Clinical and Procedural Predictors of Outcomes From the Endovascular Treatment of Posterior Circulation Strokes

Maxim Mokin, MD, PhD; Ashish Sonig, MD, MS; Sananthan Sivakanthan, BS; Zeguang Ren, MD, PhD; Lucas Elijovich, MD; Adam Arthur, MD, MPH; Nitin Goyal, MD; Peter Kan, MD, MPH; Edward Duckworth, MD; Erol Veznedaroglu, MD; Mandy J. Binning, MD; Kenneth M. Liebman, MD; Vikas Rao, MD; Raymond D. Turner IV, MD; Aquilla S. Turk, DO; Blaise W. Baxter, MD; Guilherme Dabus, MD; Italo Linfante, MD; Kenneth V. Snyder, MD, PhD; Elad I. Levy, MD, MBA; Adnan H. Siddiqui, MD, PhD

Background and Purpose—Patients with posterior circulation strokes have been excluded from recent randomized endovascular stroke trials. We reviewed the recent multicenter experience with endovascular treatment of posterior circulation strokes to identify the clinical, radiographic, and procedural predictors of successful recanalization and good neurological outcomes.

Methods—We performed a multicenter retrospective analysis of consecutive patients with posterior circulation strokes, who underwent thrombectomy with stent retrievers or primary aspiration thrombectomy (including A Direct Aspiration First Pass Technique [ADAPT] approach). We correlated clinical and radiographic outcomes with demographic, clinical, and technical characteristics.

Results—A total of 100 patients were included in the final analysis (mean age, 63.5±14.2 years; mean admission National Institutes of Health Stroke Scale score, 19.2±8.2). Favorable clinical outcome at 3 months (modified Rankin Scale score ≤2) was achieved in 35% of patients. Successful recanalization and shorter time from stroke onset to the start of the procedure were significant predictors of favorable clinical outcome at 90 days. Stent retriever and aspiration thrombectomy as primary treatment approaches showed comparable procedural and clinical outcomes. None of the baseline advanced imaging modalities (magnetic resonance imaging, computed tomographic perfusion, or computed tomography angiography assessment of collaterals) showed superiority in selecting patients for thrombectomy.

Conclusions—Time to the start of the procedure is an important predictor of clinical success after thrombectomy in patients with posterior circulation strokes. Both stent retriever and aspiration thrombectomy as primary treatment approaches are effective in achieving successful recanalization. **(*Stroke*. 2016;47:782-788. DOI: 10.1161/STROKEAHA.115.011598.)**

Key Words: endovascular procedures ■ magnetic resonance imaging ■ stents ■ stroke ■ thrombectomy

Recent randomized stroke trials Multicenter Randomized Clinical Trial of Endovascular Treatment of Acute Ischemic Stroke in the Netherlands [MR CLEAN],[1] Endovascular Treatment for Small Core and Anterior Circulation Proximal Occlusion With Emphasis on Minimizing Computed Tomography to Recanalization Times [ESCAPE],[2] Solitaire With the Intention For Thrombectomy as Primary Endovascular treatment [SWIFT PRIME],[3] Extending the Time for Thrombolysis in Emergency Neurological Deficits–Intra-arterial [EXTEND-IA],[4] Randomized Trial of Revascularization With Solitaire FR Device Versus Best Medical Therapy in the Treatment of Acute Stroke Due to Anterior Circulation Large Vessel Occlusion Presenting Within Eight Hours of Symptom Onset [REVASCAT][5]) demonstrated superiority of modern endovascular thrombectomy approaches in patients with acute ischemic stroke from large vessel occlusion when compared

Received September 22, 2015; final revision received October 26, 2015; accepted October 27, 2015.

From the Department of Neurosurgery, University of South Florida, Tampa (M.M., S.S., Z.R.); Department of Neurosurgery, University at Buffalo, State University of New York (A.S., K.V.S., E.I.L., A.H.S.); Department of Neurosurgery, Semmes-Murphey Neurologic and Spine Institute, Memphis, TN (L.E., A.A., N.G.); Department of Neurosurgery, Baylor College of Medicine, Houston, TX (P.K., E.D.); Capital Institute of Neurosciences, Capital Health Systems, Trenton, NJ (E.V., M.J.B., K.M.L., V.R.); Department of Neurosurgery and Radiology, Medical University of South Carolina, Charleston (R.D.T., A.S.T.); Department of Radiology, Erlanger Medical Center, Chattanooga, TN (B.W.B.); and Miami Cardiac and Vascular Institute and Neuroscience Center, Baptist Hospital, FL (G.D., I.L.).

Presented in part at the International Stroke Conference of the American Heart Association, Los Angeles, CA, February 17–19, 2016.

The online-only Data Supplement is available with this article at http://stroke.ahajournals.org/lookup/suppl/doi:10.1161/STROKEAHA.115.011598/-/DC1.

