Use of Strategies to Improve Door-to-Needle Times With Tissue-Type Plasminogen Activator in Acute Ischemic Stroke in Clinical Practice

Findings from Target: Stroke

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Background—The implementation of Target: Stroke Phase I, the first stage of the American Heart Association's national quality improvement initiative to accelerate door-to-needle (DTN) times, was associated with an average 15-minute reduction in DTN times. Target: Stroke phase II was launched in April 2014 with a goal of promoting further reduction in treatment times for tissue-type plasminogen activator (tPA) administration.

Methods and Results—We conducted a second survey of Get With The Guidelines-Stroke hospitals regarding strategies used to reduce delays after Target: Stroke and quantify their association with DTN times. A total of 16 901 ischemic stroke patients were treated with intravenous tPA within 4.5 hours of symptom onset from 888 surveyed hospitals between June 2014 and April 2015. The patient-level median DTN time was 56 minutes (interquartile range, 42–75), with 59.3% of patients receiving intravenous tPA within 60 minutes and 30.4% within 45 minutes after hospital arrival. Most hospitals reported routinely using a majority of Target: Stroke key practice strategies, although direct transport of patients to computed tomographic/magenetic resonance imaging scanner, premix of tPA ahead of time, initiation of tPA in brain imaging suite, and prompt data feedback to emergency medical services providers were used less frequently. Overall, we identified 16 strategies associated with significant reductions in DTN times. Combined, a total of 20 minutes (95% confidence intervals 15–25 minutes) could be saved if all strategies were implemented.

Conclusions—Get With The Guidelines-Stroke hospitals have initiated a majority of Target: Stroke–recommended strategies to reduce DTN times in acute ischemic stroke. Nevertheless, certain strategies were infrequently practiced and represent a potential immediate target for further improvements. **(*Circ Cardiovasc Qual Outcomes*. 2017;10:e003227. DOI: 10.1161/CIRCOUTCOMES.116.003227.)**

Key Words: plasminogen activator ■ quality improvement ■ stroke ■ surveys ■ tissue

Intravenous tissue-type plasminogen activator (IV tPA) remains the only medical therapy to improve outcomes for acute ischemic stroke.[1–3] Results from major clinical trials and observational studies confirm a strong influence of time to treatment on outcomes, such that the therapeutic benefit is maximal when given early, and there is no significant benefit beyond 4.5 hours.[4–8] Therefore, hospitals are seeking ways to reduce in-hospital treatment delays, which is defined as the time between patient arrival at the hospital and IV tPA initiation, or door-to-needle (DTN) times. The American Heart Association/American Stroke Association (AHA/ASA) Target: Stroke initiative was launched in January 2010 to assist hospitals in improving stroke care and providing IV tPA to eligible patients in a timely fashion.[9] The Target: Stroke disseminated 10 care strategies to reduce treatment delays in tPA administration. Our previous studies demonstrated substantial hospital variations in use of these strategies before Target: Stroke and significant improvement in terms of timeliness of

See Editorial by Prabhakaran and Mendelson

Received June 2, 2016; accepted November 11, 2016.

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The Data Supplement is available at http://circoutcomes.ahajournals.org/lookup/suppl/doi:10.1161/CIRCOUTCOMES.116.003227/-/DC1.

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WHAT IS KNOWN

- The benefits of intravenous tissue-type plasminogen activator (tPA) in acute ischemic stroke are highly time dependent.
- The American Heart Association launched the Target: Stroke phase II in April 2014 to further promote reduction in treatment times for tPA administration.

WHAT THE STUDY ADDS

- Overall, this study identified 16 strategies associated with significant reductions in door-to-needle times. Combined, a total of 20 minutes could be saved if all strategies were implemented.
- Although the majority of key Target: Stroke strategies have been implemented by Get With The Guidelines-Stroke–participating hospitals to improve the timeliness of tPA administration, certain strategies such as direct transport to computed tomographic/magenetic resonance imaging scanner by emergency medical services, premix of tPA ahead of time, protocol for routine premixing of tPA, and initiation of tPA in the brain imaging suite were applied relatively infrequently and represent a potential immediate target for further improvements.

tPA administration and clinical outcomes after the implementation of Target: Stroke quality initiative.[10,11]

With the success of the first stage of Target: Stroke, the AHA/ASA launched Target: Stroke phase II in April 2014 to continue improving DTN times by challenging hospitals to provide IV tPA in patients with acute ischemic stroke in an even more timely fashion. The Target: Stroke phase II identified new strategies for more rapid in-hospital management of patients receiving tPA. However, the extent to which hospitals are using these strategies after the Target: Stroke intervention has not been well studied. Although we demonstrated in our previous study that some strategies are more strongly associated with shorter DTN times than others, reductions in treatment delays can rarely be achieved by a single strategy but rather result from multiple concurrent interventions. Therefore, we conducted a second national survey of hospitals participating in the Target: Stroke program.

The goals were to assess use of hospital strategies to reduce DTN times after Target: Stroke and quantify the association of these hospital strategies with DTN times. Importantly, we sought to determine the incremental effect size of implementing multiple interventions, which represents opportunities to reduce all possible delays in treatment.

