

Intra-Arterial Therapy for Acute Stroke and the Effect of Technological Advances on Recanalization: Findings in a Community Hospital

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BACKGROUND Recent randomized controlled studies have shown improvement in recanalization outcomes when physicians use the latest intra-arterial therapy devices in patients with acute, large-vessel, intracranial occlusions. The goal of this study was to explore how new procedures affected degree of and time to recanalization at a single center over the past 12 years as technology has improved.

METHODS Patients were included in the study if they had a large or medium intracranial vessel occlusion and had undergone intra-arterial therapy for acute stroke during the period 2002–2013. Therapies were categorized as intra-arterial thrombolysis with tissue plasminogen activator (IA tPA), mechanical thrombectomy using 1st-generation devices (Merci and Penumbra), or mechanical thrombectomy using 2nd-generation devices (stent-trievers). Recanalization was defined using a modified Thrombolysis in Cerebral Infarction (TICI) scale.

RESULTS Primary treatment was IA tPA in 24 (12.4%) patients, 1st-generation devices in 128 (66.0%) patients, and 2nd-generation devices in 42 (21.6%) patients. TICI 2b was achieved in 7 (29.2%) patients treated with IA tPA, in 79 (61.7%) patients treated with 1st-generation devices, and in 38 (90.5%) patients treated with 2nd-generation devices. Compared to patients treated with IA tPA, patients treated with 2nd-generation devices were more likely to reach TICI 2b recanalization (odds ratio, 11.66; 95% CI, 1.56–87.01), and they did so in shorter times.

CONCLUSION Technological advances over 12 years in endovascular stroke treatments significantly improved the chance of and reduced time to achieving TICI 2b recanalization in our community hospital. This shows the importance of adopting new technologies in a rapidly evolving field in order to provide the best-practice standard of care for the people of our region.

Intra-arterial (IA) therapy for acute stroke has evolved quickly over the past decade due in large part to improved technology. Primary endovascular treatment approaches have shifted from IA infusion of a thrombolytic agent, to use of 1st-generation mechanical thrombectomy devices such as Merci and Penumbra, to use of stent-trieter devices (2nd-generation devices) with or without adjuvant large-bore suction therapy [1]. Recent clinical trials have shown that stent-trieter technology improves outcomes in patients with large-vessel intracranial occlusions who are candidates for acute therapy [2–6].

It can be challenging to apply findings from randomized controlled studies to real-world care pathways in a community hospital setting. During the past 15 years, there have been extensive efforts to formalize care for acute stroke throughout Western North Carolina. We have witnessed dramatic improvements in rates of recanalization and decreased time to recanalization. Time to recanalization and degree of recanalization are considered to be 2 of the most important factors that influence outcomes in acute stroke intervention [7–14]. Indeed, time from intervention to recanalization is one of the metrics collected as a quality indicator for comprehensive stroke centers [15].

We performed a retrospective review of our acute stroke IA treatment patients in a community hospital setting over

the last 12 years and investigated the effect of technological advances on recanalization results and times.

Methods

Setting

Mission Health, based in Asheville, is North Carolina's 6th-largest health system and the only not-for-profit, independent community hospital system governed and managed exclusively in Western North Carolina. Mission Health operates 6 hospitals and numerous outpatient clinics and surgery centers. Mission Hospital, located in Asheville, is the system's flagship hospital and is licensed for approximately 770 beds. It is the regional referral center for tertiary and quaternary care for 18 counties in Western North Carolina. Mission Hospital's acute stroke team includes emergent ground and air transportation, emergency room clinicians, hospital-based stroke neurologists, neuroradiologists, neurointerventionalists, neuro-

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surgeons, neurocritical care intensivists, and nurses. We have high-level administrative programmatic support, allowing data-driven quality improvement and oversight. We are also preparing to submit an application to become a comprehensive stroke center—the only such recognized hospital in Western North Carolina. Additionally, we are formally aligned with outpatient rehabilitation services as part of our system of care.