Correspondence to Maxim Mokin, MD, PhD, Department of Neurosurgery, University of South Florida, 2 Tampa General Cir, 7th floor, Tampa, FL 33606. E-mail maximmokin@gmail.com

Stroke **is available at http://stroke.ahajournals.org** **DOI: 10.1161/STROKEAHA.115.011598**

with the standard medical therapy alone, including the use of intravenous thrombolysis. With some variations in imaging inclusion criteria and time window for randomization, all the 5 trials shared 1 key feature, that is, only patients with anterior circulation strokes were included. Recently updated American Heart Association/American Stroke Association (AHA/ASA) guidelines for the management of patients with acute ischemic stroke stated that, although uncertain, thrombectomy may be reasonable in carefully selected patients with posterior circulation strokes, when initiated within the first 6 hours of stroke onset (Class IIb, Level of Evidence C).[6]

Outside of clinical trials, endovascular therapy of posterior circulation strokes with stent retrievers and modern distal aspiration catheters is currently offered to a variety of patients using different selection criteria and treatment approaches, resulting in a wide range of clinical outcomes.[7–10] However, clinical and imaging predictors of success outcomes, and optimal recanalization approaches in this specific group of patients are not understood as well as in anterior circulation strokes because posterior circulation strokes have not been studied extensively. The aim of this study was to review our recent multicenter experience with endovascular treatment of

Table 1. Univariate Analysis of Predictors of Outcome After Endovascular Therapy of Posterior Circulation Strokes

	Overall, n=100	Favorable Outcome (mRS Score ≤2, n=35)	Poor Outcome (mRS Score >2, n=65)	*P* Value
Demographics				
Age, y, mean±SD	63.5±14.2	63.4±15.0	63.6±13.9	0.95
NIHSS score on admission, mean±SD	19.2±8.2	15.5±6.7	21.1±8.5	0.0004
Female sex, n (%)	33/100 (33)	13/35 (37)	20/65 (31)	0.66
Atrial fibrillation, n (%)	28/100 (28)	10/35 (29)	18/65 (28)	1.0
Coronary artery disease or myocardial infarction, n (%)	34/100 (34)	14/35 (40)	20/65 (31)	0.38
Diabetes mellitus, n (%)	37/100 (37)	11/35 (31)	26/65 (40)	0.52
Hypertension, n (%)	75/100 (75)	26/35 (74)	49/65 (75)	1.0
Dyslipidemia, n (%)	59/100 (59)	23/35 (66)	36/65 (55)	0.4
Smoker, n (%)	30/100 (30)	12/35 (34)	18/65 (28)	0.5
Occlusion site involves				
Top of basilar artery, n (%)	46/100 (46)	15/35 (43)	31/65 (48)	0.68
Basilar artery, other, n (%)	48/100 (48)	14/35 (40)	34/65 (52)	0.3
Posterior cerebral artery, n (%)	31/100 (31)	9/35 (26)	22/65 (34)	0.5
Vertebral artery, n (%)	21/100 (21)	6/35 (17)	15/65 (23)	0.61
Imaging modality used				
MRI, n (%)	9/100 (9)	1/35 (3)	8/65 (12)	0.16
CT perfusion, n (%)	60/100 (60)	24/35 (69)	36/65 (55)	0.28
CTA with collaterals assessment, n (%)	80/100 (80)	30/35 (86)	50/65 (77)	0.43
Treatment details				
General anesthesia, n (%)	60/100 (60)	16/35 (46)	44/65 (68)	0.053
IV tPA administration, n (%)	32/100 (32)	17/35 (49)	15/65 (23)	0.013
Use of stent retriever as first-line strategy, n (%)	58/100 (58)	21/35 (60)	37/65 (57)	0.83
Aspiration as first-line strategy (including subsequent use of stent retriever, if needed), n (%)	42/100 (42)	14/35 (40)	28/65 (43)	0.83
Use of rescue therapy, n (%)	19/100 (19)	4/35 (11)	15/65 (23)	0.19
Symptom onset to femoral artery puncture (min), mean±SD	562±466	423±344	637±505	0.015
Symptom onset to femoral artery puncture within				
0–3 h, n (%)	16	8/16 (50)	8/16 (50)	0.053
3–6 h, n (%)	29	14/29 (48)	15/29 (52)	
6–12 h, n (%)	26	6/26 (23)	20/26 (77)	
>12 h, n (%)	29	7/29 (24)	22/29 (76)	
Procedure duration (min), mean±SD	51±38	51±35	52±40	0.87
Treatment outcome				
TICI 2b/3 (successful) recanalization, n (%)	80/100 (80)	34/35 (97)	46/65 (71)	0.0013
Symptomatic ICH, n (%)	5/100 (5)	1/35 (3)	4/65 (6)	0.66

CT indicates computed tomography; CTA, CT angiography; IV, intravenous; ICH, intracerebral hemorrhage; MRI, magnetic resonance imaging; mRS, modified Rankin Scale; NIHSS, National Institutes of Health Stroke Scale; TICI, thrombolysis in cerebral infarction; and tPA, tissue-type plasminogen activator.

posterior circulation strokes and identify clinical, imaging, and procedural predictors of successful recanalization and good neurological outcomes.

