**Name of journal:** *World Journal of Clinical Cases*

**ESPS Manuscript NO: 7229**

**Columns: CASE REPORT**

**Successful recanalization with multimodality endovascular interventional therapy in acute ischemic stroke**

Jongsathapongpan A *et al*. Recanalization with Endovascular therapy in AIS

Amorn Jongsathapongpan, Anuchit Raumthanthong, Sombat Muengtaweepongsa

**Amorn Jongsathapongpan,** Department of Cardiology, Phyathai 2 Hospital (Bangkok Hospital Group), Bangkok 10400, Thailand

**Anuchit Raumthanthong,** Department of Radiology, Pramongkutklao Hospital, Bangkok 10400, Thailand

**Sombat Muengtaweepongsa,** Department of Medicine, Thammasat University, PathumThani 12120, Thailand

**Author contributions:** Jongsathapongpan A and Muengtaweepongsa S designed the report, collected data, and wrote the report; Raumthanthong A and Jongsathapongpan A performed the procedure; Muengtaweepongsa S set up protocol for patient selection; Raumthanthong A performed angiogram and imaging diagnosis.

**Correspondence to: Sombat Muengtaweepongsa, MD,** Department of Medicine, Thammasat University, Rangsit Campus, 99 Moo 18, Paholyothin Road, KlongNueng, KlongLuang, Pathumthani 12120, Thailand. [sombatm@hotmail.com](mailto:sombatm@hotmail.com)

**Telephone:** +66-29-269794 **Fax:** +66-29-269793

**Received:** November 9, 2013 **Revised:** January 7, 2014

**Accepted:** January 17, 2014

**Published online:**

**Abstract**

Stroke is the important cause of death and disability in adult. However, effective treatments for patients with acute ischemic stroke are limited. Intravenous recombinant tissue plasminogen activator (*iv* rtPA) within 4.5 h after onset has been approved as a standard treatment for patients with acute ischemic stroke. However, due to time constrain, less than one percent of acute ischemic stroke patients in Thailand are able to reach *iv* rtPA. Although endovascular interventional therapy has not yet been approved as standard treatment in acute ischemic stroke, it is the one of the potentially effective treatment options. There are several reliable methods of endovascular therapy for acute ischemic stroke patients. Endovascular interventional therapy has been scarcely done in Thailand. We report seven patients with successful recanalization after endovascular treatment in acute large vessel stroke from a single stroke center in Thailand. Patient screening and selection with multimodal imaging protocol and multimodality methods of endovascular interventional therapy are described.

©2014 Baishideng Publishing Group Co., Limited. All rights reserved.

**Key words:** Acute Ischemic Stroke; Intra-arterial thrombolysis; Endovascular therapy; Mechanical thrombectomy

**Core tip:** We report seven patients with successful recanalization after endovascular treatment in acute large vessel stroke from a single stroke center in Thailand. Patient screening and selection with multimodal imaging protocol and multimodality methods of endovascular interventional therapy are described.

Jongsathapongpan A, Raumthanthong A, Muengtaweepongsa S. Successful recanalization with multimodality endovascular interventional therapy in acute ischemic stroke

**Available from:**

**DOI:**

**INTRODUCTION**

Stroke is the leading cause of adult disability particularly in elderly and remains the third most common cause of death in developing world as well as in Thailand[1,2]. Despite improving in quality of stroke management, morbidity and mortality related to stroke remain significant[3]. Intravenous recombinant tissue plasminogen activator (*iv* rtPA) is a standard treatment for patients with acute ischemic stroke[4]. NINDS study shows that *iv* rtPA given within 3 h of stroke onset improves modified Rankin Scale (mRS) at 90 d[5]. Recent ECASS3 trial expands indication of intravenous rtPA to 4.5 h[6]. Clinical benefit from *iv* rtPA to Thai stroke patients has been showed in the studies[7,8]. However, most of stroke patients are still not able to get *iv* rtPA due to delay arrival and tight exclusion criteria[9].

Identification of ischemic penumbra with diffusion-perfusion mismatch by magnetic resonance imaging (MRI) may have a role in patient selection for further treatment in acute ischemic stroke[10,11]. However, the benefit on clinical outcomes of this imaging selection for endovascular treatment in patients with acute ischemic stroke is still controversial[12].