Neurointerventionalists have been on staff since 1999, providing endovascular options for the acute treatment of large-vessel intracranial stroke. The current 3-member neurointerventional team has avidly adopted new technologies as they have become available. In 2004, a neurohospitalist service was started, and the hospital was certified as a primary stroke center in 2007. The first telestroke consultation using remote patient visualization occurred in 2011, and eventually a telestroke system including 9 hospitals evolved. There is continuing involvement of hospital staff and emergency medical services to recognize acute stroke-like symptoms, facilitate evaluation, and provide emergency intervention, whether it be intravenous (IV) thrombolysis, IA therapy, or both. After consultation, patients may be treated with IV thrombolysis at their local hospital, or they may be transferred to Mission Hospital in Asheville for IA therapy. In 2014, approximately 25% of acute stroke patients arrived from hospitals outside Asheville.

Patient Assessment

Institutional review board approval was obtained for retrospective chart and image review of all patients treated for acute ischemic stroke with IA therapy at Mission Hospital in Asheville during the period 2002–2013. During this period, all patients presenting to Mission Hospital with the possibility of a stroke underwent neurologic assessment by a neurologist. Preoperative evaluation also included laboratory analysis to determine prothrombin time/international normalized ratio and creatinine level. Imaging—including a non-contrast head computed tomography (CT) scan and, in nearly all cases, a CT angiogram (CTA) of the neck and head—was performed to exclude intracranial hemorrhage and large completed infarct, as well as to document the presence and location of the vessel occlusion. In all cases, the decision to proceed with IA therapy was determined by the neurologist and neurointerventionalist based on clinical, imaging, and laboratory findings. Indications for endovascular therapy included several factors: presence of an intracranial large- or medium-vessel occlusion on CTA; a National Institutes of Health Stroke Scale (NIHSS) score consistent with a large- or medium-vessel occlusion; lack of hemorrhage; lack of ischemic change of greater than one-third the vascular territory on non-contrast CT; and patient presentation within a 6- or 12-hour time window from known time of symptom onset for occlusions in the anterior or posterior circulation systems, respectively. In several cases with unknown time of onset, magnetic resonance diffusion imag-

ing was performed to document viable brain in the area of vascular occlusion prior to intervention.

Endovascular Treatment

Most patients were treated under general anesthesia. Digital subtraction angiography of the affected and collateral circulation systems was performed. Guide catheters ranged in size from 6Fr to 8Fr. Significant extracranial stenoses or occlusions were treated with angioplasty and/or stenting, if necessary. In these cases, once the extracranial circulation was re-established, cerebral angiography was performed to assess intracranial circulation. Treatments for intracranial occlusions were categorized as IA infusion of tissue plasminogen activator (tPA), mechanical thrombectomy utilizing 1st-generation devices (Merci and Penumbra), or mechanical thrombectomy utilizing 2nd-generation devices (stent-trievers with or without large-bore suction catheters).

The IA tPA technique involved navigating a microcatheter distal to the occlusion and infusing 1–2 mg of tPA, lacing the clot with an additional 1–2 mg of tPA, and then starting an infusion at the face of the occlusion at an average rate of 0.25 mg/min, typically up to 20 mg. Treatment with the Merci clot retrieval device involved crossing the occlusion, unsheathing the device, and then slowly retracting while performing suction at the guide catheter. The Penumbra device technique involved placing the largest possible catheter to the face of the occlusion and then using a separator to dislodge the clot while applying suction to the catheter. Finally, treatment with the stent-tri-
ever device involved crossing the occlusion, defining the distal aspect of the occlusion with superselective angiography, deploying the stent-tri-
ever, and then waiting 4–5 minutes before retracting the stent-tri-
ever while performing suction at the guide/
large-bore catheter. If the primary treatment method was unsuccessful and/or distal migration of the clot was seen, then secondary methods—including IA tPA infusion, Merci, Penumbra, or stent-trievers—were utilized. (The amount of adjunctive tPA, when utilized, was documented to be in the range of 2–10 mg).

