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24/7 Neurocritical Care Nurse Practitioner Coverage Reduced Door-to-Needle Time in Stroke Patients Treated with Tissue Plasminogen Activator

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Abstract

Background—Stroke centers with limited on-site neurovascular physician coverage may experience delays in acute stroke treatment. We sought to assess the impact of providing 24/7 neurocritical care acute care nurse practitioner (ACNP) “stroke code” first responder coverage on treatment delays in acute stroke patients who received tissue plasminogen activator (tPA).

Methods—Consecutive acute ischemic stroke patients treated with intravenous tPA at a primary stroke center on Oahu between 2009 and 2014 were retrospectively studied. 24/7 ACNP stroke code coverage (intervention) was introduced on July 1, 2011. The tPA utilization, door-to-needle (DTN) time, imaging-to-needle (ITN) time, and independent ambulation at hospital discharge were compared between the preintervention period (24 months) and the postintervention period (33 months).

Results—We studied 166 stroke code patients who were treated with intravenous tPA, 44 of whom were treated during the preintervention period and 122 of whom were treated during the postintervention period. After the intervention, the median DTN time was reduced from 53 minutes (interquartile range [IQR] 45–73) to 45 minutes (IQR 35–58) ($P = .001$), and the median ITN time was reduced from 36 minutes (IQR 28–64) to 21 minutes (IQR 16–31) ($P < .0001$). Compliance with the 60-minute target DTN improved from 61.4% (27 of 44 patients) in the preintervention period to 81.2% (99 of 122 patients) in the postintervention period ($P = .004$). The tPA treatment rates were similar between the preintervention and postintervention periods ($P = .60$).

Conclusions—Addition of 24/7 on-site neurocritical care ACNP first responder coverage for acute stroke code significantly reduced the DTN time among acute stroke patients treated with tPA.

Keywords

Stroke; nurse practitioner; thrombolysis; staffing; models; outcomes

Introduction

Intravenous tissue plasminogen activator (tPA) has been proven to improve functional outcome in acute ischemic stroke if it is delivered in a timely manner.¹⁻³ Although tPA can be beneficial up to 4.5 hours after symptom onset, multiple studies have shown that treatment delay reduces the chance of benefit.^{3,4} Within 90 minutes of symptom onset, only 4.5 patients need to be treated with tPA to benefit 1 patient, but, between 1.5 and 3.0 hours after symptom onset, the number of patients who need to be treated doubles to 9.^{3,5,6} An estimated 1.9 million neurons die every minute after intracranial large-vessel occlusion.⁷

The American Heart Association/American Stroke Association developed the Target Stroke guidelines, a set of best practices, to help institutions eliminate delays in treatment with tPA.⁸ Get With The Guidelines (GWTG)-Stroke has a target door-to-needle (DTN) time of less than 60 minutes.^{3,9} Despite this widely recognized target time, only about one third of acute ischemic stroke patients have tPA initiated within the first hour of hospital arrival.^{9,10}

For treatment of myocardial infarction, specially trained nurses have been shown to safely initiate thrombolytic medications with significantly shorter DTN times in several studies.¹¹⁻¹⁴ A single prior study that evaluated nurse practitioners to help facilitate the treatment of acute ischemic stroke patients showed decreased DTN time.¹⁵ We hypothesized that the introduction of around-the-clock, onsite coverage with neurocritical care-trained acute care nurse practitioners (ACNP) as first responders for acute “stroke code” would shorten DTN time and improve compliance with acute stroke time targets.

Methods

We performed a single-center retrospective cohort study of consecutive acute ischemic stroke patients before and after introduction of 24/7 ACNP first responder coverage for a hospital stroke code team (intervention). We included all consecutive patients with stroke code activations who were treated with intravenous tPA. We excluded patients who were treated with endovascular thrombolytic therapies without first receiving intravenous tPA. All data were obtained from The Queen’s Medical Center (QMC), a 505-bed tertiary referral center located in Honolulu, Hawaii. During the study period, QMC was the only Joint Commission-accredited primary stroke center in Hawaii. A retrospective review of the institutional GWTG-Stroke database was performed for the 24-month period (from July 1, 2009, to June 30, 2011) before the introduction of ACNP coverage for stroke code compared to the 33-month period (from July 1, 2011, to March 31, 2014) after the introduction of ACNP coverage.