Intraarterial thrombolysis is a viable option to some patient who arrived after the 3 h[13]. PROACT II trial showed that recanalization rate and functional outcomes are better with intraarterial thrombolysis[14]. Mechanical thromboembolectomy in acute ischemic stroke receives intense interest in the recent years. Multi MERCI trial shows that clot removal with the device, which can be done up to 8 h after stroke onset, raises recanalization rate up to 60%[15]. Penumbra pivotal trial shows that continuous thrombus aspiration with penumbra catheter can improve recanalization rate to more than 80%[16]. SWIFT trial shows that clot extraction with Solitaire device in large vessel occlusion including internal carotid artery (ICA), middle cerebral artery part 1(M1), middle cerebral artery part 2 (M2) and basilar artery (BA) also provides recanalization rate up to 80%[17]. Unfortunately, two most recent trials published in a landmark journal do not show any benefit in functional outcomes from endovascular treatment in acute ischemic stroke[18,19].

In Thailand, endovascular interventional therapy has been rarely performed in patients with acute ischemic stroke. Intraarterial recombinant tissue plasminogen activator (*ia* rtPA) is an option in some medical centers. Imaging selection is also optional for decision making in some centers. Recently, solitaire and penumbra devices are available for commercial use. We report our initial experiences with these procedures.

Phyathai 2 is a solely private hospital located in central of Bangkok. This 200-beds hospital provides 20-beds ICU for medical intensive conditions including acute ischemic stroke. Medical records of patients who received endovascular interventional therapy for acute large vessel occlusion (ICA, M1, M2 and BA) in Phyathai 2 Hospital during February 2010 to January 2013 were reviewed.

***Endovascular interventional therapy protocol***

Acute ischemic stroke patients, who not eligible for *iv* rtPA or who still had significant deficits after *iv* rtPA, were evaluated by the stroke neurologist (SM). A stroke interventional team (Jongsathapongpan A, Raumthanthong A) was alerted. Multimodal MRI (conventional MRI with MRA and MR perfusion) was done in an emergency basis. If diffusion-perfusion mismatch was more than 20%, the patient would be transferred to catheterization lab for endovascular treatment. Anesthesiologist was consulted to stand by in catheterization lab.

Right femoral artery was cannulated with an 8 F sheath. Selective angiography of carotid artery or vertebral artery was done a 5F Simmon1 or a 5F JR4 catheter. Aortic arch angiogram and 4 vessels DSA were not routinely performed. If occluded artery was confirmed, a 6F 90 cm sheath was placed as far as a distal cervical ICA or a distal V2 segment. A 018 microcatheter was advanced over guidewire to occlusion site. Low dose *ia* rtPA (less than 5 mg) was given. If no clot lysis was seen, continuous clot aspiration using Penumbra device or clot extraction with Solitaire device will be performed.

**CASE REPORT**

We identified 7 cases. Age ranged from 56-87 years. National Institutes of Health Stroke Scale (NIHSS) ranged from 9-30. Multimodal MRI was done 6 of 7 cases (86%). There were 2 patients with ICA occlusion, 2 with middle cerebral artery (MCA) occlusion and 3 with BA occlusion. Carotid stenting was performed in one case. *ia* rtPA, mechanical thrombectomy and combined treatment were done in 4, 5 and 3 cases, respectively. Solitaire and penumbra devices were used in 2 and 3 cases, respectively. Only 1 patient received intervention after intravenous thrombolysis. Case presentation and treatment were summarized in Table 1.

***Case 1***

**Left distal ICA occlusion opened with *ia* rtPA and solitaire device:** A 56-year-old female, presented with right hemiparesis and aphasia. He arrived to hospital 1 hour after onset. Emergency computer tomography (CT) brain showed cord sign in left MCA and distal ICA. Initial NIHSS was 20. Electrocardiography (EKG) showed normal sinus rhythm. Echocardiography showed no intracardiac thrombus. *iv* rtPA was given at 90 min after onset. No neurological improvement was noted. Two hours after *iv* rtPA, angiography was done. We found distal ICA occlusion. Balloon inflation with a 2.0 mm x 15 mm coronary balloon was attempted without success. Eight milligrams of *ia* rtPA was infused. No clot lysis was seen. Then, a 4.0 x 15 Solitaire device was deployed 5 hour after onset. Immediate angiography showed thrombolysis in cerebral infarction (TICI) 2 flow. Solitaire was slowly pulled back. Large thrombus was removed. Residual stenosis of mid M1 persisted, but it resolved after 1 mg of nimodipine. Final angiography showed TICI 3 in M1 and anterior cerebral artery part 1 (A1). Occlusion of anterior cerebral artery part2 (A2) was noted. No further intervention was attempted. Six months after procedure, mRS was 2 (Figure 1A and B).