Post-treatment angiography was performed to assess final recanalization. In patients who received tPA, the femoral sheath was sutured to the groin and removed 12–24 hours later.

All patients were transferred to the neurotrauma intensive care unit for post-acute stroke care for at least 24 hours. Almost all patients received a follow-up non-contrast head CT scan within 24 hours. In all patients who underwent extracranial angioplasty and/or stenting, antiplatelet medication was started within 48–72 hours if no contraindication was present.

Data Collection

Patients were identified from the neurointerventional surgery procedure log. All sequential patients were included

in the retrospective analysis if they had an intracranial occlusion and had undergone IA therapy for acute stroke. Treatment data were collected by the primary investigator via chart abstraction from inpatient hospital records, imaging studies, and operative reports. Patient demographic characteristics included age, sex, and presence of atrial fibrillation. The NIHSS score was available for 103 of 194 patients. We retrospectively calculated the NIHSS score for the patients for whom it was not documented [16]. We also recorded whether the patient received pretreatment with IV tPA and, if not, the contraindication.

Definition of Occlusions

Occlusions were defined as large-vessel (cavernous carotid and internal carotid artery terminus, distal vertebral and basilar trunk), medium-vessel (M1 ± M2 middle cerebral arteries, basilar tip and P1), or distal-vessel (distal M2/M3 middle cerebral arteries, P2/3 posterior cerebral arteries). Angiographic collateral grades were recorded utilizing the American Society of Interventional and Therapeutic Neuroradiology/Society of Interventional Radiology (ASITN/SIR) collateral flow grading system [17]. Time of the intervention was defined as the time from the first diagnostic cerebral angiogram to the time of the last angiogram. In patients needing angioplasty and/or stenting of an extracranial stenosis or occlusion, timing of the intracranial intervention started after the extracranial treatment was completed.

Outcomes

Outcome measures were degree and speed of recanalization. Time to recanalization and degree of recanalization are considered to be 2 of the most important factors that influence outcomes in acute stroke intervention [7-14]. Recanalization was defined using a modified Thrombolysis in Cerebral Infarction (TICI) scale, with treatment success defined as a score of at least TICI 2b (partial perfusion with distal branch filling of 50-99% of the expected territory) [11]. Time to TICI 2b was documented in cases where it was achieved. The ending TICI score was also recorded for each case. Procedural complications, primary endovascular treatments, and secondary endovascular treatments were documented.

Analysis

Analysis was restricted to patients with large- and medium-sized intracranial vessel occlusions who received one of the primary procedures described. The baseline characteristics of patients treated using the primary procedures were summarized using descriptive statistics. Odds ratios for reaching TICI 2b recanalization were estimated using logistic regression analysis. In addition to primary procedure, several other variables were assessed: patient age, sex, occlusion location (large- or medium-vessel), collateral grade, pretreatment with IV tPA, and procedure year. As this

TABLE 1.
Characteristics of Treated Patients With Medium- and Large-Vessel Occlusions, 2002-2013 (N = 194)

	No.	%
Age, in years		
Median (range)	71 (24-92)	
80 years or older	33	17.0%
Sex		
Male	99	51.0%
Female	95	49.0%
Presenting NIHSS		
Median (range)	19 (4-36)	
Occlusion location		
Anterior large vessel	36	18.6%
Anterior medium vessel	131	67.5%
Posterior large vessel	5	2.6%
Posterior medium vessel	22	11.3%
Collateral grade		
0	48	24.7%
1	94	48.5%
2	34	17.5%
3	15	7.7%
4	3	1.5%
Atrial fibrillation		
	48	24.7%
IV tPA pretreatment		
Yes	110	56.7%
No	84	43.3%
Time from 1st to last angiogram, in minutes		
Median (range)	90 (16-268)	
TICI 2b achieved		
	124	63.9%

Note. IV tPA, intravenous tissue plasminogen activator; NIHSS, National Institutes of Health Stroke Scale; TICI, Thrombolysis in Cerebral Infarction.

was not a randomized controlled trial but rather an observational study over a 12-year period, we included procedure year to account for changes in outcome that were associated with improvements over time but unrelated to procedure type. A limitation of this multivariate model is the high correlation between procedure type and procedure year.

