ORIGINAL RESEARCH

Initial clinical experience with the ADAPT technique: A direct aspiration first pass technique for stroke thrombectomy

Aquilla S Turk,[1] Alex Spiotta,[2] Don Frei,[3] J Mocco,[4] Blaise Baxter,[5] David Fiorella,[6] Adnan Siddiqui,[7] Maxim Mokin,[7] Michael Dewan,[4] Henry Woo,[6] Raymond Turner,[2] Harris Hawk,[1] Amrendra Miranpuri,[1] Imran Chaudry[1]

[1]Department of Radiology, Medical University of South Carolina, Charleston, South Carolina, USA
[2]Department of Neurosciences, Medical University of South Carolina, Charleston, South Carolina, USA
[3]Department of Radiology, Swedish Medical Centre, Englewood, Colorado, USA
[4]Department of Radiology and Radiological Sciences, University of Vanderbilt, Nashville, Tennessee, USA
[5]Department of Radiology, Erlanger Health System, Chattanooga, Tennessee, USA
[6]Department of Neurosurgery, Stony Brook University, Stony Brook, New York, USA
[7]Department of Neurosurgery, University at Buffalo, Buffalo, New York, USA

Correspondence to
Dr A S Turk, Department of Radiology, Medical University of South Carolina, Charleston, SC 29435, USA; turk@musc.edu

Received 20 February 2013
Revised 4 April 2013
Accepted 8 April 2013

ABSTRACT

Background The development of new revascularization devices has improved recanalization rates and time but not clinical outcomes. We report our initial results with a new technique utilizing a direct aspiration first pass technique with a large bore aspiration catheter as the primary method for vessel recanalization.

Methods A retrospective evaluation of a prospectively captured database of 37 patients at six institutions was performed on patients where the ADAPT technique was utilized. The data represent the initial experience with this technique.

Results The ADAPT technique alone was successful in 28 of 37 (75%) cases although six cases had large downstream emboli that required additional aspiration. Nine cases required the additional use of a stent retriever and one case required the addition of a Penumbra aspiration separator to achieve recanalization. The average time from groin puncture to at least Thrombolysis in Cerebral Ischemia (TICI) 2b recanalization was 28.1 min, and all cases were successfully revascularized. TICI 3 recanalization was achieved 65% of the time. On average, patients presented with an admitting National Institutes of Health Stroke Scale (NIHSS) score of 16.3 and improved to an NIHSS score of 4.2 by the time of hospital discharge. There was one procedural complication.

Discussion This initial experience highlights the fact that the importance of the technique with which new stroke thrombectomy devices are used may be as crucial as the device itself. The ADAPT technique is a simple and effective approach to acute ischemic stroke thrombectomy. Utilizing the latest generation of large bore aspiration catheters in this fashion has allowed us to achieve excellent clinical and angiographic outcomes.

To cite: Turk AS, Spiotta A, Frei D, *et al*. *J NeuroIntervent Surg* Published Online First: [*please include* Day Month Year] doi:10.1136/neurintsurg-2013-010713

BACKGROUND

Acute ischemic stroke continues to be a significant burden on worldwide health systems and remains one of the leading causes of disability and death. Improved clinical outcomes have been correlated with early vessel recanalization.[1] The development of new revascularization devices have resulted in faster and better recanalization rates, yielding better clinical outcomes compared with earlier devices.[2 3] These newer devices are available at much higher costs than other comparative endovascular devices. We believe that the push for utilizing the latest generation of devices needs to focus on quality of thrombectomy rather than ability to recanalize. We report our initial results with a new technique utilizing a direct aspiration first pass technique with a large bore aspiration catheter as the primary method for vessel recanalization.

METHODS

Retrospective analysis from a prospectively captured database was gathered on the first patients undergoing stroke thrombectomy with the ADAPT technique at the Medical University of South Carolina, Swedish Medical Centre, Vanderbilt University, Erlanger Medical Centre, Stonybrook University, and University at Buffalo using an institutional review board approved protocol.

ADAPT technique

All operators selected patients for thrombectomy according to their usual protocol (figure 1). Access to the cerebral vasculature required a 6 French Neurosheath, usually a Neuron 088 Max (Penumbra, Oakland, California, USA). This was advanced as far distally into the internal carotid artery as was safely possible, usually to the skull base or petrous segment of the internal carotid artery. For posterior circulation thrombi, the Neuron 088 was navigated into the largest caliber vertebral artery and positioned into the distal V2 segment. The largest caliber aspiration catheter that the vessel would accommodate was selected for each case, usually a Penumbra 5 Max reperfusion catheter (Penumbra) for M1 or carotid terminus occlusions. The 5 Max was advanced to the level of the thrombus over any microcatheter and microwire the operator chose, but most commonly a Velocity microcatheter (Penumbra) over a 0.016 inch Fathom wire (Boston Scientific Corp, Naidich, Massachusetts, USA). This triaxial system readily negotiated the ophthalmic bend at the carotid siphon. Under roadmap guidance, the wire and microcatheter were navigated past the thrombus, most commonly into a middle cerebral artery post bifurcation branch. Over this platform, the larger 5 Max catheter was delivered and positioned immediately adjacent to the site of occlusion. The microcatheter and wire were removed. Aspiration was applied by either 20 or 60 ml syringe or use of the Penumbra aspiration pump that is part of the