***Case 2***

**BA occlusion opened with *ia* rtPA and penumbra device:** An 80-year-old female presented with alteration of consciousness. She had hypertension and chronic AF. Warfarin was discontinued during the last month for unknown reason. Immediate CT brain showed hyperdense basilar artery. MRI and MRA brain revealed small right cerebellar infarction and occlusion of mid basilar artery. Patent bilateral fetal type posterior cerebral artery was noted. Echocardiography showed no intracardiac thrombus. She was transferred to catheterization lab 5.5 h after onset. Angiogram showed near occlusion of mid BA. Continuous thrombus aspiration with a 032 Penumbra catheter was done. TICI 3 was seen from proximal to mid basilar artery and bilateral superior cerebellar artery. Occluded distal basilar artery cannot be opened. MRI brain on the next day showed bilateral superior cerebellar infarction. No intracranial hemorrhage was seen. After 3 mo, mRS was only 4. Four months later, she suffered from left MCA stroke despite of dabigatran maintenance. No thrombolytic drug was given because of late presentation (Figure 1C and D).

***Case 3***

**Tandem ostial left ICA and distal M1 occlusion opened with carotid stent:** A 64-year-old male was admitted for prostate surgery. Two days after operation, he developed right hemiparesis and dysphasia. Initial NIHSS was 10. MRI and MRA brain showed small left MCA infarction and severe ostial left ICA stenosis. Because of symptom fluctuation, *iv* rtPA was not given. Endovascular treatment was done because of large diffusion-perfusion mismatch (> 20%). Angiography was done 5.5 h after onset. Critical ostial ICA stenosis and occlusion of supraclinoid ICA were seen. After deployment of distal protection device, carotid stenting was done using 7.0 mm x 30 mm WALLSTENT. Angiogram showed good flow of left ICA. Occluded distal M1 was noted. No further intervention was attempted because of good collateral flow. Two days after procedure, NIHSS was 1 and mRS was 1(Figure 1E and F).

***Case 4***

**Basilar artery occlusion opened with solitaire device:** An 81-year-old male presented with left hemiparesis. He arrived to hospital 7 h after onset. He had hypertension, dyslipidemia and chronic atrial fibrillation. Echocardiography revealed no intracardiac thrombus. MRI and MRA brain showed small right cerebellar infarction and mid basilar artery occlusion. He was transferred to catheterization lab 13 h after onset. Angiography showed tortuous left vertebral artery and occluded proximal BA. We failed to advance a 5F hydrophilic catheter over left vertebral artery. Then, a homemade 90 cm shortened JR 7F guiding catheter was placed at proximal vertebral artery. A 4.0 mm x 15 mm Solitaire was deployed at basilar artery. After thrombus extraction, TICI 3 flow of basilar was noted. Some residual thrombus remained in basilar artery. No further intervention was attempted. On the next day, he had full consciousness. Final NIHSS was 1 and mRS was 0 (Figure 1G and H).

***Case 5***

**Left distal M1 occlusion opened with *ia* rtPA:** A 61-year-old male presented with right arm weakness and dysphasia. He arrived to hospital 1 h after onset. Initial NIHSS was 9. EKG was sinus rhythm. Echocardiography showed no intracardiac thrombus. MRI and MRA brain revealed small infarction in left MCA area and left distal M1 occlusion. Large diffusion-perfusion mismatch was seen. He was transferred to catheterization lab 4 h after onset. Angiography showed occlusion of superior M2 and slowed flow in inferior M2 branch. Good pial collateral flow to left superior M2 area was seen. Five milligrams of *ia* rtPA was given. TICI 3 flow of M1 and inferior M2 was noted. Superior M2 branch still occluded. No further intervention was attempted. CT brain on the next day showed small spot hemorrhage in left temporal lobe and small infarction of left corona radiata. Right Hemiparesis improved after procedure. Three months later, he had only mild dysphasia and mRS was 0 (Figure 1I and J).