Methods

Target: Stroke Phase II

Target: Stroke is a national quality improvement initiative developed by the AHA/ASA in January 2010 (Figure 1).[9] The initial goal of Target: Stroke for participating hospitals was to achieve DTN times within 60 minutes in at least 50% of ischemic stroke patients treated with IV tPA. To achieve these goals, Target: Stroke provided participating hospitals with best practice strategies, supporting tools, and educational resources necessary to improve the timeliness of administration of IV tPA to eligible patients with acute ischemic stroke. An expert working group performed a systematic review of the published data on improving DTN times and identified 10 best practice strategies that could be rapidly, feasibly, and cost effectively adopted by participating hospitals. These initial strategies included advance hospital notification by emergency medical services (EMS), rapid triage protocol and stroke team notification, single-call activation system, specific stroke protocols and tools, rapid acquisition and interpretation of brain imaging, rapid laboratory testing, rapid access to tPA, premixing tPA ahead of time, a team-based approach, and providing prompt feedback to the stroke team on performance. Three years after the implementation of Target: Stroke, the median DTN times decreased from 74 minutes during the fourth quarter of 2009 to 59 minutes by the third quarter of 2013, and the percentage of patients with DTN times within 60 minutes increased from 30% to 53%.[11]

To further improve care and reduce treatment delays, the AHA/ASA launched the Target: Stroke phase II in April 2014 and invited all Get With The Guidelines-Stroke (GWTG-Stroke) hospitals to participate (Figure 1). The primary goal of Target: Stroke phase II is for hospitals to achieve DTN times within 60 minutes in at least 75% of patients treated with IV tPA and DTN times within 45 minutes in at least 50% of patients. Target: Stroke phase II identified and disseminated additional best practice strategy of direct EMS transfer of patients to computed tomographic/magenetic resonance imaging (CT/MRI) scanner for initial neurological examination and brain imaging to determine tPA eligibility, along with an updated comprehensive implementation manual; clinical decision support tools; and benchmarked performance feedback.

As part of the Target: Stroke phase II enrollment process, representatives from GWTG-Stroke hospitals were invited to complete an online survey regarding their practice for tPA administration in the 6 months preceding the survey (Figure 1). The survey questions were developed based on literature review and expert consensus to query hospitals on DTN time practices and further refined after pilot testing. These included 11 key best practice strategies and additional hospital practices that are potentially related to the timeliness of tPA administration. The survey was structured regarding use of specific strategies as a continuous 0 to 100% of the time scale or a binary yes/no. The online survey was open to all GWTG-Stroke hospitals in December 2014 and was complete in April 2015.

Statistical Analysis

Using the survey data, we conducted a cross-sectional study of GWTG-Stroke hospitals and assessed their use of specific strategies for reducing DTN time within 6 months preceding the completion of the survey. For descriptive purposes, we reported a hospital's responses for each strategy and DTN times among patients treated with IV tPA within 4.5 hours in that hospital between June 2014 and April 2015 (Figure 1). Individual patient-level data were obtained from the AHA/ASA GWTG-Stroke Registry. The design and conduct of the GWTG-Stroke Registry and the validity and reliability of data collection have been previously reported.[12,13]

Multivariable linear regression models were performed to investigate the relationships between each strategy and DTN times at the patient level, adjusting for baseline demographic and clinical characteristics. These variables included age, sex, race/ethnicity, medical history (atrial fibrillation, prosthetic heart valve, stroke or transient ischemic attack, coronary artery disease or myocardial infarction, carotid stenosis, diabetes mellitus, peripheral vascular disease, hypertension, smoking status, dyslipidemia, and heart failure), arrival mode, on-hour presentation (presenting to the emergency department [ED] between 7.00 AM and 6.00 PM on any weekday), onset-to-door times, and National Institutes of Health Stroke Scale score. Because higher tPA volume has been shown to be associated with shorter DTN times,[14] a sensitivity analysis was performed by adding annual tPA volume in the model.

The effect of each individual strategy on DTN times was calculated as the adjusted mean difference between the DTN times of

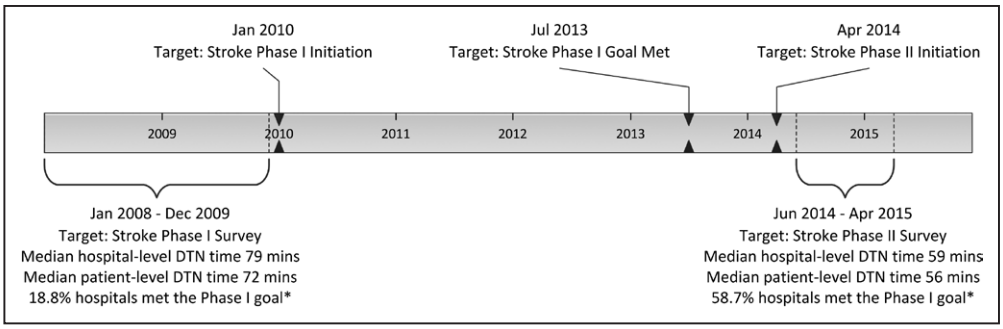

Figure 1. Target: Stroke timeline. *Phase I goal: Door-to-needle (DTN) times within 60 min in at least 50% of ischemic stroke patients treated with intravenous tissue-type plasminogen activator.

patients treated at hospitals implementing the selected strategy and hospitals not implementing the strategy (yes versus no for binary response or per 20% increase of the time for continuous response). The significant strategies were then analyzed together to evaluate the incremental effect of implementing additional strategies and identify potential opportunities to reduce possible delays by adopting all best practices. All these analyses accounted for within-hospital clustering effect using generalized estimating equations with exchangeable correlation structure.