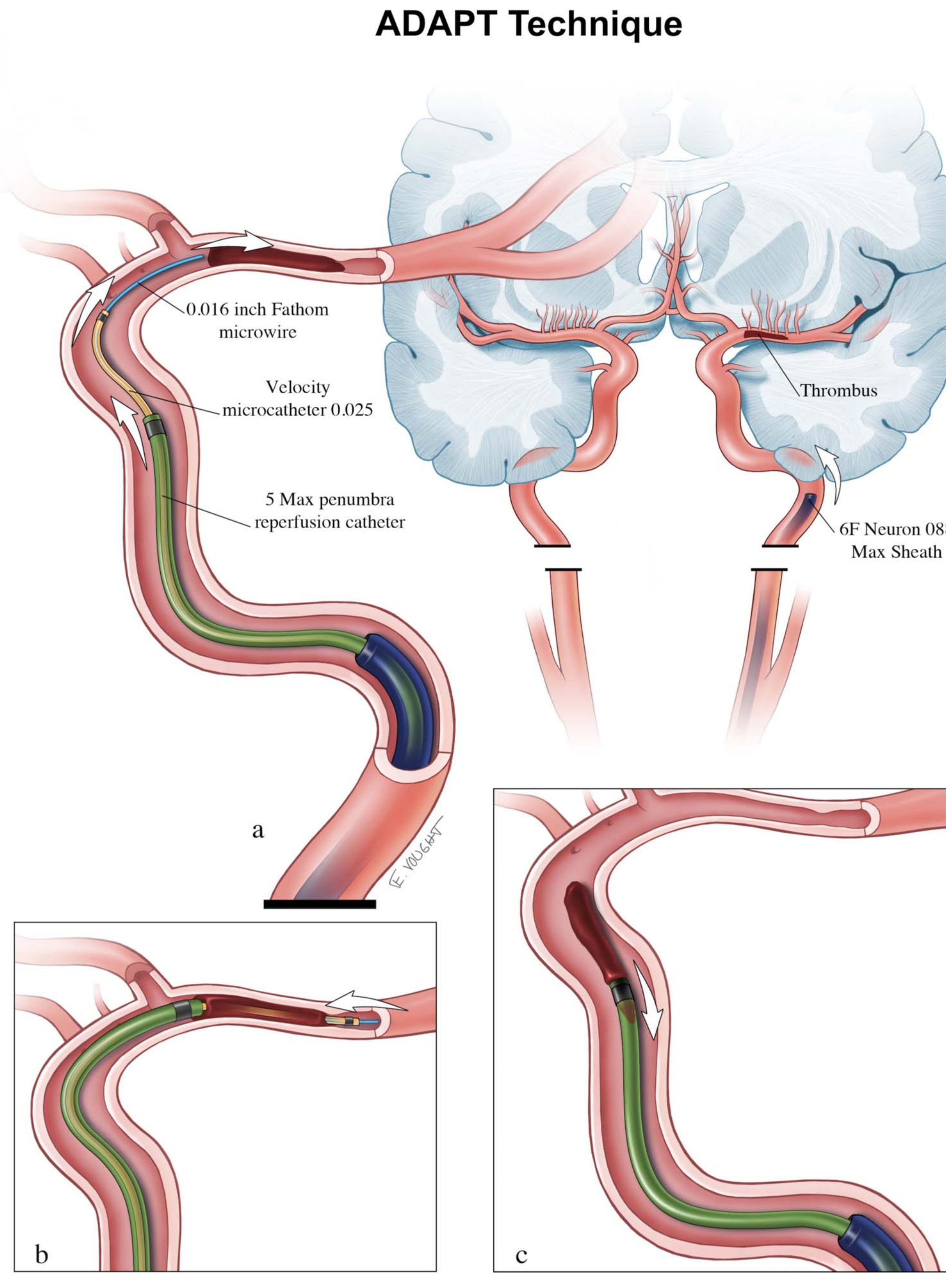

Figure 1 Illustration of the ADAPT technique in a middle cerebral artery clot. (A) The Neuron Max guide catheter is positioned as far distally as possible in the supplying internal carotid artery. Through this a 5 Max reperfusion catheter is advanced over a Velocity microcatheter with a 0.016 inch Fathom wire. (B) The Fathom wire and Velocity microcatheter are advanced through and distal to the thrombus to provide stable support for the 5Max to be advanced to the face of the thrombus. (C) Aspiration is applied to the 5 Max until aspiration becomes occlusive and the 5 Max is then removed while maintaining aspiration to ensure the clot remains engaged in the catheter tip.