***Case 6***

**BA occlusion opened with *ia* rtPA and penumbra device:** An 87-year-old female patient was referred to our hospital because of loss of consciousness. Initial CT scan showed no significant hypodensity area. EKG showed atrial fibrillation. MRI and MRA brain showed left pontine infarction and small bilateral cerebellar infarction. She was transferred to catheterization lab 5 h after onset. Angiogram showed occlusion of distal BA. *ia* rtPA 5mg was given without improvement. Four minutes of continuous thrombus aspiration with penumbra 041 catheter was done. Complete clot removal was seen. FU CT brain on the next day showed no intracranial hemorrhage. But new right occipital lobe infarction was seen. Despite of good angiographic outcome, she had only mRS 4 on the final visit (Figure 1 K and L).

***Case 7***

**Left M1 occlusion opened with *ia* rtPA and penumbra device:** A 70-year-old male patient was referred to our hospital because of stuporous, right hemiplegia and aphasia. He had diabetes, hypertension, and post coronary artery bypass surgery. EKG showed normal sinus rhythm. Echocardiography showed no intracardiac thrombus. Initial CT scan showed old cerebral infarction and then *iv* rtPA was not given. MRI and MRA brain showed occlusion of left M1. DWI showed no acute infarction. He was transferred to catheterization lab 5 h after onset. Angiogram showed occlusion of left distal M1. *ia* rtPA 5 mg was given via Rebar microcatheter without success. Three minutes of continuous aspiration with Penumbra 041 catheter was done. Complete clot removal was seen. CT brain on the next day showed small subarachnoid hemorrhage in left sylvian fissure. No new infarction was seen. Three months later, he had only mild weakness of right arm and mRS was 2 (Figure 1M and N).

**DISCUSSION**

We described 7 cases of endovascular treatment with successful recanalization in acute ischemic stroke patients. Good outcome, defined by mRS less than 2, were found in 5 of 7 cases (71%). When mechanical thromboembolectomy devices were used, successful recanalization rate and good outcome were found in 80% and 60%, respectively, which comparable to 81% and 25%, respectively in PENUMBRA pivotal trial and 61% and 58%, respectively in SWIFT trials. No mortality in our series compared to 38% in PENUMBRA pivotal trial and 17% in SWIFT trial. In our series, any intracranial hemorrhage and symptomatic intracranial hemorrhage were found in 28% and 0%, respectively, which comparable to 28% and 11%, respectively in PENUMBRA pivotal trial and 17% and 2%, respectively in SWIFT trial[16,17]. In our case series, younger (less than 80 years old) patients and good collateral supply was good prognostic indicators. We observed that in patients under 80 years old, all patients had good outcome (4 of 4). And presence of collateral supply (case 3 and case 5), good outcome may achieve even the direct flow cannot restore.

Multimodal MRI is the most reliable study to select the patients[20,21]. Patients with small infarct core but large diffusion-perfusion mismatch are more likely to have better outcomes[21-23]. There is evidence that multimodal CT is also able to identify infarct core and penumbra area[21,24]. However, high dose of iodinated contrast usage during CT may be contra-indicated in some patients[25]. Application of ASPECT score with multimodal CT may be helpful for patient selection and outcome prediction[26,27].

Intra-arterial thrombolysis is one of preferred treatment in some centers[13,28]. Based on PROACT trial, patency rate (TICI 2, 3) was 66% and mRS less than 2 at 90th day was 40%. But in our case series, no clot lysis was found in any case[14]. It might be the limited dose of rtPA we used (less than 5 mg) and the waiting time was too short (average 10-20 min). Anyway, we believed there still had a role of *ia* rtPA in some patients, such as patients with small thrombus burden and patients with very tortuous neck arteries. However, it is likely role of *ia* rtPA will be surpassed by high efficacy mechanical devices in the near future[29].

Recently, mechanical thrombectomy devices in acute stroke receive intense interest[29,30]. High patency rate (61%-86%) and improved clinical outcome were reported in SWIFT, PENUMBRA and TREVO trials[16,17,31]. However, individual device may have its own technical issues. Stent based device, using dragging method, may cause thrombus embolization into new territory. The possible solutions of this problem are to allow the device to “ingest” thrombus for few minutes, to slowly pull back (1 cm/min), and to add aspiration force through the sheath or guide catheter. Anyway, the advantage points of stent based devices are small delivery profile and speed of recanalization[32].