Methods

The study was approved by the local institutional review board at each participating center for retrospective data collection and review. Data on consecutive stroke cases with posterior circulation strokes who underwent stent retriever thrombectomy since the Food and Drug Administration approval of stent retrievers Trevo (Stryker, Kalamazoo, MI) and Solitaire FR (Medtronic, Minneapolis, MN) or primary aspiration thrombectomy using large-bore aspiration catheters (Penumbra Inc., Alameda, CA) between March 2012 and July 2015 were collected. Posterior circulation strokes were defined as strokes with large vessel occlusion including 1 or more of the following segments: basilar artery, posterior cerebral artery, or V4 segment vertebral artery. All participating centers used no upper age or National Institutes of Health Stroke Scale (NIHSS) score limit when selecting patients for endovascular therapy. All centers considered treatment of patients with up to 24 hours of stroke onset. Intubation was not an exclusion criterion. The choice of imaging modality at each participating center is listed in Table I in the online-only Data Supplement. The choice of imaging modality was based on each center's acute stroke imaging protocol. All centers excluded patients with large brain stem strokes from endovascular treatment.

The following data were collected: age, sex, cerebrovascular risk factors, admission NIHSS score, time of symptom onset, the type of screening imaging modality, and intravenous tissue-type plasminogen activator (tPA) use in the emergency room. Procedural technical details included femoral artery puncture and final recanalization times, type of primary endovascular therapy (stent retriever or direct aspiration), number of retrieval passes, and the use and description of rescue therapy. Stent retriever thrombectomy was considered the primary treatment strategy when distal aspiration alone was not performed initially, and at least one pass with the stent retriever device was attempted first. Primary aspiration was considered the first-line strategy, when aspiration thrombectomy with a large-bore aspiration catheter alone was attempted first, according to the technique described previously.[7,11]

Successful recanalization was defined as a Thrombolysis in Cerebral Infarction (TICI) score of 2b/3.[12] Functional neurological outcomes were quantified using the modified Rankin Scale at 90 days. Favorable outcome was defined as modified Rankin Scale score of ≤2. Intracranial hemorrhage was classified as symptomatic if it was associated with any worsening of NIHSS score. Baseline imaging, recanalization rates, and postprocedural imaging were reviewed by local investigators at each participating site and were not adjudicated by a central core laboratory.

Statistical analysis for each outcome variable analyzed in this study was performed with SAS statistical software (SAS Institute, Cary, NC). Analysis of univariate data was performed using the 2-tailed *t* test for continuous data, Fisher exact test for categorical data, and the Mann–Whitney *U* test, where appropriate. Multivariate analysis of variance (MANOVA) was used for all other data. For all statistical analyses, $P<0.05$ was considered statistically significant.

Results

A total of 102 patients with posterior circulation strokes from 8 participating centers were treated with endovascular therapy during the study period. In 2 cases, local intra-arterial thrombolysis with recombinant tPA was performed first resulting in successful recanalization, and planned mechanical thrombectomy was not performed. These 2 cases were excluded, thus, a total of 100 cases were included in final analysis.

Mean age was 63.5±14.2 years, with a mean admission NIHSS score of 19.2±8.2. Baseline clinical and imaging characteristics are shown in Table 1. Mean time from symptom onset to femoral artery puncture was 562±466 minutes. Successful recanalization was achieved in 80 (80%) cases. Symptomatic intracranial hemorrhage occurred in 5 patients (5%). Mortality rate during hospitalization was 30%. Thirty-five (35%) patients had favorable outcome at 3 months. Univariate analysis comparing predictors of clinical outcome (favorable versus poor) is shown in Table 1. Age, demographic factors, and sites of vessel occlusion showed similar distribution between the 2 groups. None of advanced imaging modalities used (magnetic resonance imaging [MRI], computed tomography [CT] perfusion, or CT angiography with assessment of collaterals) correlated with better clinical outcomes. Baseline NIHSS score was higher in patients with poor outcome, 21.1±8.5, than in patients with good outcome, 15.5±6.7; $P=0.0004$.

Shorter time from symptoms onset to the start of the procedure (femoral puncture, mean time 432 versus 637 minutes in patients with poor outcomes; $P=0.015$) and successful recanalization ($P=0.0013$) was associated with favorable clinical outcomes at 3 months. The rate of favorable clinical outcome progressively decreased with longer time to femoral puncture from symptom onset (Figure) but did not reach statistical significance in the entire cohort of 100 patients when the Mann–Whitney *U* test was used (Table 1; $P=0.053$). However, when dichotomization by time was applied only to the population of patient with successful recanalization (TICI 2b/3), to exclude the effect of poor recanalization on outcomes, there was a significant association between clinical success rate and the time of the procedure (Table 2; $P=0.02$). Multivariate analysis (Table 3) confirmed the association between the start of the procedure within 6 hours and favorable outcome ($P=0.011$), as well as with the ability to achieve recanalization within 6 hours ($P=0.0039$).