Penumbra system.[4] Inability to draw back on aspiration confirmed the optimal position of the 5 Max catheter abutting the thrombus. At this point, the catheter was slightly advanced to ensure firm engagement with the thrombus. The 5 Max catheter was then slowly withdrawn while maintaining aspiration. Aspiration was also applied to the sideport of the Neuron 088 Max to prevent dislodging the thrombus from the 5 Max aperture as it is withdrawn into the sheath. If aspiration failed, the 5 Max was rapidly reinserted up to the thrombus and a repeat aspiration attempted or the local aspiration with stent retriever was performed.[5] In smaller caliber or more distal vessels, the technique can be employed with either a 4 Max or 3 Max reperfusion catheter (Penumbra).

Specific parameters captured included age, gender, National Institutes of Health Stroke Scale (NIHSS) score at presentation, time to presentation from last normal, and modified Rankin Scale score at discharge, as this technique has emerged so recently that 90 day follow-up is not available. The average hospital discharge NIHSS score was calculated excluding any patients that expired during hospitalization. The modified Rankin Scale score data were obtained from the neurology clinic record. Radiological and angiographic imaging was reviewed to document the location of the vascular occlusion, Thrombolysis in Cerebral Ischemia (TICI) flow post procedure, and procedural complications. Recanalization time was defined as time from groin access to achieving at least TICI 2B flow within the affected territory.

Table 1 Demonstrates pertinent procedural and clinical data and outcomes

Patient No	Age (years)	Presenting NIHSS	Discharge NIHSS	IV tPA	Target location	Initial TICI flow	Final TICI flow	Time to recanalization TICI IIb or greater (min)	Time from symptom onset to groin puncture (min)	Guide catheter	Thrombectomy device No 1	Additional thrombectomy device	Technical complications	Comments
1	39	14	12	Y	R MCA	0	2B	12	360	Neuron Max	5 Max		None	
2	41	19	3	N	L M1	0	3	7	510	Neuron Max	5 Max	Solitaire, PTA, Wingspan	None	Underlying ICAD
3	42	13	2	Y	R M1	0	2B	7	145	Neuron Max	5 Max	3 Max DA	None	
4	43	8	1	N	R M2	0	3	45	210	Neuron 070	3 Max	3 Max DA	None	
5	48	15	3	N	R M1	0	3	27	578	Neuron Max	5 Max		None	
6	59	25	6	N	Basilar apex	0	3	10	620	Chaperone	3 Max		None	
7	61	13	3	N	L M1	0	3	19	1150	Neuron Max	5 Max		None	
8	62	18	4	N	L M1	0	3	19	585	Neuron Max	5 Max		None	
9	71	10	9	Y	L M2	0	3	23	520	70	3 Max			
10	73	13	2	N	Basilar apex	1	3	21	1602	Neuron Max	5 Max	3 Max DA	None	
11	79	7	2	N	L M2	0	3	45	297	70	3 Max			
12	82	12	3	N	L M1	0	3	11	475	Neuron Max	5 Max		None	
13	86	13	0	Y	L M1	0	3	30	520	Neuron Max	5 Max	Trevo	None	
14	90	19	Deceased	N	R ICA—T	0	2B	90	225	Neuron Max	5 Max	3 Max DA, separator	None	*
15	80	21	7	Y	R ICA	0	3	44	290	Neuron Max	5 Max	Trevo	None	
16	47	17	2	.	ICA—T	0	3	17	86	Neuron Max	5 Max	Trevo	None	
17	54	16	3	N	L M1	0	2B	12	NA	Neuron Max	5 Max		None	
18	81	19	Deceased	Y	R M1	0	3	45	255	Neuron Max	5 Max	Solitaire	None	†
19	81	17	3	N	R M1	0	3	14	650	Neuron Max	5 Max		None	
20	58	6	0	Y	L M2	0	2B	20	200	Neuron Max	5 Max		None	
21	81	18	0	Y	L M1	0	2B	10	233	Neuron Max	5 Max		None	
22	73	10	1	Y	L M1	0	3	15	260	Neuron Max	5 Max		None	
23	45	15	Deceased	N	L M1	0	3	22	183	Neuron Max	5 Max		None	*
24	81	30	26	N	Basilar tip	0	2a	22	973	Neuron Max	5 Max		Yes	Small SAH
25	57	20	12	Y	L Carotid	0	2B	25	221	Neuron Max	Neuron Max		None	
26	77	20	6	N	Basilar tip	0	3	34	235	Neuron Max	5 Max		None	
27	77	16	0	Y	L carotid	0	2B	56	125	Neuron Max	5 Max	Trevo	None	
28	70	30	Deceased	N	Basilar tip	0	3	32	165	Neuron Max	5 Max	4 Max	None	†
29	52	19	5	Y	M1	0	3	15	198	Neuron Max	5 Max	4 Max	None	‡
30	76	25	2	N	M3	0	2B	39	70	Neuron Max	3 Max		None	
31	65	8	3	N	M1	0	3	3	250	Neuron Max	5 Max		None	
32	86	15	Deceased	N	M1	0	3	43	NA	Neuron Max	5 Max		None	†
33	48	9	0	N	Basilar	0	3	14	300	Neuron Max	5 Max	Solitaire	None	
34	48	5	0	N	Basilar	0	2B	36	60	Neuron Max	5 Max		None	