Speed of reaching TICI 2b recanalization was compared between the procedure groups using Kaplan Meier survival curves with the associated log-rank test statistic and hazard ratios using Cox proportional hazards models. As with the odds ratio analyses, we included procedure year in our multivariate model to assess how much of the change we observed was due to general improvements over time and how much was due to procedural advances. In the time-to-event analyses, TICI 2b recanalization was the outcome of interest, and duration was counted in minutes. All patients who did not reach TICI 2b recanalization were censored at 234 minutes, which is the longest time recorded in the study for reaching TICI 2b recanalization. A sensitivity analysis was performed to assess the effect of varying

the time of censorship, and this analysis found no notable influence on estimates. All analyses were performed using SAS version 9.3.

Results

A total of 194 patients were treated with IA therapy for large- and medium-sized intracranial vessel occlusions as documented by diagnostic catheter-based cerebral angiography over the 12-year period. The median age of the patients was 71 years (range, 24–92 years); 51% of patients were male; 91% were white; and the median NIHSS score was 19 (range, 4–36; see Table 1). Of the 194 patients, 36 (18.6%) patients had anterior large-vessel occlusions, 131 (67.5%) had anterior medium-vessel occlusions, 5 (2.6%) had posterior large-vessel occlusions, and 22 (11.3%) had posterior medium-vessel occlusions. Medium-vessel occlusions were more common, affecting 153 (78.9%) of our patients. Extracranial occlusions were identified in 29 patients and were treated prior to intracranial treatment in 26 patients

(21 by stent, 3 by angioplasty, and 2 by suction). The median time for treatment of extracranial occlusions was 36 minutes (range, 15–76 minutes).

Pretreatment IV tPA was administered to 110 (56.7%) patients. Contraindications to IV tPA included administration of warfarin with an international normalized ratio greater than 1.7 (n = 20), recent surgery (n = 17), outside of the IV tPA time window of 3 hours (n = 42), history of bleeding or recent stroke (n = 4), and uncontrolled hypertension (n = 1).

Table 2 shows patient characteristics and procedure outcomes for the patient population, separated by primary treatment. The first line of treatment was IA tPA in 24 (12.4%) patients; 1st-generation devices in 128 (66.0%) patients, including 9 patients treated with Merci and 119 patients treated with Penumbra; and 2nd-generation devices in 42 (21.6%) patients (8 of the stent-trieter patients also had adjunctive large-bore suction catheters). IA tPA was the first-choice treatment in the first 3 years of the study period;