Intravenous tPA was administered before initiation of thrombectomy in 32 cases. Of those, endovascular therapy was initiated in 20 cases within 6 hours of stroke onset, with a 65% rate of favorable clinical outcome at 3 months. In the remaining 12 cases, thrombectomy was initiated beyond 6 hours, with favorable clinical outcome rate of only 30%.

When treatment outcomes were compared among the 8 participating centers, there was no difference in the rates of successful recanalization ($P=0.96$), but there was significant variability in the rates of favorable clinical outcome at

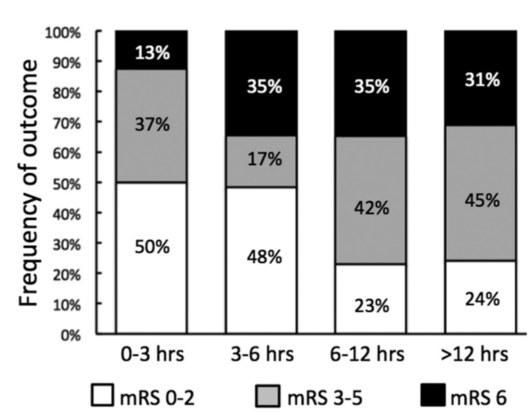

Figure. Clinical outcomes of patients according to the modified Rankin Scale (mRS) at 3 months, depending on the time from symptom onset to the start of procedure (femoral puncture).

Table 2. Univariate Analysis of Predictors of Outcome in Subgroup of Patients in Whom Successful Recanalization (TICI 2b/3) Was Achieved

	Overall, n=80	Favorable Outcome (mRS Score ≤2, n=34)	Poor Outcome, (mRS Score >2, n=46)	*P* Value
Imaging modality, n (%)				
MRI	5/80 (6)	1/34 (3)	4/46 (9)	0.39
CT perfusion	51/80 (64)	23/34 (68)	28/46 (61)	0.64
CTA with collaterals assessment	65/80 (81)	30/34 (88)	35/46 (76)	0.25
Treatment details				
General anesthesia, n (%)	48/80 (60)	16/34 (47)	32/46 (70)	0.064
Procedure duration (min), mean±SD	47±31	48±30	46±31	0.85
IV tPA use, n (%)	24/80 (30)	17/34 (50)	7/46 (15)	0.0012
Symptom onset to femoral artery puncture				
0–3 h, n (%)	12	8/12 (67)	4/12 (33)	0.020
3–6 h, n (%)	24	14/24 (58)	10/24 (42)	
6–12 h, n (%)	21	6/21 (29)	15/21 (71)	
>12 h, n (%)	23	6/23 (26)	17/23 (74)	

CT indicates computed tomography; CTA, CT angiography; IV, intravenous; MRI, magnetic resonance imaging; mRS, modified Rankin Scale; TICI, thrombolysis in cerebral infarction; and tPA, tissue-type plasminogen activator.

3 months (P=0.32), as shown in Table I in the online-only Data Supplement. This could be because of variations in time from stroke onset to start of procedure among the participating centers; the center with the shortest mean time from stroke onset to femoral puncture (296 minutes) had the highest rate of favorable clinical outcome (60%).

Stent retriever thrombectomy as the primary approach to revascularization was used in 58 of 100 (58%) of cases. In the remainder 42 cases, primary aspiration thrombectomy without the use of a stent retriever was attempted first. The rate of conversion to the use of stent retriever in those cases was 20 of 42 (48%). There was no significant difference between recanalization rates, the use of rescue therapy, overall procedure duration, and clinical outcome between the 2 treatment approaches (Tables 4 and 5).

Out of 100 cases, 19 cases required the use of rescue therapy. In 13 (68%) of those 19 cases, TICI 2b/3 was achieved after the use of rescue therapy, and the use of rescue therapy was not associated with poor clinical outcomes (Tables 4 and 5).