Continued

Table 1 Continued

Patient No	Age (years)	Presenting NIHSS	Discharge NIHSS	IV tPA	Target location	Initial TICI flow	Final TICI flow	Time to recanalization TICI IIb or greater (min)	Time from symptom onset to groin puncture (min)	Guide catheter	Thrombectomy device No 1	Additional thrombectomy device	Technical complications	Comments
														Difficult guide access
35	80	14	0	N	R ICA	0	3	44	180	Neuron Max	058 Navien		None	‡
36	46	23	6	N	M2	0	2B	59	NA	Neuron Max	5 Max		None	
37	54	19	8	N	L ICA	0	2B	52	NA	Neuron Max	5 Max	Solitaire	None	Petrous ICA occlusion
Average	64.7	16.3	4.2					28.1						
Median		16	3											

*PH-2 hemorrhage next day. †Large infarction, withdrew care. ‡Carotid stenosis requiring stent.
DA, Direct Aspiration; ICA, internal carotid artery; ICAD, intracranial artery disease; MCA, middle cerebral artery; NA, not available; NIHSS, National Institutes of Health Stroke Scale; PTA, Percutaneous Transluminal Angioplasty; SAH, subarachnoid hemorrhage; TICI, Thrombolysis in Cerebral Ischemia; tPA, tissue plasminogen activator.

RESULTS

From November 2012 to March 2013, 37 consecutive cases of acute ischemic stroke were treated with the ADAPT technique in six institutions: 30 involving the anterior circulation and seven involving the basilar artery. Table 1 contains all of the data for the treated patients. Notably, the time from groin puncture to at least TICI 2b recanalization was 28.1 min, with all cases successfully revascularized. TICI 3 recanalization was achieved 65% of the time. On average, patients presented with an admitting NIHSS score of 16.3 and improved to 4.2 by the time of discharge. There was one procedural complication. There were two patients that died from parenchymal hematomas the following day.

The direct aspiration technique alone was successful in 28 of 37 (75%) patients although six cases had large downstream emboli that required additional aspiration. The use of the large bore aspiration catheter alone to achieve complete recanalization was successful in 22 of 38 (57%) cases. Nine cases required the additional use of a stent retriever to achieve recanalization. One case required the addition of a Penumbra aspiration separator to achieve recanalization. One case had an underlying atherosclerotic lesion which, while initially recanalized with direct aspiration very quickly, ultimately required a stent to maintain patency.

There were five deaths before hospital discharge, two related to reperfusion hemorrhage and the remaining three related to cerebral infarction. There was one procedural complication in a patient with a basilar occlusion that resulted in a small subarachnoid hemorrhage, but not worsening in clinical examination.

DISCUSSION

We found the ADAPT technique to be significantly faster and more efficacious than our previous published thrombectomy experience[5] or any series reported in the literature.[2 3 6] Employing this technique, acceptable recanalization (>TICI 2b) was achieved in all patients, as fast as 7 min from groin puncture. The rate of TICI 3 recanalization was also noted to be significantly better than any previously reported. The efficacy and speed of recanalization with this technique likely contributes to the rapid neurological improvement and high rate of patients with good neurologic outcomes at discharge. In addition, when this technique is successful it eliminates the need to introduce a stent retriever or penumbra separator devices, leading to an overall much lower procedure device cost.

Five patients (13.5%) died while in hospital, of whom three were older than 80 years of age, which has been reported to be associated with worse outcome.[7] Two patients experienced parenchymal hematomas several hours after the thrombectomy and died. The cases occurred in different hospitals with different operators and were remote from the thrombectomy. In both cases, the patients had a pre-existing infarction approximating one-third to one-half of the middle cerebral territory, but were treated for various reasons. All hemorrhages occurred in the region of infarction that was present prior to thrombectomy. The symptomatic hemorrhage and mortality rates observed are similar to other reported studies for this disease and therapy.[2 3] One procedural vessel injury resulting in a small amount of subarachnoid hemorrhage occurred in an elderly patient with a basilar occlusion and was felt likely to be related to underlying atherosclerosis.