Continuous thrombus aspiration using penumbra device has one inherited problem that is “profile”[33]. Because of larger profile, it may require to deliver in triaxial fashion over guidewire and microcatheter. The strong advantage of penumbra device is more complete clot removal and less embolization into new territory[33]. This could be benefit in the patients with large thrombus burden and in the situation with residual thrombus after dragging method. Aspiration method, compared to dragging method, is perceived to provide less vessel trauma. Anyway, the clinical trials reported no difference in intracranial hemorrhage, compared to Solitaire device[29,30,33].

We plan to reduce time to recanalization in our center. Focused stroke MRI protocol may shorten few minutes in this critical condition. Using multimodal CT instead of MRI may also be time saver. Interventionist should be available 24/7. Activation of interventional team during imaging study is crucial. Using mechanical thromboembolectomy as a first line treatment, instead of intraarterial thrombolysis, should be benefit.

**COMMENTS**

***Case characteristics***

The authors report seven patients with successful recanalization after endovascular treatment in acute large vessel stroke from a single stroke center in Thailand.

***Clinical diagnosis***

There were 2 patients with internal carotid artery (ICA) occlusion, 2 with middle cerebral artery (MCA) occlusion and 3 with basilar artery (BA) occlusion.

***Imaging diagnosis***

Multimodal magnetic resonance imaging (MRI) was done 6 of 7 cases (86%).

***Treatment***

Carotid stenting was performed in one case. Intraarterial recombinant tissue plasminogen activator, mechanical thrombectomy and combined treatment were done in 4, 5 and 3 cases, respectively. Solitaire and penumbra devices were used in 2 and 3 cases, respectively.

***Related reports***

Multimodal MRI is the most reliable study to select the patients

***Experiences and lessons***

Focused stroke MRI protocol may shorten few minutes in this critical condition. Using multimodal computer tomography instead of MRI may also be time saver.

***Peer review***

The manuscript is nicely written collection of 7 cases of acute ischemic stroke that were treated with various endovascular techniques. The report is worthy publishing.

**REFERENCES**

1 **Lopez AD**, Mathers CD, Ezzati M, Jamison DT, Murray CJ. Global and regional burden of disease and risk factors, 2001: systematic analysis of population health data. *Lancet* 2006; **367**: 1747-1757 [PMID: 16731270 DOI: 10.1016/S0140-6736(06)68770-9]

2 **Hanchaiphiboolkul S**, Poungvarin N, Nidhinandana S, Suwanwela NC, Puthkhao P, Towanabut S, Tantirittisak T, Suwantamee J, Samsen M. Prevalence of stroke and stroke risk factors in Thailand: Thai Epidemiologic Stroke (TES) Study. *J Med Assoc Thai* 2011; **94**: 427-436 [PMID: 21591527]

3 **Poungvarin N**. Burden of stroke in Thailand. *Int J Stroke* 2007; **2**: 127-128 [PMID: 18705969 DOI: 10.1111/j.1747-4949.2007.00104.x]

4 **Adams HP**, del Zoppo G, Alberts MJ, Bhatt DL, Brass L, Furlan A, Grubb RL, Higashida RT, Jauch EC, Kidwell C, Lyden PD, Morgenstern LB, Qureshi AI, Rosenwasser RH, Scott PA, Wijdicks EF. Guidelines for the early management of adults with ischemic stroke: a guideline from the American Heart Association/American Stroke Association Stroke Council, Clinical Cardiology Council, Cardiovascular Radiology and Intervention Council, and the Atherosclerotic Peripheral Vascular Disease and Quality of Care Outcomes in Research Interdisciplinary Working Groups: the American Academy of Neurology affirms the value of this guideline as an educational tool for neurologists. *Stroke* 2007; **38**: 1655-1711 [PMID: 17431204]

5 **Tissue plasminogen activator for acute ischemic stroke**. The National Institute of Neurological Disorders and Stroke rt-PA Stroke Study Group. *N Engl J Med* 1995; **333**: 1581-1587 [PMID: 7477192]

6 **Hacke W**, Kaste M, Bluhmki E, Brozman M, Dávalos A, Guidetti D, Larrue V, Lees KR, Medeghri Z, Machnig T, Schneider D, von Kummer R, Wahlgren N, Toni D. Thrombolysis with alteplase 3 to 4.5 hours after acute ischemic stroke. *N Engl J Med* 2008; **359**: 1317-1329 [PMID: 18815396]

