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Stroke 2009;40;3841-3844; originally published online Oct 29, 2009;

DOI: 10.1161/STROKEAHA.108.540377

Stroke is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75214
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ISSN: 1524-4628

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A Citywide Prehospital Protocol Increases Access to Stroke Thrombolysis in Toronto

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Background and Purpose—Intravenous tissue plasminogen activator for ischemic stroke is approved for eligible patients who can be treated within a 3-hour window, but treatment rates remain disappointingly low, often <5%. To improve rapid access to stroke thrombolysis in Toronto, Canada, a citywide prehospital acute stroke activation protocol was implemented by the provincial government to transport acute stroke patients directly to one of 3 regional stroke centers, bypassing local hospitals. This comprised a paramedic screening tool, ambulance destination decision rule, and formal memorandum of understanding of system stakeholders. This report describes the initial impact of the activation protocol at our regional stroke center.

Methods—We compared consecutive patients with stroke arriving to our stroke center during the first 4 months of this new triage protocol (February 14 to June 14, 2005) versus the same 4-month period in 2004.

Results—The protocol resulted in an immediate doubling in the number of patients with acute stroke arriving to our regional stroke center within 2.5 hours of symptom onset. We observed a 4-fold increase in patients who were eligible for and treated with tissue plasminogen activator. The tissue plasminogen activator treatment rate for ischemic stroke patients increased from 9.5% to 23.4% ($P=0.01$), and one in 2 patients with ischemic stroke arriving within 2.5 hours received thrombolysis during this period (one in 5 of patients with ischemic stroke overall). The median onset-to-needle time for tissue plasminogen activator-treated patients was significantly reduced. Many implementation challenges were identified and addressed.

Conclusions—This prehospital triage was immediately successful in improving tissue plasminogen activator access for patients with ischemic stroke, enabling our center to achieve one of the highest tissue plasminogen activator treatment rates in North America and underscoring the need for coordinated systems of acute stroke care. Sustainability of such an initiative will be dependent on interdisciplinary teamwork, ongoing paramedic training, adequate hospital staffing, bed availability, and repatriation agreements with community hospitals. (*Stroke*. 2009;40:3841-3844.)

Key Words: ambulance ■ prehospital ■ stroke ■ thrombolysis

Stroke is a medical emergency in which “time is brain.”¹ Intravenous tissue plasminogen activator (tPA) administered to eligible patients with stroke can rescue ischemic brain tissue and improve outcomes, but its effects are highly time-sensitive.^{2,3} Untreated, nearly 2 million brain neurons die every minute during an evolving acute ischemic stroke.¹

Despite more than a decade of knowledge about the effectiveness of stroke thrombolysis, many patients with acute stroke still do not receive tPA because of a lack of rapid access to centers that provide this treatment. It has been estimated that tPA only reaches approximately <2% of patients with stroke on a national level.⁴ In Ontario, Canada, the percentage of patients with ischemic stroke treated with tPA at regional stroke centers increased from 10.1% in 2003 to 14.5% in 2005, coinciding with a provincial reorganization

of stroke services.⁵ Guidelines emphasize the necessity of systemwide changes with regionalization of services to improve access to tPA,^{6–9} and this approach has been successful in several jurisdictions.^{10–15}

To improve access to stroke thrombolysis in Toronto, a citywide activation of an emergency medical services prehospital redirect protocol was launched on February 14, 2005, as part of a provincial government commitment to building an organized stroke system in Ontario. The aim was to provide rapid identification and transport of appropriate patients with acute stroke directly to one of 3 designated regional stroke centers (bypassing the nearest hospitals) for emergency consultation by a 24/7 on-call stroke team. The purpose of this study was to evaluate the initial experience of this protocol at our center. This report provides a descriptive analysis of the

Received October 18, 2008; final revision received January 11, 2009; accepted January 19, 2009.

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Stroke is available at <http://stroke.ahajournals.org>

DOI: 10.1161/STROKEAHA.108.540377

Table. Comparison of Patients With Stroke Arriving to a Regional Stroke Center in Toronto Before and After Implementation of a Citywide Prehospital Stroke Protocol

	Before Protocol (February 14 to June 14, 2004)	After Protocol (February 14 to June 14, 2005)	<i>P</i> Value
Total no. of patients with suspected stroke arriving to the ED	217	290	
No. (%) of patients with suspected stroke arriving to the ED <2.5 hours	66/217 (30.4%)	141/290 (48.6%)	0.0001
Most common diagnoses for patients arriving <2.5 hours			0.03
Ischemic stroke	26 (39.4%)	63 (44.7%)	
Transient ischemic attack	9 (13.6%)	24 (17%)	
Intracerebral hemorrhage	4 (6.1%)	22 (15.6%)	
Stroke mimic	22 (33.3%)	29 (20.6%)	
Total no. of patients with ischemic stroke arriving to the ED	74	128	
No. (%) of patients with ischemic stroke arriving to the ED <2.5 hours	26/74 (35.1%)	63/128 (49.2%)	0.05
No. (%) of patients with ischemic stroke who received tPA	7/74 (9.5%)	30/128 (23.4%)	0.01
No. (%) of patients with ischemic stroke arriving <2.5 hours who received tPA	5/26 (19.2%)	30/63 (47.6%)	0.01
Median stroke onset-to-needle time for tPA-treated patients, minutes	195	141	0.003
Median stroke onset-to-ED arrival time for tPA-treated patients, minutes (IQR)	46 (7)	63 (30)	0.83
Median ED arrival-to-needle time for tPA-treated patients, minutes (IQR)	128 (7)	83 (30)	0.007

IQR indicates interquartile range.

impact on patient care, operational challenges, and lessons learned.