Distal access catheters from a variety of manufacturers are now routinely utilized to deliver catheters and devices into the distal intracranial circulation. The 5 Max aspiration catheter is

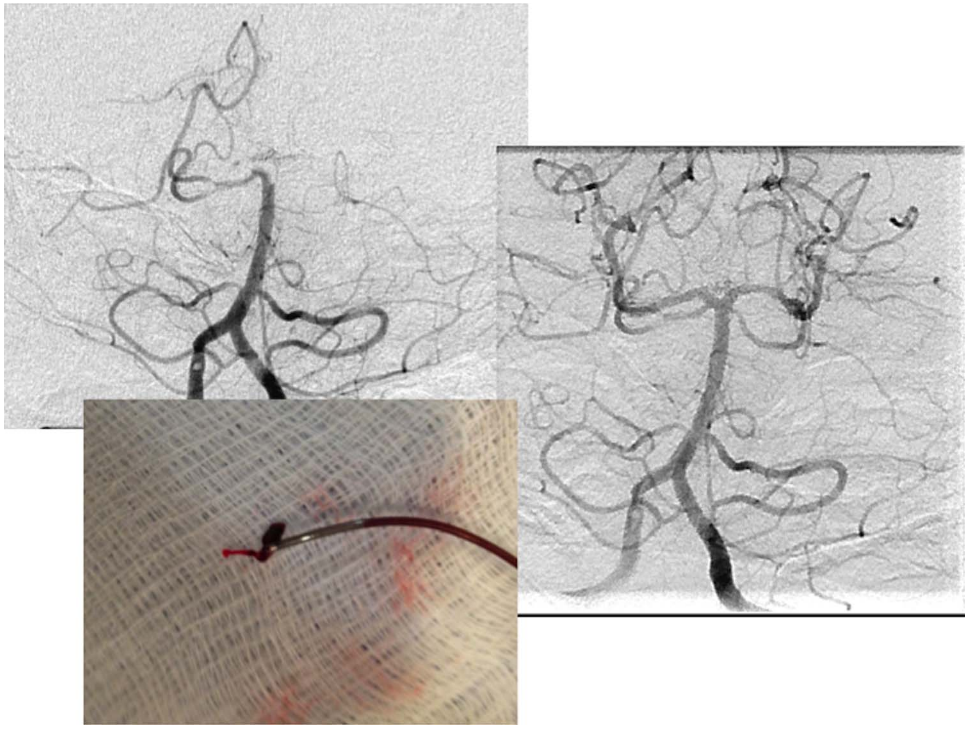

Figure 2 Patient No 6 with distal basilar artery occlusion. The first aspiration attempt was unsuccessful. The second attempt allowed removal of the photographed specimen. Control angiogram showed Thrombolysis in Cerebral Ischemia 3 recanalization. Total time to recanalization from groin puncture was 10 min.

the most prevalent catheter we have used in the setting of large vessel occlusions, and has significantly increased the ease and speed of navigation of a large bore catheter into the intracranial circulation. The ADAPT technique differs from prior aspiration methods as it focuses on engaging and removing the clot in its entirety, rather than the use of the separator that was designed to macerate the thrombus and clear the tip of the aspiration catheter. Historically, due to the challenges with tracking an aspiration catheter into the intracranial circulation, catheters had to be telescoped with other catheters together or other