In the preintervention period, the hospital acute stroke code coverage was staffed by an on-call, board-certified vascular neurologist or neurointensivist but without onsite neurovascular physician coverage overnight. The inpatient neurology services had no clinical coverage by residents or fellows and all stroke code evaluations were performed by the attending physician. In the preintervention period, the on-call vascular neurologist or neurointensivist had a 30-minute window for arrival to the bedside after the stroke code was activated.

Post intervention, the stroke code pages went to both the on-site ACNP who functioned as a first responder and the neurovascular attending physician on call for stroke code. The 5 ACNPs primarily provided around-the-clock coverage for the hospital neurocritical care unit. Before the intervention, the ACNPs underwent stroke training that included a lecture series, National Institutes of Health Stroke Scale (NIHSS) certification, and 6 months of proctored on-the-job training responding to acute stroke code. Emergency Neurological Life Support training was recommended but was not required.

The 24-month preintervention period was chosen because July 1, 2009, marked the beginning of an exclusive hospital-employed vascular neurologist or neurointensivist stroke code coverage. Before this date, stroke code coverage had been staffed by a hybrid model of hospital-employed neurologists and community neurologists. The hospital-employed vascular neurologists or neurointensivists functioned as the first responder to acute stroke code activations until July 1, 2011. After this date, the on-site ACNP became the first responder for acute stroke code activations.

The role of the ACNP was to take the initial history, obtain the NIHSS score, obtain and review imaging, review the indications and contraindications for tPA, and discuss tPA eligibility with the on-call vascular neurologist by telephone. For patients who were ineligible for tPA, the ACNP documented the clinical encounter. For patients who were eligible for tPA, the on-call vascular neurologist directly evaluated the patient and made the final decision regarding tPA administration. The 33-month postintervention period lasted until March 31, 2014, at which time the Emergency Medical Services began prehospital stroke code activation using the Los Angeles Prehospital Stroke Screen. No other systematic changes to staffing or stroke code care pathways were made during the intervention period.

The hospital policy for stroke code activation required evaluation by the emergency medicine physician after patient arrival to the emergency department (ED). Stroke code was activated for all patients with a new focal neurological deficit and time last known normal within 6 hours. Eligibility for tPA was determined by the stroke code team rather than the ED staff. Hospital policy required in-person evaluation of the patient and administration of the bolus dose of tPA by a provider on the stroke code team, which could be a physician or ACNP. The treatment window for intravenous tPA was 4.5 hours and that for mechanical thrombectomy was 6 hours. All of these policies were unchanged during the pre- and postintervention periods.

The GWTG-Stroke database is a national quality improvement database focusing on stroke process measures and outcomes.^{1,3} Data were prospectively entered into the GWTG-Stroke database by a dedicated hospital-employed research nurse throughout the study period. Data fields that were collected included age, sex, symptom onset-to-arrival time, door-to-stroke code-activation time, door-to-computed tomography (CT) time, DTN time, initial NIHSS score, discharge disposition, and length of stay.

Data utilized in the study that were not part of the GWTG-Stroke database were collected via a retrospective chart review. Independent ambulation status at hospital discharge was determined by a board-certified vascular neurologist (M.A.K.) who reviewed the electronic

medical record. The independent ambulation status was assigned based on the physical therapist notes in the 24-hour period immediately before discharge. As the presence of an on-site clinical pharmacist in the ED may also have impacted the DTN time or imaging-to-needle (ITN) time, the data on their presence during the stroke code were also obtained based on ED pharmacist hours (10 AM–11 PM). We also retrospectively abstracted the type of attending neurologist covering the stroke code (vascular neurologist or neurointensivist) and whether endovascular treatment was attempted.

Patient characteristics that were reviewed included race; significant past medical history (presence of hypertension, diabetes, atrial fibrillation or atrial flutter, coronary artery disease or prior myocardial infarction, hyperlipidemia, and prosthetic valve); lifestyle risk factors (smoking and alcohol use); and current anticoagulant or antiplatelet medications (warfarin, aspirin, clopidogrel, and novel oral anticoagulants). The primary outcome measure for the present study was median DTN time for tPA administration. The secondary outcome measure was independent ambulation at hospital discharge.

Data were analyzed using commercially available statistical software (SPSS 22.0; SPSS Inc., Chicago, IL). Patient characteristics were summarized using descriptive statistics appropriate to the variable type. The preintervention period was compared to the postintervention period using the chi-square test for categorical data, 2-tailed *t*-test for normally distributed, continuous variables, and the Mann–Whitney *U*-test for nonparametric data. Normal distribution was tested using the Kolmogorov–Smirnov test. *P* levels less than .05 were considered statistically significant.