Discussion

Our study represents a real world experience with the endovascular treatment of posterior circulation strokes using modern endovascular therapies, including stent retrievers and large-bore distal aspiration catheters. One of the key findings is the strong effect of time to treatment on the rate of clinical outcome. In our series, the rate of good clinical outcome was twice as high in patients, whose thrombectomy was initiated within the first 6 hours than in patients treated beyond the 6-hour window. The strong effect of time to intervention and reperfusion on clinical outcomes is well described in anterior circulation strokes. This includes the recent analysis of SWIFT and Solitaire FR Thrombectomy for Acute Revascularisation (STAR) trials,[13] studies focusing on early generation thrombectomy approaches, such as the IMS III data set analysis,[14] and the pooled analysis of the Mechanical Embolus Removal in Cerebral Ischemia (MERCI) and Multi Mechanical Embolus Removal in Cerebral Ischemia (MERCI) trials.[15] However, there was no effect of time to the start of

Table 3. Multivariate Predictors of Good Clinical Outcome (mRS Score ≤2) at 3 Months

	Overall, n=100	mRS Score ≤2, Total n=35	mRS Score >2, Total n=65	*P* Value
Age >80 y	12/100 (12%)	5/35 (14%)	7/65 (11%)	0.748
NIHSS>20	36/100 (36%)	9/35 (25%)	27/65 (42%)	0.086
Time of treatment (femoral puncture) within 0–6 h of onset	45/100 (45%)	22/35 (63%)	23/65 (35%)	0.011
Procedure duration >60 min (data available on 90 cases)	20/90 (22%)	8/34 (24%)	12/56 (21%)	0.48
Time to recanalization within 0–6 h (data available on 90 cases)	33/90 (36%)	19/34 (56%)	14/56 (25%)	0.0039
Use of general anesthesia	60/100 (60%)	16/35 (46%)	44/65 (68%)	0.053
Use of rescue therapy	19/100 (19%)	4/35 (11%)	15/65 (23%)	0.189
TICI 2b/3	80/100 (80%)	34/35 (97%)	46/65 (71%)	0.00085

mRS, modified Rankin Scale; NIHSS, National Institutes of Health Stroke Scale; and TICI, thrombolysis in cerebral infarction.

Table 4. Comparison of Endovascular Treatment Approaches Using Multivariate Analysis

	Overall, n=100	Stent Retriever as Primary Strategy, n=58	Aspiration as Primary Strategy (Including Subsequent Stent Retriever Use), n=42	*P* Value
Procedure duration (min), mean±SD	52±38	56±44	46±28	0.093
Use of rescue therapy, n (%)	19/100 (19)	13/58	6/42	0.439
TICI 2b/3, n (%)	80/100 (80)	45/58 (78)	35/42 (83)	0.32
mRS score ≤2 at 3 mo, n (%)	35/100 (35)	21/58 (36)	14/42 (33)	0.5

mRS indicates modified Rankin Scale; and TICI, thrombolysis in cerebral infarction.

intervention on the rate of successful recanalization in our series, which remained consistently around 80%.

The 6-hour window cutoff might be an important criterion for prediction of outcomes in patients with posterior circulation strokes, who undergo thrombectomy, but this needs to be further investigated. In a systematic review of studies describing outcomes of basilar artery occlusion treated with stent retriever thrombectomy, of 10 articles that reported time to recanalization, 8 indicated that thrombectomy was initiated beyond the 6-hour window.[16] In our cohort, patients who received intravenous tPA first had a delay in initiation of endovascular therapy beyond 6 hours in 38% of cases. This could be a reflection of a paradigm where endovascular therapy would only be considered once intravenous tPA failure was demonstrated, which is no longer recommended by the AHA/ASA guidelines for anterior circulation strokes.[6]

Presently, no evidence-based recommendations for endovascular therapy of posterior circulation strokes exist, either within or beyond the 6-hour window. The Basilar Artery International Cooperation Study (BASICS) is recruiting patients to determine whether endovascular therapy provides additional benefit to best medical management (including intravenous tPA within 4.5 hours).[17] The protocol of this randomized trial requires initiation of endovascular therapy within 6 hours of stroke onset.

Singer et al[18] recently analyzed 148 consecutive patients with basilar artery occlusion as a part of the Endovascular Stroke Treatment (ENDOSTROKE) registry. This study currently represents the largest series of posterior circulation strokes treated with contemporary thrombectomy devices, of which 84% were stent retrievers. Thirty-four percent of their patients were functionally independent (modified Rankin Scale score, 0–2) at 3 months, and mortality was 35%, which is similar to our findings. However, in ENDOSTROKE, symptom onset to treatment time was not significantly associated with clinical outcomes, although a trend toward a higher rate of poor outcomes from thrombectomy initiated beyond the 9-hour window was noted by the authors.

In our series, none of the advanced imaging studies was associated with higher rates of clinical outcomes. In contrast,