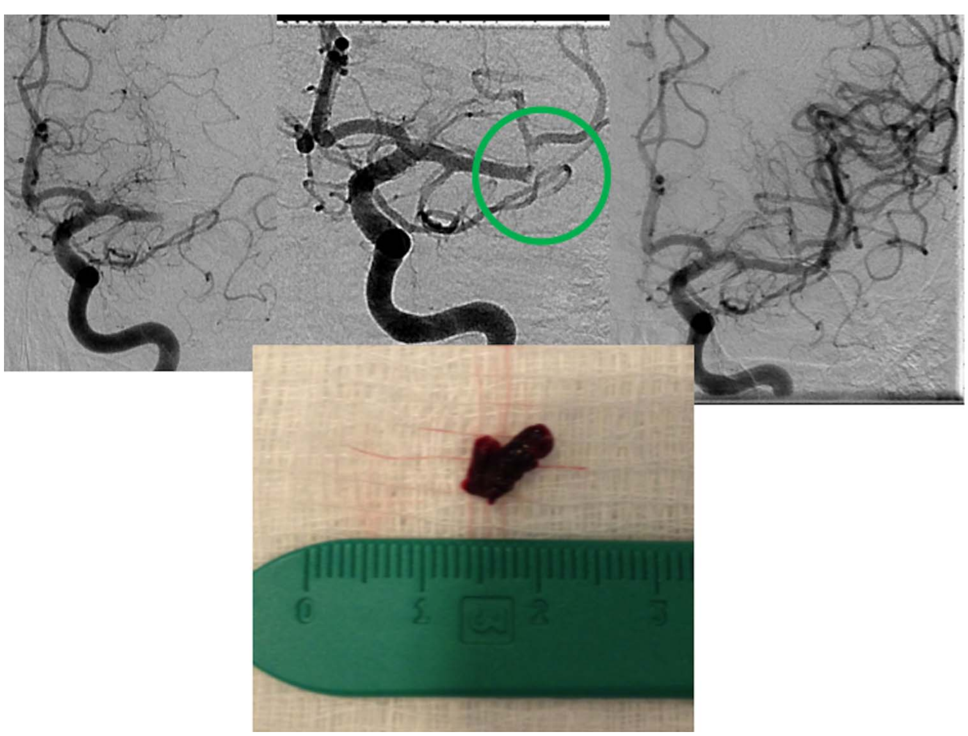

Figure 3 Patient No 7. Left middle cerebral artery occlusion at bifurcation. The first aspiration attempt was unsuccessful. The second attempt allowed removal of the photographed specimen with a bifurcation morphology. Control angiogram shows Thrombolysis in Cerebral Ischemia 3 recanalization. Total time to recanalization from groin puncture was 19 min.

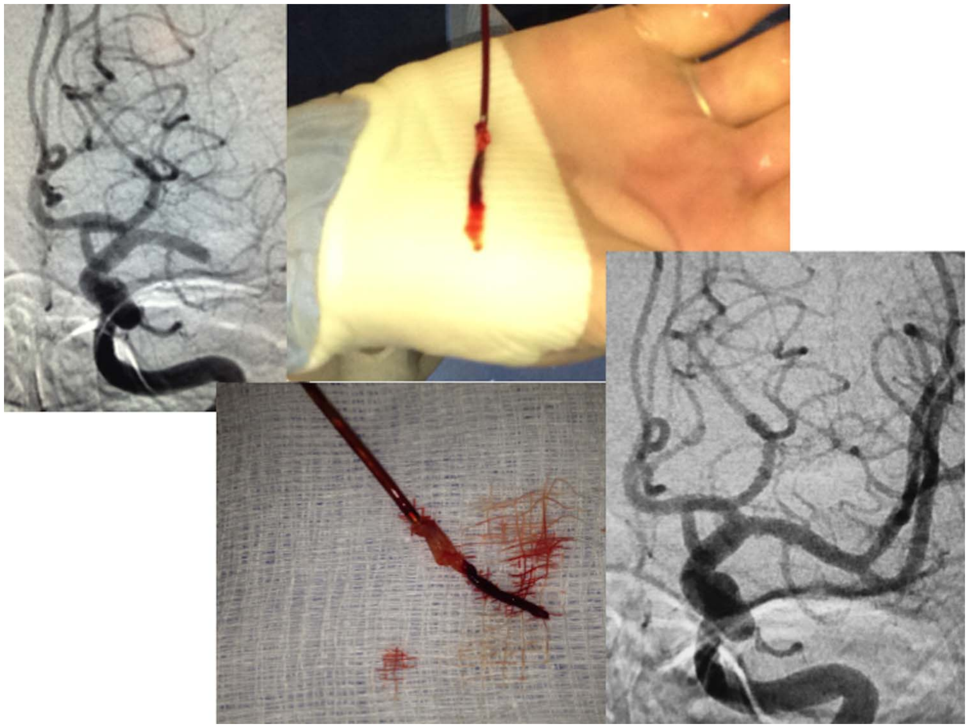

Figure 4 Patient No 17. Left middle cerebral artery occlusion at bifurcation. The first attempt allowed removal of the photographed specimen. Control angiogram showed Thrombolysis in Cerebral Ischemia 3 recanalization. Total time to recanalization from groin puncture was 22 min.

tricks employed to advance through the siphon.[4 8–12] However, the superior trackability of the 5 Max compared with the prior Penumbra 054 has given us the confidence to attempt direct aspiration alone without the fear that it will cost significant time and risk to the patient if intracranial access is lost. The 5 Max also provides a platform for direct aspiration using the catheter itself as the primary device or as a conduit for other devices, such as smaller aspiration catheters for direct aspiration in more distal branches (M2, P2, or P3, for example) or stent retrievers, balloons, or stents should the primary strategy not be successful in achieving recanalization.