Results

There were 1563 patients discharged with a principal diagnosis of ischemic stroke at QMC during the 24-month preintervention period (from July 1, 2009, to June 30, 2011). During this period, there were 394 acute stroke code activations, of which 151 patients were diagnosed with acute ischemic stroke. Of those 151 patients, 44 (29.1%) were treated with intravenous tPA. During the 33-month postintervention period (from July 1, 2011, to March 31, 2014), there were 2317 patients discharged with a principal diagnosis of ischemic stroke. During this period, there were 789 acute stroke code activations, of which 388 patients were diagnosed with acute ischemic stroke. Of those 388 patients, 122 (31.4%) were treated with intravenous tPA. The tPA treatment rates were similar in the periods before and after the introduction of ACNP first responders (*P* = .60).

Baseline clinical characteristics and demographics of the study population are shown in Table 1. The pre- and postintervention study populations had similar age, gender and racial distribution, medical comorbidities, and initial NIHSS score. Onset-to-door, door-to-activation, and door-to-CT times were similar in the pre- and postintervention periods. The median DTN time improved significantly from 53 minutes (interquartile range [IQR] 45–73) preintervention to 45 minutes (IQR 35–58) post intervention (*P* = .001). In addition, compliance with the DTN time target of 60 minutes or less improved from 61.4% (27 of 44 patients) in the preintervention period to 81.2% (99 of 122 patients) in the postintervention period (*P* = .004). The improvement of DTN time was attributable to a shorter interval from

completion of head CT to initiation of tPA, called the ITN time. The median ITN time decreased from 36 minutes (IQR 28–64) preintervention to 21 minutes (IQR 16–31) post intervention ($P < .0001$).

As a secondary outcome measure, we compared the frequency of independent ambulation at the time of hospital discharge between the pre- and postintervention periods. In the preintervention period, 18 of 44 patients (41%) could ambulate independently at hospital discharge compared to 66 of 122 patients (54%) in the postintervention period, but the difference was nonsignificant ($P = .133$).

Discussion

In this single-center retrospective cohort study, we compared stroke target times before and after the addition of 24/7 neurocritical care ACNP first responders to a hospital stroke code team. We found that the median DTN time significantly decreased from 53 to 45 minutes and that compliance with the time target of 60 minutes or less improved from 61% to 81% after changing the stroke team staffing model to include ACNP first responders. Because other aspects of our stroke code care pathway remained the same during the study period, we attributed this improvement to the introduction of ACNP staffing to the stroke team.

We attempted to minimize the risk that other changes in practice may have contributed to shorter DTN times by selecting time periods where no other systematic changes were made to our staffing model or stroke code care pathway. We also attempted to minimize this risk by studying potential confounders that could alter DTN time, such as presence of an ED pharmacist and use of anticoagulant medications.

One prior study from Taiwan showed that a parallel thrombolysis protocol with nurse practitioners on a hospital stroke team improved DTN time in a single-center retrospective cohort study.¹⁵ In this study, the median DTN was shortened from 68.5 to 58 minutes after the initiation of a nurse practitioner-based stroke team. The authors attributed the improvement in DTN to expedited identification of tPA-eligible patients by nurse practitioners. The rapid availability of a nurse practitioner to the bedside facilitated assessment of the patient's neurological deficits, potential candidacy for thrombolysis, and contraindications to tPA.

There are numerous studies which show that specialized nurses and nurse practitioners are able to accurately recognize and provide safe and effective treatment for patients with acute myocardial infarction (AMI).^{11,12,14} Nurse practitioners have been utilized broadly in the United Kingdom to help institutions adhere to the national standards of initiation of thrombolytic therapy in at least 75% of AMI patients within 30 minutes of presentation.¹³ In 1 study from the United Kingdom, which compared nurse-initiated thrombolysis times to those of junior doctors, a significant reduction in time to thrombolysis was seen with median time for nurses being 15 minutes and the median time for doctors being 35 minutes.¹¹ In another study performed in the United Kingdom, it was noted that nurse practitioners significantly improved the DTN time for AMI patients by a median of 30 minutes. This was

attributed in part to the nurse practitioners' ability to focus on coordinating the care of the AMI patient, thus improving the delivery time of thrombolytics.¹²