Methods

We prospectively documented all consecutive patients with suspected stroke who presented to the emergency department (ED) at Sunnybrook Health Sciences Centre, one of 3 designated regional stroke centers in Toronto, Ontario, Canada. Data were collected through chart abstraction by a trained stroke nurse using the methodology of the Registry of the Canadian Stroke Network, which received approval from the institutional research ethics board.⁵

Stroke admission rates, arrival times, and tPA use were assessed during the first 4 months of the prehospital triage protocol (February 14 to June 14, 2005) and compared with the same 4-month time period 1 year before protocol implementation (February 14 to June 14, 2004). The 2 cohorts were compared using χ^2 statistics for categorical variables and the Kruskal-Wallis test for continuous variables.

Prehospital identification of patients with acute stroke for transport to a regional stroke center under the new triage protocol was guided by a standardized paramedic prompt card, which had not been in effect previously. Inclusion criteria were a new onset of at least one of: (1) unilateral arm/leg weakness or drift; (2) facial droop; or (3) slurred or inappropriate words or mute; and ability to be transported within 2 hours of onset. Exclusions were: Canadian Triage and Acuity Scale Level 1 (ie, resuscitation) or uncorrected airway, breathing or significant circulatory problem, symptoms of the stroke have resolved, blood sugar ≤ 4 mmol/L, seizure at onset or witnessed by paramedic, Glasgow Coma Scale < 10 , and/or the patient is terminally ill or palliative. Toronto emergency medical services dispatch software was revised to include a new diagnostic algorithm for acute stroke.

A 24/7 hospital on-call stroke team had been in place long before the protocol was launched. Coinciding with the prehospital protocol implementation, paramedic prenotification of the ED was initiated enabling the hospital stroke team to be mobilized before patient arrival, an internal "code stroke" hospital paging system was established, and patients arriving through the emergency medical services stroke protocol began to be referred directly to the stroke team (bypassing the ED physician assessment in most cases). We used a multimodality CT protocol for acute stroke imaging (noncontrast head CT, CT angiography, CT perfusion scan). Participating hospitals in our region signed a memorandum of understanding about the protocol, which included a repatriation agreement specifying timelines for patient transfers (within 48 hours for admitted patients and 24 hours for nonadmitted patients). A television advertising campaign on the warning signs of stroke by the Heart and Stroke Foundation of Ontario was in effect during both time periods (before and after the prehospital protocol was launched).¹⁶

Results

The prehospital triage initiative resulted in an immediate doubling in the number of patients with acute stroke transported to our regional stroke center within 2.5 hours of symptom onset (Table). The percentage of all patients with stroke arriving <2.5 hours increased from 30% to 49%. There was a 4-fold increase in the absolute number of patients who were treated with tPA after implementation of the protocol, corresponding to a significant increase in the proportion of patients with ischemic stroke receiving tPA, one in 2 patients with ischemic stroke arriving <2.5 hours (or one in 5 of all patients with ischemic stroke). Furthermore,

there was a significant reduction in the onset-to-needle time for tPA-treated patients (Table). Intra-arterial thrombolysis was administered to one patient during the preprotocol phase and one patient in the postprotocol phase; the remainder received intravenous tPA alone. Patients transported from outside the hospital catchment area were repatriated to one of 10 community hospitals in our region. Median hospital length of stay for patients arriving <2.5 hours decreased from 5 days before the protocol to 4 days afterward ($P=0.44$).

Among the 30 tPA-treated patients, stroke severity improved as measured by a reduction in the median National Institutes of Health Stroke Scale score from 16 at baseline to 12 at 24 hours; 28% of survivors were functionally independent at hospital discharge (modified Rankin scale score ≤ 2), and 24% recovered neurologically by 24 hours (National Institutes of Health Stroke Scale score 0 or 1). Symptomatic intracranial hemorrhage occurred in 3 patients who had very severe strokes at baseline (mean National Institutes of Health Stroke Scale score 21; mean age 78 years) and 2 of these patients died (one with uncontrolled pretreatment hypertension). There was one serious systemic hemorrhage and one case of transient orolingual angioedema in a patient taking an angiotensin-converting enzyme inhibitor.