Direct aspiration of thrombus with intermediate catheters has been described previously.[11 13] In these reports direct aspiration was performed not as a primary strategy but rather as an alternative technique when more conventional strategies had already been attempted and exhausted. Kang *et al* previously reported a primary aspiration technique, but with more modest results likely due to smaller caliber and older technology aspiration catheters.[14] They also involved older generations of intermediate catheters, such as the distal access catheter (Concentric Medical) and the 041, and 032 family of Penumbra reperfusion catheters (Penumbra) which have been supplanted by newer iterations. The increased internal diameter of the 5 Max aspiration catheter allows for an increased surface area that provides more optimal contact at the catheter tip–thrombus interface. In addition, it is more capacious along its proximal segment, increasing its luminal volume and thereby resulting in an increased aspiration capacity over prior versions of aspiration catheters.

The modifications made to the Max series catheters likely contribute to the ability to engage the thrombus and remove it as a single specimen while minimizing fragmentation and the creation of distal emboli (figures 2–4). There were no cases of emboli to new territories, which has been reported to occur in up to 14% of cases with stent retrievers.[2 3] While we did experience some fragmentation of thrombus in the downstream territories, they were usually large macromolecular fragments that lodged in the proximal M2 branches that could then be removed with the initial 5 Max or a 3 Max catheter with subsequent TICI 3 flow. This is contrary to the approach with the use of a separator, where the fragments appear to be micromolecular and lodge in innumerable small distal M4 branches that are not well suited for mechanical thrombectomy and also have less potential for collateralization. This phenomenon has recently been described with an in vitro model where all current thrombectomy devices demonstrated varying size and number of downstream emboli.[15]

These observations address a critical component in our evolution of conceptualizing stroke thrombectomy in that we have moved beyond the success of recanalization to the quality of the recanalization. This technique raises the bar for neurointerventionalists; we are no longer satisfied in simply achieving recanalization, but rather should focus on achieving optimal recanalization to maximize the likelihood that the patient will achieve a good functional outcome. This implies that we need to focus on the effect of showering downstream emboli to the involved territory, as has been reported in an in vitro model and clinically.[2 3 13] The ADAPT technique is remarkable for the ability to usually remove the offending thrombus whole or in large fragments engaged in the end of the aspiration catheter (figure 1).

The performance of the 5 Max to rapidly and repeatedly access the intracranial circulation coupled with very fast and efficacious thrombectomy times have driven us to alter our approach to stroke thrombectomy procedure. Due to the brevity of the procedure, we no longer routinely place a bladder catheter or an arterial line prior to the procedure, unless easily obtained. We can monitor blood pressure with arm cuff pressures monitored every 2 min. Perhaps most importantly, the majority of these procedures were also performed with moderate sedation rather than general anesthesia, which had previously been our preferred method. The ADAPT method anecdotally appears less painful to the patient compared with thrombectomy attempts with MERCI or Penumbra separators which minimize patient movement to stimuli during the procedure. In addition, since these emergent procedures are often performed after hours in patients with a compromised pre-intervention neurological examination, the anesthesiology team is generally reluctant to extubate patients on the table. The impact on clinical outcomes from this step alone should not be overlooked, as it is well shown that thrombectomy patients' postprocedural intensive care unit stays are often complicated, with a significant likelihood of pneumonia, other nosocomial infection, deep vein thrombosis, or other complicating factor in patients who undergo general anesthesia with endotracheal intubation.[16–19]

There are significant limitations to this study, including the small initial experience population and retrospective nature. The limited follow-up does not allow us to project to long term clinical outcomes. While discharge follow-up outcome data rather than 90 day outcome data are a limitation to this study, it would likely only bias the results in fashion against the technique. The absence of a core laboratory adjudicate angiographic results confers a bias to better angiographic outcomes than may be truly present.[2 3] The absence of procedural complications while achieving superior rates of TICI 3 recanalization, fast procedure times, and the fact that this method was performed at multiple institutions belies the simplicity and ease with which this technique is employed and describes the success of the initial experience.

In conclusion, the ADAPT technique is a simple and effective approach to acute ischemic stroke thrombectomy. Utilizing the latest generation of large bore aspiration catheters in this fashion has allowed us to achieve excellent clinical and angiographic outcomes.

Contributors Each author listed should receive authorship credit based on material contribution to this article, revision of this article, and final approval of this article for submission to this journal.

Competing interests None.

Ethics approval Retrospective analysis from a prospectively captured database was gathered on the first patients undergoing stroke thrombectomy with the ADAPT technique at the Medical University of South Carolina, Swedish Medical Centre, Vanderbilt University, Erlanger Medical Centre, Stonybrook University, and University at Buffalo, using an institutional review board approved protocol

Provenance and peer review Not commissioned; externally peer reviewed.