TABLE 2.
Patient Demographic Characteristics, Procedures Used, and Outcomes

	IA tPA ≥ 10 mg (n=24)		1st-generation devices (n=128)		2nd-generation devices (n=42)	
	No.	%	No.	%	No.	%
Year range	2002-2012		2005-2013		2012-2013	
Age, in years						
Median (range)	72 (25-78)		69 (24-92)		76 (47-89)	
80 years or older	0	0%	21	16.4%	12	28.6%
Occlusion location						
Large vessel	4	16.7%	29	22.7%	8	19.0%
Medium vessel	20	83.3%	99	77.3%	34	81.0%
Time from 1st to last angiogram, in minutes						
Median (range)	109 (23-201)		94 (16-268)		80 (18-257)	
IV tPA pretreatment						
Yes	8	33.3%	77	60.2%	25	59.5%
No	16	66.7%	51	39.8%	17	40.5%
Rescue procedure used						
	2	8.3%	48	37.5%	11	26.2%
TICI score achieved						
Grade 0	3	12.5%	7	5.5%	1	2.4%
Grade 1	8	33.3%	8	6.3%	1	2.4%
Grade 2	6	25.0%	19	14.8%	2	4.8%
Grade 2a	0	0%	15	11.7%	0	0%
Grade 2b	6	25.0%	63	49.2%	13	31.0%
Grade 2c	0	0%	4	3.1%	5	11.9%
Grade 3	1	4.2%	10	7.8%	11	26.2%
Grade 4	0	0%	2	1.6%	9	21.4%
TICI 2b achieved						
	7	29.2%	79	61.7%	38	90.5%
Procedural complications						
	0	0%	3	2.3%	1	2.4%
Distal emboli						
	6	25.0%	70	54.7%	18	42.9%

Note. IA, intra-arterial; IV, intravenous; TICI, Thrombolysis in Cerebral Infarction; tPA, tissue plasminogen activator.

TABLE 3.
Odds Ratios for Reaching TICl 2b Recanalization

	Univariate model		Multivariate model ^a	
	Odds ratio (95% CI)	P-value	Odds ratio (95% CI)	P-value
Age (10-year increments)				
	1.10 (0.90–1.35)	.35	0.99 (0.79–1.24)	.91
Female sex				
	0.94 (0.52–1.68)	.83	0.73 (0.37–1.41)	.34
Occlusion location				
Large vessel	Reference	—	Reference	—
Medium vessel	1.34 (0.66–2.70)	.42	1.48 (0.67–3.26)	.33
Collateral grade (1-unit increments)				
	1.21 (0.87–1.67)	.26	1.07 (0.74–1.54)	.71
IV tPA pretreatment				
	1.53 (0.85–2.76)	.16	1.33 (0.68–2.60)	.40
Procedure year				
	1.32 (1.16–1.50)	< .01*	1.10 (0.89–1.35)	.37
Primary procedure				
IA tPA	Reference	—	Reference	—
1st-generation devices	3.92 (1.51–10.12)	< .01*	2.42 (0.64–9.21)	.20
2nd-generation devices	23.07 (5.95–89.45)	< .01*	11.66 (1.56–87.01)	.02*

Note. CI, confidence interval; IA, intra-arterial; IV, intravenous; TICl, Thrombolysis in Cerebral Infarction; tPA, tissue plasminogen activator.
^aModel includes age, sex, occlusion location, collateral grade, pretreatment with IV tPA, procedure year, and primary procedure.
*P-value less than .05.

1st-generation mechanical thrombectomy devices were preferred over the next 7 years; and 2nd-generation mechanical thrombectomy devices were preferred in the last 2 years, corresponding to when the new technology was adopted at our facility. When mechanical thrombectomy was not technically possible, IA tPA was utilized.

Although median patient age was similar among primary treatment groups, treatment of those 80 years and older increased from 0% in the IA tPA group to 16.4% and 28.6% in the 1st- and 2nd-generation device groups, respectively. Occlusion locations were similar among the primary treatment groups. Secondary techniques (rescue procedures) were utilized for patients in whom TICl 2b recanalization was not obtained with the primary technique, and additional IA tPA was given in cases where TICl 2b recanalization was attained but emboli or distal occlusions that could not be accessed safely were present.

Recanalization of at least TICl 2b was achieved in 124 patients (63.9%; see Table 1). When separated by primary treatment, we found that TICl 2b and greater recanalization was achieved in 7 (29.2%) patients treated with primary IA tPA, in 79 (61.7%) patients treated with 1st-generation devices, and in 38 (90.5%) patients treated with 2nd-generation devices (see Table 2).

