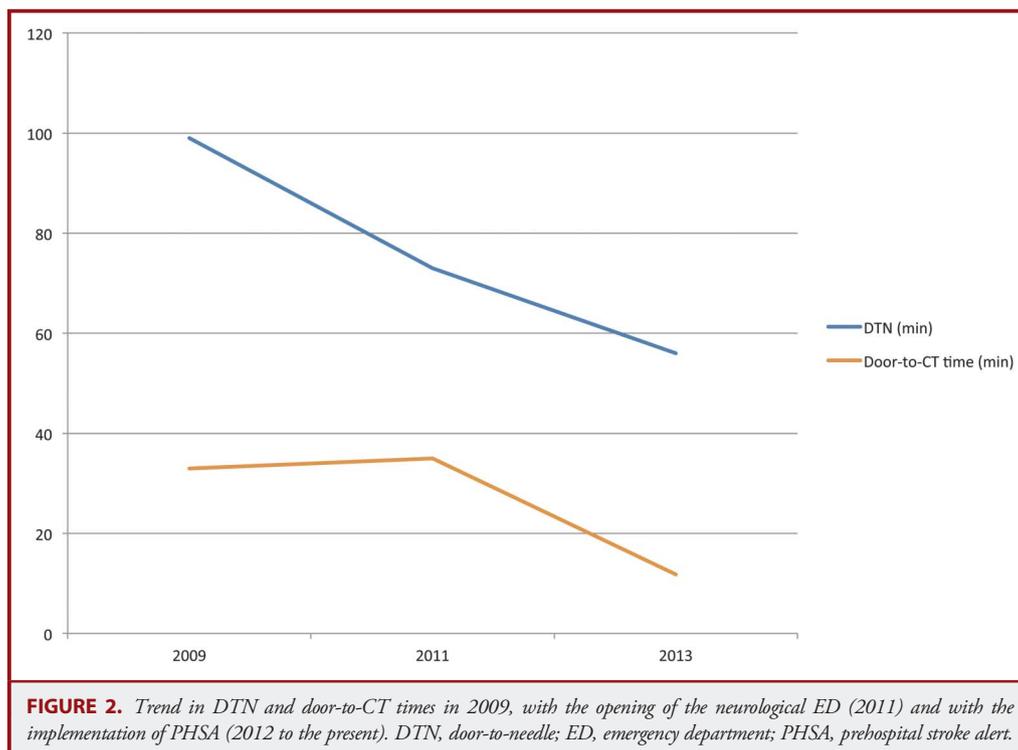
Twenty-six of the 141 patients (18%) received IV tPA, compared with our historical average of 5% for the 3 previous years. The average time from arrival to IV tPA bolus was 56.5 minutes. The median time was 44 minutes. This average is 43% less than our historical DTN time mean of 99 minutes from 2009. The average PHSADTN is also 23% less than our 2011 average DTN time of 73 minutes with the neurological ED alone before the PHS protocol was in effect (Figure 2). The 3 fastest DTN times were 12, 16, and 18 minutes. Data were trended quarterly and door-to-CT and DTN times remained consistent throughout the data collection period.

Three patients had prolonged DTN times of 137 minutes, 127 minutes, and 145 minutes, respectively. These delays were due to patient factors and not system issues. The average DTN time excluding these outliers was 46.1 minutes with a median of 42 minutes. This average is 54% less than our historical DTN time mean of 99 minutes from 2009. The average PHSADTN time without outliers is also 37% less than our 2011 average DTN time of 73 minutes with the neurological ED alone before PHS protocol was in effect.

DISCUSSION

EMS prenotification of the arrival of a patient with a potential stroke is meant to make the ED assessment of the patient more streamlined to minimize the time between arrival and therapeutic intervention. In fact, the American Heart Association/American Stroke Association guidelines recommend prehospital notification by EMS before the arrival of patients with potential strokes.⁷