REFERENCES

1 Rha JH, Saver JL. The impact of recanalization on ischemic stroke outcome: a meta-analysis. *Stroke* 2007;38:967–73.
2 Nogueira RG, Lutsep HL, Gupta R, *et al*. Trevo versus Merci retrievers for thrombectomy revascularisation of large vessel occlusions in acute ischaemic stroke (TREVO 2): a randomised trial. *Lancet* 2012;380:1231–40.
3 Saver JL, Jahan R, Levy EI, *et al*. Solitaire flow restoration device versus the Merci retriever in patients with acute ischaemic stroke (SWIFT): a randomised, parallel-group, non-inferiority trial. *Lancet* 2012;380:1241–9.
4 Yoo AJ, Frei D, Tateshima S, *et al*. The Penumbra Stroke System: a technical review. *J Neurointerv Surg* 2012;4:199–205.
5 Turk AS, 3rd, Campbell JM, Spiotta A, *et al*. An investigation of the cost and benefit of mechanical thrombectomy for endovascular treatment of acute ischemic stroke. *J Neurointervent Surg* 2013. Published Online First: 1 February 2013. doi: 10.1136/neurintsurg-2012-010616.
6 Tarr R, Hsu D, Kulcsar Z, *et al*. The POST trial: initial post-market experience of the Penumbra system: revascularization of large vessel occlusion in acute ischemic stroke in the United States and Europe. *J Neurointerv Surg* 2010;2:341–4.
7 Brinjikji W, Rabinstein AA, Kallmes DF, *et al*. Patient outcomes with endovascular embolectomy therapy for acute ischemic stroke: a study of the national inpatient sample: 2006 to 2008. *Stroke* 2011;42:1648–52.
8 Chaudhary N, Pandey AS, Thompson BG, *et al*. Utilization of the Neuron 6 French 0.053 inch inner luminal diameter guide catheter for treatment of cerebral vascular pathology: continued experience with ultra distal access into the cerebral vasculature. *J Neurointerv Surg* 2012;4:301–6.
9 Hui FK, Hussain MS, Spiotta A, *et al*. Merci retrievers as access adjuncts for reperfusion catheters: the grappling hook technique. *Neurosurgery* 2012;70:456–60.
10 Park MS, Stiefel MF, Fiorella D, *et al*. Intracranial placement of a new, compliant guide catheter: technical note. *Neurosurgery* 2008;63:E616–17.
11 Spiotta AM, Hussain MS, Sivapatham T, *et al*. The versatile distal access catheter: the Cleveland Clinic experience. *Neurosurgery* 2011;68:1677–86.
12 Turk A, Manzoor MU, Nyberg EM, *et al*. Initial experience with distal guide catheter placement in the treatment of cerebrovascular disease: clinical safety and efficacy. *J Neurointerv Surg* 2012;5:247–52.
13 Jankowitz B, Aghaebrahim A, Zirra A, *et al*. Manual aspiration thrombectomy: adjunctive endovascular recanalization technique in acute stroke interventions. *Stroke* 2012;43:1408–11.
14 Kang DH, Hwang YH, Kim YS, *et al*. Direct thrombus retrieval using the reperfusion catheter of the Penumbra system: forced-suction thrombectomy in acute ischemic stroke. *AJNR Am J Neuroradiol* 2011;32:283–7.
15 Chueh JY, Wakhloo AK, Gounis MJ. Effectiveness of mechanical endovascular thrombectomy in a model system of cerebrovascular occlusion. *AJNR Am J Neuroradiol* 2012;33:1998–2003.
16 Hassan AE, Chaudhry SA, Zacharatos H, *et al*. Increased rate of aspiration pneumonia and poor discharge outcome among acute ischemic stroke patients following intubation for endovascular treatment. *Neurocrit Care* 2012;16:246–50.
17 Abou-Chebl A, Lin R, Hussain MS, *et al*. Conscious sedation versus general anesthesia during endovascular therapy for acute anterior circulation stroke: preliminary results from a retrospective, multicenter study. *Stroke* 2010; 41:1175–9.
18 Jumaa MA, Zhang F, Ruiz-Ares G, *et al*. Comparison of safety and clinical and radiographic outcomes in endovascular acute stroke therapy for proximal middle cerebral artery occlusion with intubation and general anesthesia versus the nonintubated state. *Stroke* 2010;41:1180–4.
19 Nichols C, Carrozzella J, Yeatts S, *et al*. Is periprocedural sedation during acute stroke therapy associated with poorer functional outcomes? *J Neurointerv Surg* 2010;2:67–70.

Initial clinical experience with the ADAPT technique: A direct aspiration first pass technique for stroke thrombectomy

Aquilla S Turk, Alex Spiotta, Don Frei, et al.

J NeuroIntervent Surg published online April 27, 2013
doi: 10.1136/neurintsurg-2013-010713