All statistical analyses were performed using SAS version 9.4 (SAS Institute, Inc). Outcome, a Quintiles Company, is the data collection co-ordination center for the AHA/ASA Get With The Guidelines program. The Duke Clinical Research Institute served as the data analysis center, and institutional review board approval was granted to analyze aggregate deidentified data for research purposes.

Results

Of 1701 GWTG-Stroke hospitals, 1034 hospitals (61% response rate) completed the survey by April 2015. We excluded 127 hospitals that responded to the survey as they did not administer tPA during the study period. Because DTN times were calculated as the difference between patient arrival time and time of tPA initiation, we further excluded 19 hospitals with missing treatment timelines, treatments beyond the 4.5-hour window, tPA given to inpatient with stroke, or transferred in patients. After these exclusions, our analyses included 888 hospitals treating 16901 ischemic stroke patients with IV tPA within 4.5 hours of symptom onset between June 2014 and April 2015. The characteristics of hospitals completing the Target: Stroke phase II survey versus not are shown in Table 1. Compared with nonparticipating hospitals, hospitals completing the survey were more frequently larger, primary stroke centers, with higher ischemic stroke volume, shorter DTN times, and more experience with tPA administration. The hospital-level median DTN time was 59 minutes (interquartile range, [IQR], 51–71), and 58.7% (521/888) of hospitals achieved DTN times within 60 minutes for at least 50% patients. In comparison, in a previous survey between January 2008 and December 2009 before Target: Stroke phase I, the median hospital-level DTN time was 79 minutes (IQR, 71–89), and only 18.8% hospitals met the goal of DTN time of ≤60 minutes in at least 50% of treated patients (Figure 1).[10]

Figure 2 shows the distribution of DTN times of 16901 patients treated with IV tPA. Compared with the DTN times in the previous survey before Target: Stroke,[10] the patient-level median DTN time decreased from 72 minutes (IQR, 55–94) to 56 minutes (IQR, 42–75) in Target: Stroke Phase II. The percentage of patients with DTN time of ≤60 minutes increased from 33.9% (1849/5460) before Target: Stroke to 59.3% (10020/16901) during Target: Stroke phase II. More than 30.4% patients (5142/16901) had DTN time ≤45 minutes.

According to the Target: Stroke phase II survey, most hospitals reported routinely using a majority of key strategies (>90%, Figure 3), with the exception of EMS transport of patients directly to CT/MRI scanner (median, 40%; IQR, 0–95), premix of tPA ahead of time (median, 25%, IQR, 0–90), initiation of tPA in the brain imaging suite (median, 0%; IQR, 0–5), and prompt data feedback to EMS providers (median, 60%; IQR, 15–95). The reported use of other non-key strategies varied substantially across hospitals. Strategies including a timer or clock attached to a chart, clip board, or patient's bed to track time (median, 0%, IQR, 0–5) and placing a CT/MRI scanner physically in the ED (46.4%) were less frequently used.

Table 1. Characteristics of the GWTG-Stroke Hospitals Participating in Target: Stroke Phase II Survey and Nonparticipating Hospitals

Characteristic	Participating Hospitals (n=888), %	Nonparticipating Hospitals (n=431), %
No. of beds, median (IQR)	308 (201–446)	264 (183–373)
Annual ischemic stroke volume, median (IQR)	174 (116–258)	127 (84–197)
Annual tPA volume, median (IQR)	14 (9–24)	9 (6–15)
Teaching hospital	432 (51.7)	181 (48.9)
Primary stroke center	360 (40.5)	112 (26.0)
Comprehensive stroke center	65 (7.3)	9 (2.1)
Geographic region		
West	230 (25.9)	50 (11.6)
South	331 (37.3)	134 (31.1)
Midwest	132 (14.9)	130 (30.2)
Northeast	194 (21.9)	117 (27.1)
Rural hospital	52 (5.9)	42 (9.8)
Median door-to-needle time (IQR), min	59 (51–71)	72 (60–87)

GWTG indicates Get With The Guidelines; IQR, interquartile range; and tPA, tissue-type plasminogen activator.