Although PHSAs are not a new concept, our system is unique. The neurological ED at Capital Health was opened in January 2011 and was the first of its kind in the United States.⁸ The neurological ED is a dedicated area of the general ED staffed by ED physicians who have additional neurological education. The physicians are trained in the assessment of the patient with stroke and are able to administer IV tPA. The neurological ED physicians are the first part of our system that is unique. The historical DTN time at our institution was identified based on previous annual averages. In 2009, the average DTN time was 99 minutes. The average dropped to 73 minutes in 2011 after the initiation of the neurological ED, a 27% reduction. However, the neurological ED was limited by the fact that many patients arrived outside of the tPA window or had to wait to be registered into the hospital system before laboratory tests or CT scans could be performed, because they arrived without prenotification. Therefore, we sought to further reduce our DTN times by the early recognition of stroke in the field by EMS as well as by expediting the assessment of patients with stroke immediately upon arrival. Our staff trained EMS from our county as well as surrounding counties in ASLS in order to adequately identify those patients who may be having a neurological emergency. The diagnosis of stroke (ischemic, hemorrhagic stroke, or transient ischemic attack) by EMS was correct 66% of the time in this study. Eighty-nine percent of the time, the diagnosis was neurological, and all of these were convincing stroke mimics (Table). These data are comparable to other studies in which EMS diagnostic accuracy of stroke was 72%.⁹



Once the PHSA is called, the neurological ED physician and nurse are alerted. EMS is able to bypass the ED and deliver the patient directly to CT where the patient is met by the neurological ED team that already knows the basics about the patient, such as time last seen normal, blood glucose, and blood pressure. Once the patient arrives in CT, the blood for laboratory tests is drawn, and the initial assessment and CT are performed. Our average time from arrival to CT was 11.8 minutes; a 67% reduction from our 2011 mean. As soon as the CT is done, the neurological ED physician is able to administer IV tPA to eligible candidates without requiring further consultation with neurology, again minimizing delays in treatment. With the use of the PHSA protocol as an adjunct to the neurological ED, DTN times continue to decrease. The average PHSA DTN was 23% less than our 2011 means. Although the reduction in door-to-CT time can be attributed to the PHSA protocol, it is the combination of early recognition by EMS and the expertise of the neurological ED that has significantly improved DTN times since 2009.

There were 3 patients with prolonged DTN times not related to system issues, but instead to specific patient factors. The first patient (137 minutes) arrived with severe hypertension. After IV pushes of antihypertensive drugs failed, she was started on an IV antihypertensive drip. Ensuring adequate control of her hypertension caused a delay in her tPA administration. The second patient (127 minutes) had a tPA bolus ready with a possible DTN time of 43 minutes. His neurological examination results then improved, so tPA was held. Later, his neurological examination results worsened again, the family consented, and tPA was then given immediately. The fourth patient (145 minutes) per EMS reportedly had a seizure witnessed by the family. However, once the patient's family arrived, they reported no seizure activity and the patient had not improved neurologically, so tPA was administered. The average DTN time, excluding these outliers, was 46 minutes with a median of 42 minutes. These results are

shown, not because the outliers should not count in the data, but because our system did not fail in these cases. Each patient had unique circumstances that led to delayed DTN time. In the absence of complicated circumstances, which could not be controlled, our PHSA system has dramatically reduced our DTN times even further than would be suggested by the absolute average seen with all comers in the study. However, the outliers bring up another important point. Patients who may not receive tPA at less experienced EDs are managed medically in our neurological ED in order to become candidates for tPA; for example, the patient who arrived with severe hypertension and received tPA after blood pressure control was achieved. We are ensuring that we continue to treat all patients who are still within the tPA window to improve their chances of becoming tPA candidates. If a patient's symptoms rapidly improve, then return, our neurological ED physicians have the experience to still consider tPA if the patient becomes a candidate. These outliers are patients who may not be thought of as possible candidates or treated in order to become candidates once they are initially found to be ineligible for tPA upon arrival at other institutions.

In addition to having an impact on metrics, such as DTN and door-to-CT time, the neurological ED and PHSA seem to have impacted the total number of total stroke alerts seen by both campuses. Although one of our campuses is The Joint Commission primary stroke center designated and the other has The Joint Commission comprehensive designation, we offer parallel comprehensive services at both hospitals. EMS knows this and thus delivers patients to the closest campus. However, since the inception of the neurological ED and PHSA, EMS has continued to bypass other community hospitals in favor of our stroke centers. This is evidenced by the fact that the total number of ED stroke alerts in 2009 was 391, compared with 683 in 2011 after significant education of both EMS crews and the community regarding our neurological ED and comprehensive services. Since the addition of the PHSA protocol, the total number of stroke alerts (including PHSA) for both campuses has further increased to 895 in 2012 and is on target for over 1000 patients in 2013.