Table 5. Predictors of Successful Versus Poor Recanalization

	Overall	Successful Recanalization (TICI 2b/3, Total n=80)	Poor Recanalization (TICI 0–2a, Total n=20)	*P* Value
Occlusion segment involves, n (%)				
Top of basilar artery	46/100 (46)	36/80 (45)	10/20 (50)	0.80
Basilar artery, other	48/100 (48)	40/80 (50)	8/20 (40)	0.46
Posterior cerebral artery	31/100 (31)	23/80 (29)	8/20 (40)	0.42
Vertebral artery	21/100 (21)	18/80 (23)	3/20 (15)	0.55
Treatment approaches, n (%)				
IV tPA administration	32/100 (32)	24/80 (30)	8/20 (40)	0.43
Use of stent retriever as first-line strategy	58/100 (58)	45/80 (56)	13/20 (65)	0.61
Aspiration as first-line strategy (including subsequent use of stent retriever, if needed)	42/100 (42)	35/80 (44)	7/20 (35)	0.61
Use of rescue therapy	19/100 (19)	13/80 (16)	6/20 (30)	0.20
No. of stent retriever passes (data available from 71 cases), n (%)				
1 pass	31/71 (44)	…	…	…
2 passes	27/71 (38)	…	…	…
≥3 passes	13/71 (18)	…	…	…
Symptom onset to femoral artery puncture				
0–3 h, n (%)	16	13/16 (81)	3/16 (19)	0.804
3–6 h, n (%)	29	24/29 (83)	5/29 (17)	
6–12 h, n (%)	26	21/26 (81)	5/26 (19)	
>12 h, n (%)	29	23/29 (79)	6/29 (21)	

IV indicates intravenous; TICI, thrombolysis in cerebral infarction; and tPA, tissue-type plasminogen activator.

in the ENDOSTROKE registry, the use of MRI was found to be associated with better clinical outcomes than CT-based patient selection.[18] In our series, the number of patients, who were selected with MRI-based approach, was disproportionally low, which might have introduced a type II error. An alternative explanation would be that perfusion-guided selection or assessment of collateral status with CT angiography is equally accurate for patient selection when compared with the use of MRI. All of the cases included in our series had at least 1 type of advanced imaging modality used for selection purposes. Other studies indicate that all 3 imaging modalities (MRI, CT perfusion, and CT angiography assessment of collaterals) could be used for prediction of clinical outcomes in posterior circulation strokes.[19–21]

Another important finding in our series is that both stent retriever thrombectomy and aspiration thrombectomy demonstrate comparable angiographic and clinical outcomes. In cases, where aspiration thrombectomy alone was attempted first, nearly half of cases (48%) subsequently required the use of stent retrievers. This conversion rate is higher than what was demonstrated in A Direct Aspiration First Pass Technique for Acute Stroke Thrombectomy (ADAPT FAST) series, where successful recanalization with aspiration alone was achieved in 78% of cases. One potential explanation is that in ADAPT FAST, only 5% of cases involved the posterior circulation, which might be more challenging for the primary aspiration approach.[7] Son et al[22] compared procedural details of basilar artery occlusion thrombectomy from a single center, where 13 patients were treated with the Solitaire stent retriever and 18 patients were treated with primary aspiration thrombectomy alone. There was no significant difference between clinical outcomes. The overall rates of TICI 2b/3 recanalization were similar, but the rate of complete recanalization, defined as TICI 3, was significantly higher in patients treated with aspiration thrombectomy. None of the 18 patients treated with aspiration thrombectomy required the use of stent retrievers or other rescue therapy. Jankowitz et al[10] in their series of 112 patients with aspiration thrombectomy (of which only 12 patients had posterior circulation strokes) reported 41% rate of conversion for adjunct therapy, which mostly included stent retriever. Given the variability in procedural details, a prospective randomized study is needed to definitively determine whether one of the thrombectomy approaches is superior to the other.

Limitations of our study include its retrospective design, variations in treatment protocols, and patient selection criteria at individual participating centers. The images were not adjudicated by an independent core laboratory, creating the possibility of miscalculating angiographic results and symptomatic intracranial hemorrhage rates.

Conclusions

Time to the start of procedure is an important predictor of clinical success after thrombectomy in patients with posterior circulation strokes. The rate of good clinical outcome was twice as high in patients whose thrombectomy was initiated within the first 6 hours than in patients treated beyond the 6-hour window. Both stent retriever and aspiration thrombectomy as primary treatment approaches are effective in achieving successful recanalization and have similar rates of good clinical outcome.