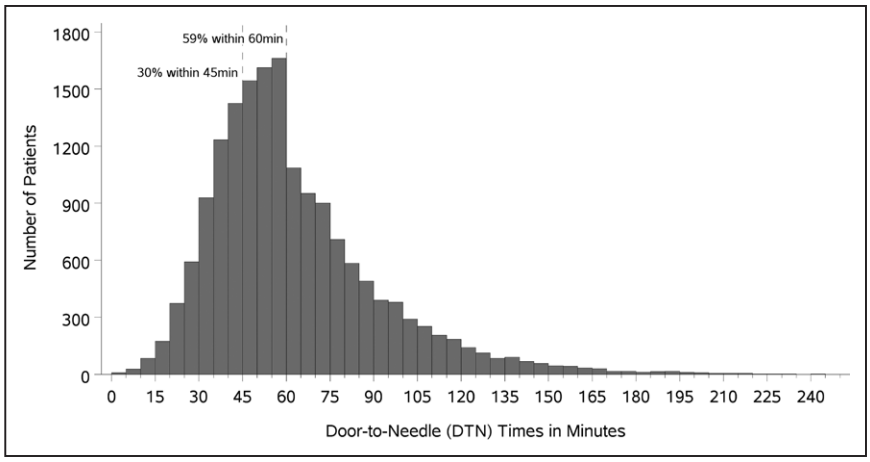

Figure 2. Distribution of door-to-needle (DTN) time among 16 901 patients receiving intravenous tissue-type plasminogen activator within 4.5 h of symptom onset from 888 Target: Stroke phase II Hospitals.

Multivariable models identified 16 strategies that were associated with a significant reduction in DTN times (Table 2). These practices included use of EMS prehospital stroke screening tool (adjusted mean reduction in DTN time; 0.9 minute per 20% increase), rapid triage protocol and stroke team notification (2.5 minutes per 20% increase), single-call activation system (1.1 minutes per 20% increase), a timer or clock to track time (0.6 minute per 20% increase), EMS direct transport of patient to the CT/MRI scanner (0.7 minute per 20% increase), written informed consent not required before tPA administration (0.8 minute per 20% increase), international normalized ratio and platelet count not required (1.2 minutes per 20% increase), immediate interpretation of brain imaging by stroke team members (1.6 minutes per 20% increase), treatment decision made by neurologist attending or trainee after in-person evaluation (1.2 minutes per 20% increase), trainees (resident, fellows) involved in stroke team (1.1 minutes per 20% increase), premix of tPA ahead of time (1.1 minutes per 20% increase), initiation of tPA while patients are still in the brain imaging suite (3.4 minutes per 20% increase), prompt data feedback to the ED staff and stroke team (1.6 minutes per 20% increase), prompt data feedback to EMS providers (1.0 minute per 20% increase), CT/MRT scanner physically located in the ED (2.1 minutes, yes versus no), and protocol for routine premixing tPA (2.6 minutes, yes versus no). The sensitivity analyses including annual tPA volume found similar results, with few exceptions (Table I in the Data Supplement)

When all 16 significant DTN strategies were analyzed incrementally, hospitals adopting a greater number of strategies tended to have shorter DTN times. On average, 1.3 minutes (95% confidence interval, 1.0–1.6) could be saved for each strategy implemented or a total of 20 minutes (95% confidence interval, 15–25 minutes) if all strategies were used.

Discussion

In this national survey of 888 GWTG-Stroke hospitals participating in Target: Stroke phase II, hospitals reported moderate-to-extensive use of most Target: Stroke key strategies to evaluate acute stroke cases for tPA eligibility and reduce DTN