TABLE. EMS Nonstroke Diagnoses^a

Neurological Diagnosis	No. of Patients	Nonneurological Diagnosis	No. of Patients
Seizure	17	Syncope	7
Encephalitis/encephalopathy	6	Cardiac	7
Complicated migraine	4	Hypoglycemia	3
Subdural hematoma	3	Labyrinthitis	2
Intracranial mass	2	Dehydration	2
Ulnar neuropathy	1	Pneumonia with hypoxia	1
		Urinary tract infection unmasking old symptoms	1
		Inhalation of paint fumes	1

^aEMS, emergency medical services.

CONCLUSION

Specific training allows EMS to correctly identify patients who are experiencing neurological/neurosurgical emergencies. EMS training in addition to the PHSA system is effective in delivering patients to our comprehensive stroke center in a timely fashion. The prehospital stroke alert protocol bypasses the ED, allowing the patient to be met in CT by the neurological ED team. The PHSA protocol has been shown to decrease door-to-CT and DTN times from our historical means. Both of these indices suggest that we are triaging and treating patients with acute neurological and neurosurgical emergencies more quickly. In the future, we will be evaluating door-to-recanalization times in patients who undergo mechanical thrombectomy, as well as comparing outcomes in the patients who came as part of our PHSA protocol with historical means.

Disclosures

Dr Veznedaroglu is a consultant for CODDIS, Codman, Micrus, Microvention, and Stryker; Dr Liebman is a consultant for Stryker. The other authors have no personal, financial, or institutional interest in any of the drugs, materials, or devices described in this article.

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COMMENTS

Stroke is a leading cause of disability and death worldwide. It is well established in the literature that intravenous tissue-type plasminogen activator (IV tPA) is effective in improving neurological outcomes of ischemic stroke,^{1,2} and the time window for treatment has been expanded to 4.5 hours from the onset of symptoms.^{4,5} Nevertheless, national penetration of IV tPA therapy remains a dismal 5% or less³ despite the passage of 18 years since the publication of the results of the landmark National Institute of Neurological Disorders and Stroke trial.¹ Moreover, earlier administration of IV tPA is crucial: approximately 2 million neurons could be lost for every minute of no reperfusion, and the benefit of tPA is halved for every 90 minutes of delay for treatment.⁶ Thus, debate continues within the stroke community nationwide as to how to ensure better and faster delivery of an effective therapy. This article offers a potential solution to the national problem. The authors described the impact of having Emergency Medical Services (EMS) personnel prenotify emergency department physicians about potential stroke patients on the door-to-needle time target for IV tPA administration. EMS prenotification reduced door-to-CT time by 67% (35-11.8 min) and door-to-needle time by 43%

(99-56.5 min). The implementation of a prehospital stroke alert (PHSA) protocol also elevated the rate of IV tPA administration from the historical average of 5% to 18%, which is highly impressive. Moreover, EMS made a correct neurological diagnosis most of the time (66%), and the authors provided a detailed analysis and breakdown based on the original assumption by EMS to be stroke related. These results collectively argue for a specialized triage system for patients who have acute stroke that can be initiated by EMS in the field and bypass the emergency department unless additional hemodynamic or respiratory concerns need to be addressed emergently. Ischemic stroke is increasingly managed by endovascular-trained neurosurgeons alongside emergency department physicians and stroke neurologists. Further, there is a real push toward the creation of Comprehensive Stroke Centers. This well-described protocol may serve as a useful template as more regional centers consider optimization of acute stroke patient-specific triage protocols in their own systems.

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The authors should be congratulated on leading the charge for high-quality advanced stroke care from the moment the patient arrives to the ED. The authors' efforts demonstrate that a neuro-specific ED not only can work, but can be very successful. The era of nihilism following acute ischemic stroke is past. Patient care must occur in a rapid systematic process, along the model that trauma established over 2 decades ago. The authors are clearly on the forefront of the evolving paradigm of stroke care. It is of tremendous value to neurosurgery as a field, and to stroke patients themselves, that neurosurgery plays a vital and integral role in this evolution. The authors, and other centers like theirs, are providing a significant service by working to develop novel stroke management pathways.

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