7 **Muengtaweepongsa S**, Dharmasaroja P, Kummark U. Outcomes of intravenous thrombolytic therapy for acute ischemic stroke with an integrated acute stroke referral network: initial experience of a community-based hospital in a developing country. *J Stroke Cerebrovasc Dis* 2012; **21**: 42-46 [PMID: 22225863 DOI: 10.1016/j.jstrokecerebrovasdis.2010.03.017]

8 **Suwanwela NC**, Phanthumchinda K, Likitjaroen Y. Thrombolytic therapy in acute ischemic stroke in Asia: The first prospective evaluation. *Clin Neurol Neurosurg* 2006; **108**: 549-552 [PMID: 16289309]

9 **Kasner SE**, Gorelick PB.Prevention and Treatment of Ischemic Stroke: Blue Books of Practical Neurology Series. Oxford: Butterworth-Heinemann, 2004: 267-281

10 **Davis SM**, Donnan GA, Parsons MW, Levi C, Butcher KS, Peeters A, Barber PA, Bladin C, De Silva DA, Byrnes G, Chalk JB, Fink JN, Kimber TE, Schultz D, Hand PJ, Frayne J, Hankey G, Muir K, Gerraty R, Tress BM, Desmond PM. Effects of alteplase beyond 3 h after stroke in the Echoplanar Imaging Thrombolytic Evaluation Trial (EPITHET): a placebo-controlled randomised trial. *Lancet Neurol* 2008; **7**: 299-309 [PMID: 18296121 DOI: 10.1016/S1474-4422(08)70044-9]

11 **Albers GW**, Thijs VN, Wechsler L, Kemp S, Schlaug G, Skalabrin E, Bammer R, Kakuda W, Lansberg MG, Shuaib A, Coplin W, Hamilton S, Moseley M, Marks MP. Magnetic resonance imaging profiles predict clinical response to early reperfusion: the diffusion and perfusion imaging evaluation for understanding stroke evolution (DEFUSE) study. *Ann Neurol* 2006; **60**: 508-517 [PMID: 17066483 DOI: 10.1002/ana.20976]

12 **Kidwell CS**, Jahan R, Gornbein J, Alger JR, Nenov V, Ajani Z, Feng L, Meyer BC, Olson S, Schwamm LH, Yoo AJ, Marshall RS, Meyers PM, Yavagal DR, Wintermark M, Guzy J, Starkman S, Saver JL. A trial of imaging selection and endovascular treatment for ischemic stroke. *N Engl J Med* 2013; **368**: 914-923 [PMID: 23394476 DOI: 10.1056/NEJMoa1212793]

13 **Nguyen TN**, Babikian VL, Romero R, Pikula A, Kase CS, Jovin TG, Norbash AM. Intra-arterial treatment methods in acute stroke therapy. *Front Neurol* 2011; **2**: 9 [PMID: 21516256]

14 **Furlan A**, Higashida R, Wechsler L, Gent M, Rowley H, Kase C, Pessin M, Ahuja A, Callahan F, Clark WM, Silver F, Rivera F. Intra-arterial prourokinase for acute ischemic stroke. The PROACT II study: a randomized controlled trial. Prolyse in Acute Cerebral Thromboembolism. *JAMA* 1999; **282**: 2003-2011 [PMID: 10591382 DOI: 10.1001/jama.282.21.2003]

15 **Smith WS**, Sung G, Saver J, Budzik R, Duckwiler G, Liebeskind DS, Lutsep HL, Rymer MM, Higashida RT, Starkman S, Gobin YP, Frei D, Grobelny T, Hellinger F, Huddle D, Kidwell C, Koroshetz W, Marks M, Nesbit G, Silverman IE. Mechanical thrombectomy for acute ischemic stroke: final results of the Multi MERCI trial. *Stroke* 2008; **39**: 1205-1212 [PMID: 18309168 DOI: 10.1161/STROKEAHA.107.497115]

16 **Penumbra Pivotal Stroke Trial I**. The penumbra pivotal stroke trial: safety and effectiveness of a new generation of mechanical devices for clot removal in intracranial large vessel occlusive disease. *Stroke* 2009; **40**: 2761-2768 [PMID: 19590057 DOI: 10.1161/STROKEAHA.108.544957]

17 **Saver JL**, Jahan R, Levy EI, Jovin TG, Baxter B, Nogueira RG, Clark W, Budzik R, Zaidat OO. 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**: 1241-1249 [PMID: 22932715 DOI: 10.1016/S0140-6736(12)61384-1]