Disclosures

Dr Arthur—speaker's bureau: Stryker, Siemens, and Medtronic; ownership interest: Lazarus Effect; consultant/advisory board: Silk Road, Penumbra, and Codman. Dr Baxter—consultant/speaker: Medtronic, Stryker, Penumbra, Silk Road, Rapid Medical, and Pulsar. Dr Dabus—honoraria: Medtronic, Microvention, and Penumbra; ownership interest: Medina/Medtronic, Surpass/Stryker, and InNeuroCo; consultant/advisory board: Medtronic, Microvention, and Penumbra. Dr Elijovich—consultant: Stryker Neurovascular, Microvention, and Codman Neurovascular. Dr Kan—consultant/advisory board: Medtronic and Stryker. Dr Levy—shareholder/ownership interests: Intratech Medical Ltd, Blockade Medical LLC, and Medina Medical; principal investigator: Covidien US SWIFT PRIME trials; honoraria for training and lecturing: Covidien; consultant: Pulsar, Medina Medical, and Blockade Medical; other financial support: Abbott for carotid training for physicians. Dr Liebman—consultant: Stryker. Dr Linfante—consultant and speaker bureau: Covidien, Codman, Stryker. Dr Siddiqui—speaker's bureau: Codman & Shurtleff; honoraria: Penumbra Inc and Toshiba America Medical Systems; ownership interest: Hotspur, IntraTech Medical, StimSox, Valor Medial, Blockade Medical, Lazarus Effect, Pulsar Vascular, and Medina Medical; consultant/advisory board: Codman & Shurtleff Inc, Covidien Vascular Therapies, GuidePoint Global Consulting, Blockade Medical, Reverse Medical, W.L. Gore & Associates, ICAVL, and Medican Medical. Dr Snyder—speaker's bureau: Toshiba; honoraria: Toshiba. Dr Turk—ownership interest: Lazarus Effect; consultant/advisory board: Penumbra, Lazarus Effect, and Siemens. Dr Turner—consultant: Medtronic, Microvention, Codman, Blockade, Penumbra, and Pulsar Vascular. Dr Veznedaroglu—consultant/advisory board: Codman, Cordis, Micrus, Microvention, and Stryker. The other authors report no conflicts. Dr Snyder received research grants from Toshiba, Medtronic, Abbott Vascular, Boston Scientific, and EV3, and also received other research support from Toshia, Medtronic, Abbott Vascular, Boston Scientific, and EV3.

References

1. Berkhemer OA, Fransen PS, Beumer D, van den Berg LA, Lingsma HF, Yoo AJ, et al. A randomized trial of intraarterial treatment for acute ischemic stroke. *N Engl J Med*. 2015;372:11–20.
2. Goyal M, Demchuk AM, Menon BK, Eesa M, Rempel JL, Thornton J, et al; ESCAPE Trial Investigators. Randomized assessment of rapid endovascular treatment of ischemic stroke. *N Engl J Med*. 2015;372:1019–1030. doi: 10.1056/NEJMoa1414905.
3. Saver JL, Goyal M, Bonafe A, Diener HC, Levy EI, Pereira VM, et al; SWIFT PRIME Investigators. Stent-retriever thrombectomy after intravenous t-PA vs. t-PA alone in stroke. *N Engl J Med*. 2015;372:2285–2295. doi: 10.1056/NEJMoa1415061.
4. Campbell BC, Mitchell PJ, Kleinig TJ, Dewey HM, Churilov L, Yassi N, et al. Endovascular therapy for ischemic stroke with perfusion-imaging selection. *N Engl J Med*. 2015;372:1009–1018.
5. Jovin TG, Chamorro A, Cobo E, de Miquel MA, Molina CA, Rovira A, et al; REVASCAT Trial Investigators. Thrombectomy within 8 hours after symptom onset in ischemic stroke. *N Engl J Med*. 2015;372:2296–2306. doi: 10.1056/NEJMoa1503780.
6. Powers WJ, Derdeyn CP, Biller J, Coffey CS, Hoh BL, Jauch EC, et al; American Heart Association Stroke Council. 2015 American Heart Association/American Stroke Association Focused Update of the 2013 Guidelines for the Early Management of Patients With Acute Ischemic Stroke Regarding Endovascular Treatment: A Guideline for Healthcare Professionals From the American Heart Association/American Stroke Association. *Stroke*. 2015;46:3020–3035. doi: 10.1161/STR.0000000000000074.
7. Turk AS, Frei D, Fiorella D, Mocco J, Baxter B, Siddiqui A, et al. ADAPT FAST study: a direct aspiration first pass technique for acute stroke thrombectomy. *J Neurointerv Surg*. 2014;6:260–264. doi: 10.1136/neurintsurg-2014-011125.