Given the correlation between procedure type and procedure year, we wanted to assess how much of this improvement was due to improved technology (apart from other influences that could be associated with a later procedure year). As shown in Table 3, the odds of TICl 2b or greater recanalization increased with later procedure year. Each year

was associated with 32% higher odds of reaching TICl 2b recanalization (odds ratio [OR], 1.32; 95% CI, 1.16–1.50). This estimate remained unchanged when adjusting for age, sex, occlusion location, angiographic collateral grade, and IV tPA pretreatment. When primary procedure type was added to the analysis (as shown in the multivariate model in Table 3), we found that a large portion of the improvement associated with later procedure year can be attributed to the use of new devices. As compared to IA tPA treatment, the odds of reaching at least TICl 2b recanalization was 2.42 (95% CI, 0.64–9.21) for 1st-generation devices and 11.66 (95% CI, 1.56–87.01) for 2nd-generation devices, when adjusted for age, sex, occlusion location, angiographic collateral grade, IV tPA pretreatment, and procedure year. Comparing 2nd-generation devices to 1st-generation devices, we also see increased odds of achieving at least TICl 2b recanalization (OR, 4.82; 95% CI, 1.40–16.66; as shown in the multivariate model).

First-generation and 2nd-generation device procedures showed higher proportions of patients reaching TICl 2b recanalization and shorter times to reach this stage of recanalization. As shown in Figure 1, 50% of patients treated with a 2nd-generation device reached TICl 2b recanalization by 54 minutes; for 1st-generation devices, 50% of patients reached TICl 2b recanalization by 99 minutes. In contrast, only 29% of patients whose primary treatment was IA tPA reached TICl 2b recanalization status. Rates of reaching TICl 2b recanalization improved with increasing procedure year (see Table 4; hazard ratio [HR], 1.22; 95% CI, 1.13–1.33). This estimate changed little when adjusting for age, sex, occlu-

sion location, angiographic collateral grade, and IV tPA pretreatment. Similar to the OR assessment, when procedure type was included in the model, we see that the improvement over time can mostly be explained by the adoption of new techniques. As compared to IA tPA treatment, the rate of reaching at least TICl 2b recanalization was 1.89 (95% CI, 0.74–4.86) for 1st-generation devices and 3.64 (95% CI, 1.12–11.87) for 2nd-generation devices, when adjusted for age, sex, occlusion location, angiographic collateral grade, IV tPA pretreatment, and procedure year. Comparing 2nd-generation devices to 1st-generation devices, we also see an increased rate of reaching at least TICl 2b recanalization (HR, 1.93; 95% CI, 1.15–3.22; as shown in the multivariate model).

Additionally, patient recanalization more often reached scores of TICl 3 or 4 with advancements in treatment options. Among patients treated with IA tPA, only 1 (4.2%) patient reached TICl 3 recanalization; in comparison, 12 (9.4%) and 20 (47.6%) patients reached TICl 3 or 4 with 1st- and 2nd-generation device primary treatment, respectively.

In our population, pretreatment with IV tPA was not associated with an increased odds of reaching at least TICl 2b recanalization (adjusted OR, 1.33; 95% CI, 0.68–2.60; see Table 3).

There were 4 (2.1%) procedural complications that occurred in our patient population. Three of these complications occurred during Penumbra procedures in which there was a vascular perforation, and 1 complication occurred during a stent-trieter procedure in which the stent-trieter detached.

Discussion

Ischemic stroke continues to be a leading cause of morbidity and mortality in the United States, with upwards of 795,000 people in the United States affected yearly [18, 19]. This led to a focus on acute treatment for ischemic stroke starting in the 1990s, supported by data from trials such as the National Institute of Neurological Disorders and Stroke study for IV tPA therapy, which showed that treatment resulted in significant reduction in stroke morbidity [20]. Many studies of acute stroke therapy have supported the notion that quicker reperfusion leads to more favorable outcomes [7–14]. The degree of recanalization has also been shown to impact patients' clinical and mortality outcomes [9, 10, 13, 21].