18 **Ciccone A**, Valvassori L, Nichelatti M, Sgoifo A, Ponzio M, Sterzi R, Boccardi E. Endovascular treatment for acute ischemic stroke. *N Engl J Med* 2013; **368**: 904-913 [PMID: 23387822 DOI: 10.1056/NEJMoa1213701]

19 **Broderick JP**, Palesch YY, Demchuk AM, Yeatts SD, Khatri P, Hill MD, Jauch EC, Jovin TG, Yan B, Silver FL, von Kummer R, Molina CA, Demaerschalk BM, Budzik R, Clark WM, Zaidat OO, Malisch TW, Goyal M, Schonewille WJ, Mazighi M, Engelter ST, Anderson C, Spilker J, Carrozzella J, Ryckborst KJ, Janis LS, Martin RH, Foster LD, Tomsick TA. Endovascular therapy after intravenous t-PA versus t-PA alone for stroke. *N Engl J Med* 2013; **368**: 893-903 [PMID: 23390923 DOI: 10.1056/NEJMoa1214300]

20 **Chaturvedi S**, Selim M. Multimodal imaging for acute stroke: when is it worth it? *Neurology* 2013; **81**: 608-609 [PMID: 23851961 DOI: 10.1212/WNL.0b013e3182a08f98]

21 **Fisher M**, Albers GW. Advanced imaging to extend the therapeutic time window of acute ischemic stroke. *Ann Neurol* 2013; **73**: 4-9 [PMID: 23378323 DOI: 10.1002/ana.23744]

22 **Lansberg MG**, Straka M, Kemp S, Mlynash M, Wechsler LR, Jovin TG, Wilder MJ, Lutsep HL, Czartoski TJ, Bernstein RA, Chang CW, Warach S, Fazekas F, Inoue M, Tipirneni A, Hamilton SA, Zaharchuk G, Marks MP, Bammer R, Albers GW. MRI profile and response to endovascular reperfusion after stroke (DEFUSE 2): a prospective cohort study. *Lancet Neurol* 2012; **11**: 860-867 [PMID: 22954705 DOI: 10.1016/S1474-4422(12)70203-X]

23 **Lemmens R**, Mlynash M, Straka M, Kemp S, Bammer R, Marks MP, Albers GW, Lansberg MG. Comparison of the response to endovascular reperfusion in relation to site of arterial occlusion. *Neurology* 2013; **81**: 614-618 [PMID: 23851962 DOI: 10.1212/WNL.0b013e3182a08f07]

24 **Campbell BC**, Christensen S, Levi CR, Desmond PM, Donnan GA, Davis SM, Parsons MW. Comparison of computed tomography perfusion and magnetic resonance imaging perfusion-diffusion mismatch in ischemic stroke. *Stroke* 2012; **43**: 2648-2653 [PMID: 22858726 DOI: 10.1161/STROKEAHA.112.660548]

25 **Tarlov N**, Nien YL, Zaidat OO, Nguyen TN. Periprocedural management of acute ischemic stroke intervention. *Neurology* 2012; **79**: S182-S191 [PMID: 23008396 DOI: 10.1212/WNL.0b013e31826958d3]

26 **Kent DM**, Hill MD, Ruthazer R, Coutts SB, Demchuk AM, Dzialowski I, Wunderlich O, von Kummer R. "Clinical-CT mismatch" and the response to systemic thrombolytic therapy in acute ischemic stroke. *Stroke* 2005; **36**: 1695-1699 [PMID: 16002756]

27 **Yaghi S**, Bianchi N, Amole A, Hinduja A. ASPECTS is a predictor of favorable CT perfusion in acute ischemic stroke. *J Neuroradiol* 2013; [Epub ahead of print] [PMID: 24156874]

28 **Kirmani JF**, Alkawi A, Panezai S, Gizzi M. Advances in thrombolytics for treatment of acute ischemic stroke. *Neurology* 2012; **79**: S119-S125 [PMID: 23008386 DOI: 10.1212/WNL.0b013e3182695882]

29 **Taqi MA**, Vora N, Callison RC, Lin R, Wolfe TJ. Past, present, and future of endovascular stroke therapies. *Neurology* 2012; **79**: S213-S220 [PMID: 23008401 DOI: 10.1212/WNL.0b013e31826959e5]