8. Stampfl S, Kabbasch C, Muller M, Mpotsaris A, Brockmann M, Liebig T, et al. Initial experience with a new distal intermediate and aspiration catheter in the treatment of acute ischemic stroke: clinical safety and efficacy. [published online ahead of print May 29, 2015]. *J Neurointerv Surg*. 2015. http://jnis.bmj.com/content/early/2015/05/29/neurintsurg-2015–011801.abstract. Accessed October 22, 2015.
9. Kowoll A, Weber A, Mpotsaris A, Behme D, Weber W. Direct aspiration first pass technique for the treatment of acute ischemic stroke: initial experience at a European stroke center. [published online ahead of print January 12, 2015]. *J Neurointerv Surg*. 2015. http://jnis.bmj.com/content/early/2015/01/12/neurintsurg-2014–011520.abstract. Accessed October 22, 2015.
10. Jankowitz B, Grandhi R, Horev A, Aghaebrahim A, Jadhav A, Linares G, et al. Primary manual aspiration thrombectomy (MAT) for acute ischemic stroke: safety, feasibility and outcomes in 112 consecutive patients. *J Neurointerv Surg*. 2015;7:27–31. doi: 10.1136/neurintsurg-2013-011024.
11. Turk AS, Spiotta A, Frei D, Mocco J, Baxter B, Fiorella D, et al. Initial clinical experience with the ADAPT technique: a direct aspiration first pass technique for stroke thrombectomy. *J Neurointerv Surg*. 2014;6:231–237. doi: 10.1136/neurintsurg-2013-010713.
12. Zaidat OO, Yoo AJ, Khatri P, Tomsick TA, von Kummer R, Saver JL, et al; Cerebral Angiographic Revascularization Grading (CARG) Collaborators; STIR Revascularization working group; STIR Thrombolysis in Cerebral Infarction (TICI) Task Force. Recommendations on angiographic revascularization grading standards for acute ischemic stroke: a consensus statement. *Stroke*. 2013;44:2650–2663. doi: 10.1161/STROKEAHA.113.001972.
13. Sheth SA, Jahan R, Gralla J, Pereira VM, Nogueira RG, Levy EI, et al; SWIFT-STAR Trialists. Time to endovascular reperfusion and degree of disability in acute stroke. *Ann Neurol*. 2015;78:584–593. doi: 10.1002/ana.24474.
14. Khatri P, Yeatts SD, Mazighi M, Broderick JP, Liebeskind DS, Demchuk AM, et al; IMS III Trialists. Time to angiographic reperfusion and clinical outcome after acute ischaemic stroke: an analysis of data from the Interventional Management of Stroke (IMS III) phase 3 trial. *Lancet Neurol*. 2014;13:567–574. doi: 10.1016/S1474-4422(14)70066-3.
15. Nogueira RG, Smith WS, Sung G, Duckwiler G, Walker G, Roberts R, et al; MERCI and Multi MERCI Writing Committee. Effect of time to reperfusion on clinical outcome of anterior circulation strokes treated with thrombectomy: pooled analysis of the MERCI and Multi MERCI trials. *Stroke*. 2011;42:3144–3149. doi: 10.1161/STROKEAHA.111.624163.
16. Gory B, Eldesouky I, Sivan-Hoffmann R, Rabilloud M, Ong E, Riva R, et al. Outcomes of stent retriever thrombectomy in basilar artery occlusion: an observational study and systematic review. [published online ahead of print May 18, 2015]. *J Neurol Neurosurg Psychiatry*. 2015. http://jnnp.bmj.com/content/early/2015/05/17/jnnp-2014–310250.abstract. Accessed October 22, 2015.
17. van der Hoeven EJ, Schonewille WJ, Vos JA, Algra A, Audebert HJ, Berge E, et al; BASICS Study Group. The Basilar Artery International Cooperation Study (BASICS): study protocol for a randomised controlled trial. *Trials*. 2013;14:200. doi: 10.1186/1745-6215-14-200.
18. Singer OC, Berkefeld J, Nolte CH, Bohner G, Haring HP, Trenkler J, et al; ENDOSTROKE Study Group. Mechanical recanalization in basilar artery occlusion: the ENDOSTROKE study. *Ann Neurol*. 2015;77:415–424. doi: 10.1002/ana.24336.
19. Pallesen LP, Gerber J, Dzialowski I, van der Hoeven EJ, Michel P, Pfefferkorn T, et al; BASICS Study Group. Diagnostic and Prognostic Impact of pc-ASPECTS Applied to Perfusion CT in the Basilar Artery International Cooperation Study. *J Neuroimaging*. 2015;25:384–389. doi: 10.1111/jon.12130.
20. Goyal N, Tsivgoulis G, Nickele C, Doss VT, Hoit D, Alexandrov AV, et al. Posterior circulation CT angiography collaterals predict outcome of endovascular acute ischemic stroke therapy for basilar artery occlusion. [published online ahead of print August 17, 2015]. *J Neurointerv Surg*. 2015. http://jnis.bmj.com/content/early/2015/08/17/neurintsurg-2015–011883.abstract. Accessed October 22, 2015.
21. Son S, Kim YW, Oh MK, Kim SK, Park KJ, Choi NC, et al. Initial factors affecting the clinical outcome after successful recanalization via MR-based mechanical thrombectomy in patients with acute ischemic stroke due to basilar artery occlusion. [published online ahead of print September 14, 2015]. *J Neurointerv Surg*. 2015. http://jnis.bmj.com/content/early/2015/09/13/neurintsurg-2015–011912.abstract. Accessed October 22, 2015.
22. Son S, Choi DS, Oh MK, Hong J, Kim SK, Kang H, et al. Comparison of Solitaire thrombectomy and Penumbra suction thrombectomy in patients with acute ischemic stroke caused by basilar artery occlusion. [published online ahead of print November 19, 2014]. *J Neurointerv Surg*. 2015. http://jnis.bmj.com/content/early/2014/11/19/neurintsurg-2014–011472.abstract. Accessed October 22, 2015.