Discussion

This citywide prehospital activation protocol for acute stroke was immediately successful in its primary objective of improving tPA access for eligible patients with stroke, enabling our stroke center to achieve one of the highest tPA treatment rates in North America and underscoring the need for coordinated systems of acute stroke care. Door-to-needle times for tPA were reduced significantly and one in 5 tPA-treated patients achieved a full neurological recovery at 24 hours. The intracerebral hemorrhage rate likely reflects our population of older patients who had more severe strokes than those in clinical trials of tPA. The triage protocol also facilitated rapid specialist consultation, advanced diagnostic neuroimaging, and treatment for patients with neurovascular emergencies other than acute ischemic stroke (ie, transient ischemic attack and intracerebral hemorrhage), which may become increasingly important in the future as new time-sensitive treatments are developed for these conditions.

Our findings confirm other reports demonstrating the benefits of prehospital and hospital protocols for acute stroke.⁷⁻¹⁵ We suspect that the increased proportion of patients arriving <2.5 hours resulted from a combination of more patients being transported to our center (rather than to a community hospital) plus patients being identified and transported faster by paramedics, although we cannot determine the relative contributions of these factors from the available data. For the tPA-treated patients, onset-to-arrival times were actually longer after implementation of the protocol, probably reflecting the transport of more patients from farther distances. Despite this, the average door-to-needle time for tPA decreased significantly, implying more rapid response from the dedicated hospital on-call stroke team that received prenotification from paramedics before patient arrival and assessed patients immediately on arrival without awaiting ED physician assessment.

The sudden and unprecedented increase in stroke volumes resulting from this activation protocol presented new challenges for hospital staff and resources. Despite many months of planning and education involving key stakeholders, government implementation of the activation protocol came at a time when the monthly hospital bed capacity on the medical wards was already $\geq 120\%$ and paramedic training on the new protocol was incomplete. Bed shortages created increased pressure to repatriate patients quickly, and many hours of staff time became consumed with coordinating interhospital transfers. Determining when patients were medically and neurologically stable for transfer was sometimes challenging, and the mandate to repatriate patients was met with resistance by some families. The fact that some patients were repatriated to hospitals without a geographic stroke unit raised concerns that protocols aiming to improve hyperacute stroke care could potentially disadvantage postacute care and rehabilitation. A small group of neurologists at our center provided 24/7 urgent consultation for all suspected patients with acute stroke (including the stroke mimics) transported under the ambulance protocol. The increased on-call workload led to exhaustion of the front-line clinicians. One in 5 patients presenting within 2.5 hours of a suspected acute stroke was later found to have a stroke mimic condition, most commonly seizure. The initiative led to a much higher volume of patients with acute stroke transported to our center compared with the 2 other stroke centers in Toronto that share the downtown core, given that Sunnybrook is located at the geographic center of the city. With a population of >5.1 million in the Greater Toronto Area and 18 acute care hospitals, the regional geography and hospital system in Toronto presents unique challenges for the delivery of tPA and establishment of coordinated systems of stroke care.

To overcome such obstacles, efforts were initiated to improve the system activation and ensure sustainability of this worthy initiative. First, more complete paramedic training has now taken place to encourage greater adherence to the stroke screening criteria and protocol and minimize false-positive triages. Second, the geographic ambulance transport boundaries for medical redirect to the 3 regional stroke centers were revised by Toronto Emergency Medical Services for a more appropriate distribution of patients to each of the 3 centers based on city traffic patterns and regional center volumes. The modified geographic boundaries have now been adopted under local dispatch center software developments for standardized application and variance monitoring. Third, a study to evaluate the validity of the paramedic stroke screening tool is in progress. We speculate that isolated facial palsy will not be useful as a sole criterion for triage of patients to a regional stroke center; whereas this sign may reliably identify patients with stroke, its ability to select patients who are tPA candidates deserves further investigation. Fourth, a new component of the protocol has been implemented by which paramedics are expected to patch through to an emergency room physician at our center for validation of the stroke screening criteria before instituting the bypass protocol. This procedure aims to minimize inappropriate patient transports to regional stroke centers, and a study to evaluate this hypothesis is underway. Fifth, local and interhospital

operational processes were implemented to educate staff about repatriation agreements and to streamline repatriation procedures. Finally, additional staffing was facilitated by the recruitment of stroke fellows and establishment of a hospitalist training program that participated in the care of stroke inpatients. Another approach for improving tPA access involves telemedicine; our center currently participates in a provincial telestroke program that provides consultation to several distant hospitals that are too far for ambulance transfer.¹⁷

In conclusion, this report highlights the initial success of a prehospital stroke protocol and the strategies underway to overcome several implementation challenges. Hopefully, our experience will assist other regions in developing similar protocols to optimize the emergency management of patients with acute stroke.

Acknowledgments

We gratefully acknowledge the Ontario Stroke System of the Ontario Ministry of Health and Long-Term Care, the Toronto Regional Stroke Centres, the Heart and Stroke Foundation of Ontario, Toronto Emergency Medical Services, Sunnybrook Osler Centre for Prehospital Care, the Institute for Clinical Evaluative Sciences, and the Registry of the Canadian Stroke Network.

Sources of Funding

D.J.G. is supported by the Heart and Stroke Foundation of Ontario, the Heart and Stroke Foundation Centre for Stroke Recovery, and the Department of Medicine (Sunnybrook Health Sciences Centre and University of Toronto).

Disclosures

None.

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