IA therapy for acute stroke has evolved quickly over the past decade, due in large part to changes in technology. Initial trials such as PROACT II, published in 1998, studied IA infusion of pro-urokinase in acute stroke [22]. Although pro-urokinase was not approved by the US Food and Drug Administration (FDA) for intracranial IA use, these trials led to the IA use of FDA-approved thrombolytics such as tPA for this purpose. The 2 hours necessary to infuse the recommended dose of a thrombolytic agent is a potential drawback, however, as rapid recanalization is generally recognized to improve outcomes [8, 12, 13].

The need for faster and more effective recanalization led to development of the 1st generation of mechanical thrombectomy devices, which included the Merci device (2004) and the Penumbra device (2006) [23, 24]. Trials using these

TABLE 4.
Hazard Ratios for Reaching TICl 2b Recanalization

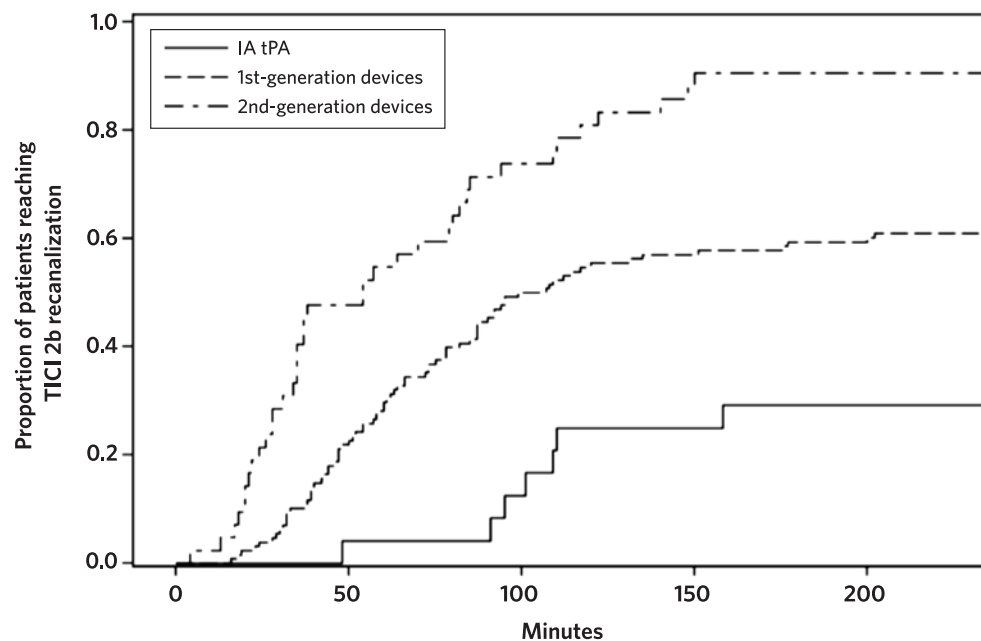
	Univariate model		Multivariate model ^a	
	Hazard ratio (95% CI)	P-value	Hazard ratio (95% CI)	P-value
Age (10-year increments)				
	1.08 (0.95–1.23)	.22	1.00 (0.87–1.14)	.99
Female sex				
	0.97 (0.68–1.38)	.85	0.78 (0.54–1.12)	.18
Occlusion location				
Large vessel	Reference	—	Reference	—
Medium vessel	1.26 (0.81–1.96)	.31	1.37 (0.86–2.16)	.18
Collateral grade (1-unit increments)				
	1.18 (0.97–1.45)	.10	1.09 (0.88–1.36)	.41
IV tPA pretreatment				
	1.33 (0.93–1.91)	.12	1.23 (0.84–1.80)	.28
Procedure year				
	1.22 (1.13–1.33)	< .01*	1.10 (0.97–1.25)	.13
Primary procedure				
IA tPA	Reference	—	Reference	—
1st-generation devices	2.97 (1.37–6.43)	< .01*	1.89 (0.74–4.86)	.19
2nd-generation devices	7.22 (3.21–16.23)	< .01*	3.64 (1.12–11.87)	.02*

Note. CI, confidence interval; IA, intra-arterial; IV, intravenous; TICl, Thrombolysis in Cerebral Infarction; tPA, tissue plasminogen activator.