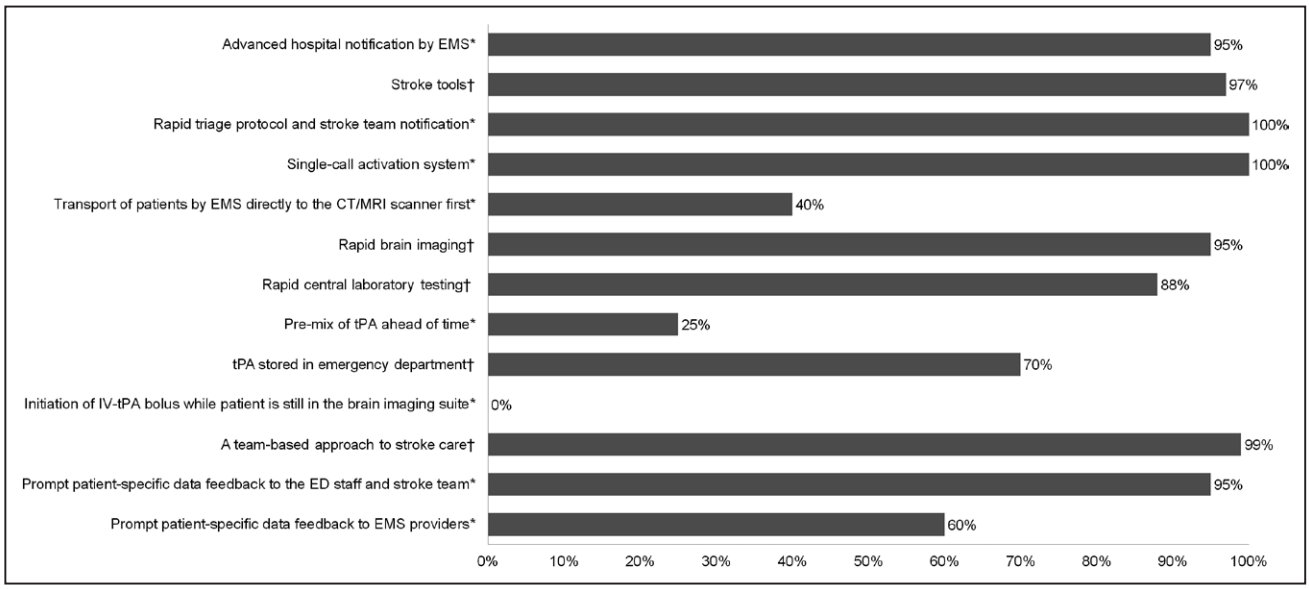

Figure 3. Frequency of Target: Stroke best practice strategies. *Percent of the time (median). †Yes. EMS indicates emergency medical service; and tPA, tissue-type plasminogen activator.

Table 2. Hospitals Reporting Use of Strategies and Association With DTN Time

Strategy	Hospital Use of Strategy % of the Time		Unadjusted Differences in DTN Times (95% CI)	Adjusted Differences in DTN Times (95% CI)	*P* Values for Adjusted Differences
Strategy (0%–100% of the Time)	Median (IQR)	Mean (SD)	Per 20% Increase		
EMS prehospital stroke-screening tool	95 (75 to 100)	80 (29)	–1.0 (–1.6 to –0.3)	–0.9 (–1.5 to –0.2)	0.008
EMS triage to primary or comprehensive stroke center	100 (85 to 100)	83 (30)	–0.3 (–1.0 to 0.4)	–0.3 (–1.0 to 0.4)	0.38
Advanced hospital notification by EMS	95 (75 to 100)	83 (25)	–0.7 (–1.4 to 0.1)	–0.5 (–1.3 to 0.3)	0.30
Rapid triage protocol and stroke team notification	100 (90 to 100)	91 (17)	–2.6 (–4.0 to –1.3)	–2.5 (–3.9 to –1.2)	<0.001
Single-call activation system	100 (100 to 100)	91 (26)	–1.1 (–1.9 to –0.3)	–1.1 (–1.9 to –0.3)	0.006
A timer or clock attached to a chart, clip board, or patient's bed to track time	0 (0 to 5)	20 (37)	–0.6 (–1.1 to 0.0)	–0.6 (–1.2 to –0.0)	0.04
Transport of patients by EMS directly to the CT/MRI scanner	40 (0 to 95)	46 (43)	–0.8 (–1.2 to –0.3)	–0.7 (–1.1 to –0.2)	0.005
Written informed consent is not required before tPA administration	100 (25 to 100)	72 (42)	–0.8 (–1.3 to –0.3)	–0.8 (–1.3 to –0.3)	0.001
INR and platelet results are not required before tPA administration	80 (10 to 100)	60 (40)	–1.2 (–1.7 to –0.8)	–1.2 (–1.6 to –0.7)	<0.001
Interpretation of brain imaging is performed immediately by stroke team members	95 (15 to 100)	68 (42)	–1.7 (–2.2 to –1.3)	–1.6 (–2.0 to –1.1)	<0.001
Treatment decision made by neurologist attending or trainee after in-person evaluation	75 (20 to 100)	61 (39)	–1.5 (–1.9 to –1.0)	–1.2 (–1.7 to –0.7)	<0.001
Treatment decision made by neurologist attending or trainee after telephone only evaluation	25 (0 to 75)	38 (39)	0.4 (–0.2 to 0.9)	0.3 (–0.3 to 0.8)	0.31
Treatment decision made by ED physician, without input from neurologist or trainee	0 (0 to 10)	13 (27)	0.1 (–0.6 to 0.8)	0.0 (–0.6 to 0.8)	0.87
Trainees (residents and fellows) are involved in the stroke team and perform the initial assessment	0 (0 to 100)	39 (45)	–1.1 (–1.6 to –0.6)	–1.1 (–1.5 to –0.6)	<0.001
Premix of tPA ahead of time	25 (0 to 90)	41 (41)	–1.2 (–1.7 to –0.7)	–1.1 (–1.6 to –0.7)	<0.001
Initiation of IV-tPA bolus while patient is still in the brain imaging suite	0 (0 to 5)	9 (23)	–3.5 (–4.2 to –2.8)	–3.4 (–4.1 to –2.7)	<0.001
Prompt patient-specific data feedback to the ED staff and stroke team	95 (70 to 100)	79 (30)	–1.7 (–2.3 to –1.0)	–1.6 (–2.3 to –1.0)	<0.001
Prompt patient-specific data feedback to EMS providers	60 (15 to 95)	56 (38)	–1.2 (–1.7 to –0.7)	–1.0 (–1.5 to –0.5)	<0.001
Strategy (yes or no)	Yes, %		Yes vs no		
Stroke tools*	96.7		…	…	…
In-house stroke expertise 24×7	79.6		–1.4 (–3.7 to 1.0)	–1.6 (–3.8 to 0.7)	0.18
tPA stored in the ED	70.0		–1.6 (–3.6 to 0.5)	–1.1 (–3.2 to 0.9)	0.27
Protocol to perform rapid brain imaging and interpretation*	99.2		…	…	…
CT/MRI scanner physically located in the ED	46.4		–2.8 (–4.7 to –1.0)	–2.1 (–4.0 to –0.3)	0.02
Policy in place that CT/MRI scanner assigns highest priority to suspect stroke patients	94.4		–2.7 (–6.9 to 1.5)	–3.3 (–7.6 to 1.1)	0.14
Rapid central laboratory testing is routinely available	88.2		–0.7 (–3.4 to 2.0)	0.0 (–2.6 to 2.7)	0.99
Point of care testing is routinely available	55.7		–0.3 (–2.2 to 1.6)	0.2 (–1.6 to 2.1)	0.82
Protocol for routine premixing tPA	29.4		–2.7 (–4.8 to –0.6)	–2.6 (–4.7 to –0.6)	0.01
A team-based approach to stroke care*	98.9		…	…	…
Protocol for rapid admission to stroke unit or ICU for patients who receive IV-tPA	82.1		–2.2 (–4.6 to 0.3)	–1.7 (–4.1 to 0.8)	0.18
Protocol for rapid administration of IV-tPA for in-hospital stroke*	96.0		…	…	…
Total number of hospital strategies per 1 increase of 16 significant strategies (from 0% to 100% of time or from no to yes)			–1.4 (–1.7 to –1.1)	–1.3 (–1.6 to –1.0)	<0.001