In our study, we found that DTN time was primarily improved due to a reduction in the interval between completion of the head CT and initiation of tPA. In a prior study, faster ITN time was found to be more effective in shortening the DTN time than the door-to-CT time.¹⁶ There are many variables that influence the ITN time, including communication between the stroke team and nurses, emergency physicians, radiologists, pharmacists, and the patient and/or family members.¹⁶

Reduction in DTN time was seen in the postintervention period regardless of the time of day that the stroke code occurred. Although having an on-site provider would be expected to improve the DTN time during night-time hours when the on-call neurologist is typically not located at the hospital, we also demonstrated reduction of the DTN time during typical working hours. We believe that having an ACNP first responder on the stroke team helped facilitate communication and improved DTN time by allowing the stroke team to "multitask." For example, if the stroke physician was on-site, he or she generally accompanied the patient to CT and quickly interpreted the imaging study while the patient was in the scanner. Simultaneously, the ACNP gathered information from witnesses and reviewed the patient's prior medical records. If the patient was eligible for thrombolytic therapy, the stroke physician focused on stabilizing the patient and reviewing risks and benefits of tPA, while the ACNP obtained the patient's weight, calculated the tPA dose, and ordered and mixed the drug. These parallel workflows allowed treatment decisions to be made more rapidly and hastened drug administration.

It is important to note that ACNP participation on the stroke team did not alter the overall tPA treatment rate of stroke code patients, most likely because the final decision to treat remained with the on-call stroke physician.

One limitation of the present study is that we did not measure time targets or outcome data for stroke patients who were not treated with tPA. Comparing time targets such as the door-to-CT time of patients who were not treated with tPA could help determine whether additional improvements in our stroke code pathway could be made. Other limitations include the retrospective determination of an independent ambulation status at hospital discharge. Standard outcome assessments at 3 or 6 months post stroke would more reliably demonstrate whether the intervention had a durable impact on functional outcomes.

We were unable to test the extent to which a practice effect with increased stroke treatment experience or outside factors such as national education campaigns also contributed to the reduced DTN time. During the study period, local factors likely contributed to an increase in the total number of stroke patients admitted to QMC. In particular, the closure of a nearby hospital in January 2012 resulted in an increase in the hospital census and the total number of emergency room visits.

Our results are also derived from a single-center study of an institution with an uncommon staffing model. Therefore, these results may not be generalizable to other institutions that have 24/7 on-site residents or attending stroke coverage or participate in telestroke

programs. We did not test whether similar results could be achieved with other staffing models utilizing bedside nurses, physician assistants, or trainees.

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Table 1

Comparison of pre- and post intervention with 24/7 neurocritical care acute care nurse practitioners

Characteristics	Preintervention	Post intervention	<i>P</i>
Number of patients	44	122	
Age (years)	68 (55–83)	73 (60–84)	.10
Female (%)	20 (46)	62 (51)	.54
Race			.56
White (%)	9 (21)	31 (25)	
Asian (%)	21 (48)	58 (48)	
NHOPI (%)	13 (30)	26 (21)	
Other (%)	1 (2)	7 (6)	
Hypertension (%)	34 (77)	94 (77)	.98
Diabetes mellitus (%)	10 (23)	37 (30)	.34
Atrial fibrillation/atrial flutter (%)	18 (41)	53 (43)	.77
Coronary artery disease or prior MI (%)	11 (25)	20 (16)	.21
Hyperlipidemia (%)	24 (55)	54 (44)	.24
Prosthetic valve (%)	1 (2)	3 (3)	.95
Peripheral vascular disease (%)	3 (7)	4 (3)	.32
Smoking (%)	9 (21)	20 (16)	.54
Use of warfarin (%)	2 (5)	8 (7)	.63
On-site pharmacist present (%)	25 (57)	71 (58)	.87
Initial NIHSS score	14 (8–19)	13 (6–20)	.47
Endovascular treatment (%)	14 (32)	26 (21)	.16
Onset-to-needle time (min)	118 (96–157)	110 (80–141)	.13
Imaging-to-needle time (min)	36 (28–64)	21 (16–31)	<.0001
Door-to-needle time (min)	53 (45–73)	45 (35–58)	.001
Hospital mortality (%)	8 (18)	15 (12)	.33
Independent ambulation at discharge (%)	18 (41)	66 (54)	.13

Abbreviations: MI, myocardial infarction; NHOPI, Native Hawaiians and other Pacific Islanders; NIHSS, National Institutes of Health Stroke Scale.

Data are n (%) or median (interquartile range).