^aModel includes age, sex, occlusion location, collateral grade, pretreatment with IV tPA, procedure year, and primary procedure.

*P-value less than .05.

FIGURE 1.
Kaplan Meier Curves Showing Time to Reach TICl 2b Recanalization, by Primary Procedure Type^a



Note. IA tPA, intra-arterial tissue plasminogen activator; TICl, Thrombolysis in Cerebral Infarction.
^aLog-rank test statistic = 36.75; $P < .01$.

devices demonstrated improved recanalization outcomes as well as faster recanalization, compared to IA tPA [23-25]. Second-generation devices consisting of stent-trievers (2011) and large-bore suction catheters (2013) continued this trend [1, 26], with recanalization rates reaching as high as 90% and the time to recanalization markedly decreasing [14, 26-28]. Recent randomized controlled trials using stent-trievers for acute treatment of stroke confirmed these better recanalization rates and found that stent-triever treatment led to better functional outcomes and reduced mortality [2-6].

Mission Hospital was designated as a primary stroke center in 2007, and we began to use telehealth in 2011. Currently, the hospital treats approximately 150 acute stroke patients per year, 30-50 of whom are candidates for IA treatment. We evaluated the degree of recanalization and time to recanalization associated with the adoption of new IA technologies by reviewing patient records and imaging results for 194 patients treated for acute stroke with IA therapies over the past 12 years.

With increased attention to stroke treatment at our institution over this time period, we saw, as expected, a higher chance of TICl 2b recanalization associated with a later procedure year. We also saw that a large portion of this improvement was associated with the advancement of endovascular technologies. Second-generation devices showed a clinically and statistically significant increase in the odds of TICl 2b recanalization as compared to both IA tPA treatment and procedures using 1st-generation

devices. Not only were the patients treated with newer techniques more likely to reach TICl 2b recanalization, they reached this stage faster. Assessment of 1st-generation devices pointed towards improved recanalization outcomes as compared to IA tPA treatment, but this estimate was not statistically significant. Although other reports have found a correlation between collateral grade and recanalization rates and times [29], we did not find this in our analysis.

Our findings showed no significant effect on likelihood of TICl 2b recanalization or speed of TICl 2b recanalization when patients were pretreated with IV tPA. We plan to investigate our patients with acute large- and medium-vessel occlusions who were treated only with IV tPA to further clarify the role of IV tPA treatment in these patients.

There are several limitations to our study. This was a retrospective, observational (nonrandomized) study at a single institution, thus limiting both our sample size and perhaps our generalizability to patient populations at other institutions. We included only patients with medium- and large-vessel occlusions. We also may have omitted patients with large-vessel occlusions documented on CTA who received IV tPA. Our outcome measures were degree and speed of recanalization and not inpatient mortality, symptomatic intracranial hemorrhage, discharge destination, or long-term functional outcomes. However, time to recanalization and degree of recanalization are considered to be 2 of the most important factors that influence outcomes in acute stroke intervention [7-14].

Conclusion

This retrospective review of patients treated in a single community hospital illustrates how technological advances in endovascular stroke therapy over a 12-year period significantly improved the chances of TICI 2b or greater recanalization and reduced time to TICI 2b recanalization. This study highlights how care pathways and techniques found to be efficacious in randomized controlled studies conducted at academic institutions can be effectively translated into practice in community hospitals. Our study shows that adopting new acute stroke treatment technologies in the community hospital setting helps to provide the highest standard of care for our patients. NCMJ

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