*Differences in DTN time were not reported for strategies that were universally adopted.

CT indicates computed tomography; DTN, door-to-needle; ED, Emergency Department; EMS, emergency medical services; ICU, intensive care unit; MRI, magnetic resonance imaging; INR, international normalized ratio; IV, intravenous; and tPA, tissue-type plasminogen activator.

times. Among 16 901 patients receiving tPA in the surveyed hospitals, the median DTN time was 56 minutes. Importantly, ≈60% of patients in the surveyed hospitals received tPA within 60 minutes and >30% within 45 minutes after hospital arrival. However, strategies that most strongly associated with shorter DTN times, such as direct transport to CT/MRI scanner by EMS, premix of tPA ahead of time, protocol for routine premixing of tPA, initiation of tPA in the brain imaging suite, CT/MRI scanner physically located in the ED, and a timer or clock attached to track time, were applied relatively infrequently (eg, <50%). Assuming all significant strategies could be universally adopted, as much as 20 minutes might be saved, which could have meaningful clinical implications and represents a clear opportunity for further improvement.

The importance of achieving rapid reperfusion for stroke cannot be overemphasized. Although the maximum treatment window can be extended up to 4.5 hours after symptom onset, the benefits of tPA are highly time dependent. Early treatment is associated with reduced risk of mortality and symptomatic intracranial hemorrhage and improved functional outcomes.[4,6,15] Therefore, rapid reperfusion is a critical factor in the outcomes of acute stroke patients who are treated with tPA. Effective strategies to minimize DTN times in acute ischemic stroke have previously been reported in US and European studies.[16–22] Consequently, the AHA/ASA launched the Target: Stroke quality improvement initiative to assist hospitals in their efforts to improve DTN times. However, our previous survey of 304 GWTG-Stroke hospitals before Target: Stroke found that many of the best practice strategies were not routinely used.[10] Although hospitals were not entirely the same in both surveys, we observed significant uptake of best practice strategies to reduce DTN times when assessed 5 years after the launch of Target: Stroke. Advance hospital notification by EMS, rapid triage protocol and stroke team notification, single-call activation system, stroke tools, rapid acquisition and interpretation of braining image, team-based approach to stroke care, and prompt feedback to the ED staff and stroke team were reported >90% of the time by the hospitals. This increasing adoption of Target: Stroke strategies was accompanied by substantial improvement in timeliness of tPA administration, with a median DTN time of 56 minutes in Target: Stroke phase II and ≈60% of patients achieving DTN times within 60 minutes. Although we cannot prove any causal relationship or generalizability beyond GWTG-Stroke–participating hospitals, these findings suggest that it is possible to reduce treatment delays by implementing evidence-based strategies across US hospitals.

Several strategies that were most strongly associated with shorter DTN times were nevertheless infrequently adopted. Notably, the DTN times were significantly shorter for hospitals with a protocol for routine premixing tPA (2.6 minutes reduction). For each 20% increase in premixing tPA ahead of time, 1.6 minutes could be saved. Unlike some strategies such as relocation of CT/MRI scanner to the ED (2.1 minutes reduction) that might be impractical for some hospitals, premixing tPA could be easily implemented without additional resources. It is the policy of the drug manufacturer to replace unused vials free of charge. However, <30% hospitals reported having protocol for routine premixing tPA, and premixing is seldom practiced among surveyed hospitals (median 25% of the time). An appropriate protocol with explicit inclusion/exclusion criteria could be developed to identify highly probable tPA candidates while avoiding potential tPA wasting. Other strategies such as direct transfer of the patient to the CT/MRI scanner (0.7 minute reduction per 20% increase) and initiation of tPA in the brain imaging suite (3.4 minutes reduction per 20% increase) only require reorganization of existing procedures. Similarly, a timer or clock attached to a chart, clip board, or patient's bed to track time (0.6 minute per 20% increase) can be achieved with little or no extra investment. Another key strategy in the Target: Stroke initiative is prompt data feedback. Although most hospitals monitored performance and provided data feedback to the ED staff and stroke team, there were substantial hospital variations in patient-specific data feedback to the EMS providers (median, 60%; IQR, 15%–95% of the time). Because EMS plays a critical role in deliver of stroke care, a data feedback system can help EMS operators and dispatchers identify specific delays and devise strategies to overcome these barriers.