30 **Hennerici MG**, Kern R, Szabo K. Non-pharmacological strategies for the treatment of acute ischaemic stroke. *Lancet Neurol* 2013; **12**: 572-584 [PMID: 23684083]

31 **Nogueira RG**, Lutsep HL, Gupta R, Jovin TG, Albers GW, Walker GA, Liebeskind DS, Smith WS. Trevo versus Merci retrievers for thrombectomy revascularisation of large vessel occlusions in acute ischaemic stroke (TREVO 2): a randomised trial. *Lancet* 2012; **380**: 1231-1240 [PMID: 22932714 DOI: 10.1016/S0140-6736(12)61299-9]

32 **Novakovic RL**, Toth G, Narayanan S, Zaidat OO. Retrievable stents, "stentrievers," for endovascular acute ischemic stroke therapy. *Neurology* 2012; **79**: S148-S157 [PMID: 23008390 DOI: 10.1212/WNL.0b013e3182697e9e]

33 **Hussain SI**, Zaidat OO, Fitzsimmons BF. The Penumbra system for mechanical thrombectomy in endovascular acute ischemic stroke therapy. *Neurology* 2012; **79**: S135-S141 [PMID: 23008388 DOI: 10.1212/WNL.0b013e31826958a8]

**P-Reviewers:** Rafay M, Sharma V, Zhang M

**S-Editor:** Zhai HH **L-Editor: E-Editor:**

**Figure 1** **Case angiogram.** A: Pre-procedure imaging showed occlusion of distal left internal carotid artery (black arrow); B: Post-procedure imaging showed good flow of middle cerebral artery (MCA) and A1 (open arrow), occlusion of A2 (arrowhead) was noted. **C**: Pre procedure imaging showed near total occlusion of mid BA (black arrow); D: Post procedure imaging showed improved in mid basilar artery (BA), anyway distal BA (arrowhead) still occluded;E: Pre procedure imaging showed critical stenosis of ostial left including internal carotid artery (ICA) (black arrow); F: Post procedure imaging showed mild residual stenosis of proximal ICA after carotid stenting (arrowhead);G: Pre procedure imaging showed proximal BA occlusion (black arrow); H: Post procedure imaging showed patent BA with some residual thrombus in proximal part (arrowhead);I: Pre procedure imaging showed thrombotic occlusion of superior M2 branch and slow flow of inferior M2 branch (black arrow); J: Post procedure imaging showed good flow of inferior M2 branch, superior M2 branch still occluded and that area was supplied from pial collateral (arrowhead);K: Pre procedure imaging showed occlusion of distal BA (black arrow); L: Post procedure imaging showed patent BA (white arrow) and right posterior cerebral artery (PCA), anyway left PCA still occluded (arrowhead);M: pre procedure imaging showed occlusion of distal left M1 (black arrow); N: Post procedure imaging showed good flow of left MCA (arrowhead) and all branches.

**Table 1 Summary of clinical presentation, treatment provided and clinical outcome**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Sex | Age | Location | NIHSS | onset (h) | AF | *iv* rtPA (mg) | *ia* rtPA(mg) | Solitaire | Penumbra | Carotid stent | Final mRS | Any ICH | sICH |
| 1 | F | 56 | ICA | 20 | 3 | - | 59 | 8 | Y | - | - | 2 | N | N |
| 2 | F | 80 | BA | NA | 5.5 | Y | - | - | - | 032” | - | 4 | N | N |
| 3 | M | 64 | ICA, M1 | 10 | 5.5 | - | - | - | - | - | Wall stent | 1 | N | N |
| 4 | M | 81 | BA | 30 | 13 | Y | - | - | Y | - | - | 0 | N | N |
| 5 | M | 61 | M1 | 9 | 6 | - | - | 5 | - | - | - | 0 | Y | N |
| 6 | F | 87 | BA | NA | 5 | Y | - | 5 | - | 041” | - | 4 | N | N |
| 7 | M | 70 | M1 | NA | 5 | - | - | 5 | - | 041” | - | 2 | Y | N |

F: Female; M: Male; ICA: Internal carotid artery; BA: Basilar artery; NIHSS:National Institutes of Health Stroke Scale; *iv* rtPA: Intravenous recombinant tissue plasminogen activator; *ia* rtPA: Intraarterial recombinant tissue plasminogen activator; NA: Not available; Y: Yes; N: Not.