We identified 16 strategies associated with shorter DTN times. Although some strategies only improve timeliness of tPA administration by a minute or less, previous study has suggested that an average patient loses 2 million neurons for every minute delay in treatment.[5] Each minute saved translates into an average 1.8 days of extra healthy life for each patient receiving tPA.[23] Importantly, these approaches are not mutually exclusive, and substantial reduction in treatment delays can be achieved with multiple concurrent strategies. Our survey was completed during the first 12 months after the initiation of Target: Stroke Phase II. Although it is too early to assess the effectiveness of the program, some individual participating hospitals have met the Target: Stroke phase II goals. Nevertheless, many hospitals have not met the goals for Target: Stroke phase II yet. A more complete application of these strategies by participating hospitals is recommended.

This study has limitations. First, hospital strategies were self-reported and may have some subjectivity that cannot be avoided in survey-based research. We extensively pilot tested the survey instrument to ensure its clarity and completeness before the launch of the program. An AHA/ASA staff member was also available to provide assistance and ensure accurate interpretation of questionnaires during the survey. Second, the Target: Stroke phase II survey is voluntary, and hospitals participate in Target: Stroke based on their level of interest in quality improvement in stroke care. Although the 61% response rate was not as high as desired, it does compare favorably with similar survey research. Nevertheless, hospitals completing the survey might not be representative of the overall hospital population. Indeed, these hospitals were more likely to be primary stroke centers, with higher stroke volume, more experience in administering tPA, and shorter DTN times. However, the adoption of DTN strategies is likely worse in nonparticipating centers. Therefore, it could be argued that greater improvement could be achieved in lagging centers by implementing evidence-based strategies. Third, this study was a cross-sectional analysis. Although we observed significant reductions in DTN times as compared

with those before Target: Stroke,[10] any causal relationships cannot be established using the current study design. Fourth, we did not evaluate the effect of telestroke system for image interpretation and clinical evaluation. A follow-up study is planned to examine how the implementation of telestroke system may facilitate timely evaluation, decision making, and treatment in hospitals without stroke expertise on-site. Finally, although the focus of the Target: Stroke is to reduce treatment delays, the ultimate effect on outcome should be part of the assessment of the Target: Stroke strategies. Further studies are needed to evaluate the impact of safety and outcomes with increased used of these strategies.

Conclusions

Among 888 hospitals participating in the Target: Stroke phase II survey, the majority of key Target: Stroke strategies have been implemented to improve the timeliness of tPA administration. Nearly 60% of patients achieved DTN times within 60 minutes and 30% within 45 minutes. These results suggest that DTN times could be effectively reduced with simple policy and organizational changes. Nevertheless, several strategies most strongly associated with shorter DTN times were rarely practiced, further supporting the need for a continuous national campaign to promote best evidence-based strategies and improve the timeliness of tPA treatment in the United States.

Acknowledgments

This was previously presented at the International Stroke Conference 2016, February 2016.

Sources of Funding

Target: Stroke is an initiative provided by the American Heart Association/American Stroke Association.

Disclosures

Y. Xian reports receiving a research grant directed to the Duke Clinical Research Institute from Daiichi Sankyo, Janssen Pharmaceutical Companies, and Genentech. Dr Peterson reports receiving research grants from Lilly, Johnson & Johnson, Bristol-Myers Squibb, Sanofi-Aventis, and Merck-Schering Plow partnership and serving as principal investigator of the data analytic center for Get With The Guidelines (GWTG). A.F. Hernandez reports receiving research grants from Amgen, Bristol Myers Squibb, GlaxoSmithKline, Janssen, Novartis, and Portola Pharmaceuticals and receiving honoraria from Amgen, GlaxoSmithKline, Janssen, and Novartis. Dr Saver is an employee of the University of California. The Regents of the University of California receive funding for his services as a scientific consultant regarding trial design and conduct to Medtronic/Covidien, Stryker, Neuravia, BrainsGate, Pfizer, Squibb, Boehringer-Ingelheim (prevention only), ZZ Biotech, and St. Jude Medical. He has served as an unpaid site investigator in multicenter trials run by Lundbeck for which the UC Regents received payments on the basis of clinical trial contracts for the number of subjects enrolled. He serves as an unpaid consultant to Genentech advising on the design and conduct of the Study of the Efficacy and Safety of Activase (Alteplase) in Patients With Mild Stroke (PRISMS) trial; neither the University of California nor Dr Saver received any payments for this voluntary service. The University of California has intellectual property rights in retrieval devices for stroke and certification vignettes for the modified Rankin Scale. Dr Messé has served on the speaker's bureau for Boehringer-Ingelheim and receives research support from the National Institutes of Health and WL Gore. M Paulsen reports employment with the American Heart Association. Dr Suter reports previous employment with the American Heart Association. E.C. Jauch reports research funding from Genentech for the PRISMS study. Dr Schwamm reports being the principal investigator of an investigator-initiated study of extended-window intravenous thrombolysis funded by the National Institute of Neurological Disorders and Stroke (clinicaltrials.gov/show/NCT01282242) for which Genentech provides alteplase free of charge to Massachusetts General Hospital and supplemental per-patient payments to participating sites; serving as chair of the American Heart Association/American Stroke Association GWTG-Stroke Clinical Work Group; serving as a stroke systems consultant to the Massachusetts Department of Public Health; and serving as a scientific consultant for trial design and conduct of Lundbeck (international steering committee, DIAS3, 4 trial) and Penumbra (data and safety monitoring committee, Separator 3D trial). G.C. Fonarow reports receiving research support from the Patient Centered Outcome Research Institute, GWTG Steering Committee, and is an employee of the University of California, which has a patient on an endovascular device.

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Use of Strategies to Improve Door-to-Needle Times With Tissue-Type Plasminogen Activator in Acute Ischemic Stroke in Clinical Practice: Findings from Target: Stroke

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Circ Cardiovasc Qual Outcomes. 2017;10:
doi: 10.1161/CIRCOUTCOMES.116.003227
Circulation: Cardiovascular Quality and Outcomes is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231

Print ISSN: 1941-7705. Online ISSN: 1941-7713

SUPPLEMENTAL MATERIAL

Supplemental Table. Association between Hospital Strategies and Door-to-needle (DTN) Time: Sensitivity Analyses

Strategy	Adjusted Differences in DTN Times (95% CI)	P values
Strategy (0-100% of the time)	**Per 20% increase**	
EMS prehospital stroke screening tool	-0.6 (-1.2, 0.0)	0.07
EMS triage to primary or comprehensive stroke center	-0.1 (-0.8, 0.5)	0.63
Advanced hospital notification by EMS	-0.5 (-1.2, 0.3)	0.21
Rapid triage protocol and stroke team notification	-2.0 (-3.2, -0.8)	<0.001
Single-call activation system	-0.9 (-1.6, -0.2)	0.02
A timer or clock attached to a chart, clip board, or patient's bed to track time	-0.7 (-1.2, -0.1)	0.01
Transport of patients by EMS directly to the CT/MRI scanner	-0.5 (-1.0, -0.1)	0.01
Written informed consent is not required prior to tPA administration	-0.4 (-0.9, 0.0)	0.06
INR and platelet results are not required prior to tPA administration	-0.9 (-1.3, -0.4)	<0.001

Interpretation of brain imaging is performed immediately by stroke team members	-1.2 (-1.6, -0.7)	<0.001
Treatment decision made by neurologist attending or trainee after in-person evaluation	-0.6 (-1.1, -0.1)	0.01
Treatment decision made by neurologist attending or trainee after telephone only evaluation	0.0 (-0.6, 0.5)	0.87
Treatment decision made by ED physician, without input from neurologist or trainee	-0.2 (-0.9, 0.5)	0.57
Trainees (residents, fellows) are involved in the stroke team and perform the initial assessment	-0.5 (-1.0, -0.1)	0.02
Pre-mix of tPA ahead of time	-1.1 (-1.5, -0.6)	<0.001
Initiation of IV-tPA bolus while patient is still in the brain imaging suite	-2.7 (-3.4, -2.0)	<0.001
Prompt patient-specific data feedback to the ED staff and stroke team	-1.7 (-2.3, -1.2)	<0.001
Prompt patient-specific data feedback to EMS providers	-1.0 (-1.4, -0.5)	<0.001
Strategy (yes or no)	Yes vs. no	
Stroke tools*	-	
In-house stroke expertise 24x7	-1.6 (-3.8, 0.5)	0.14

tPA stored in the ED	-0.5 (-2.4, 1.4)	0.59
Protocol to perform rapid brain imaging and interpretation*	-	-
CT/MRI scanner physically located in the ED	-0.5 (-2.2, 1.3)	0.61
Policy in place that CT/MRI scanner assigns highest priority to suspect stroke patients	-2.8 (-6.8, 1.2)	0.17
Rapid central laboratory testing is routinely available	0.2 (-2.4, 2.8)	0.87
Point of care testing is routinely available	0.9 (-0.9, 2.6)	0.33
Protocol for routine pre-mixing tPA	-2.9 (-4.8, -0.9)	0.004
A team-based approach to stroke care*	-	-
Protocol for rapid admission to stroke unit or ICU for patients who receive IV-tPA	-1.6 (-3.8, 0.7)	0.17
Protocol for rapid administration of IV tPA for in-hospital stroke*	-	-
Total number of hospital strategies per 1 increase of significant strategies (from 0 to 100% of time or from no to yes)	-1.0 (-1.3, -0.7)	<0.001

*Differences in DTN time were not reported for strategies that were universally adopted.