Recieved: 14 July 2015/ Accepted: 20 August 2015/ Published online: 30 September 2015

Mechanical Blood Clot Retrievers

Ekaterina Kochetova [1]; http://orcid.org/0000-0001-7079-6380
E-mail: katerina15101994@gmail.com

[1] Department of Pathological Physiology, I.M. Sechenov First Moscow State Medical University, Moscow, Russian Federation

ABSTRACT

Stroke is one of the leading cause of death and serious long-term disability. There are two types of stroke – hemorrhaging and ischemic. The last one can be treated with clot-busting drugs such as tissue plasminogen activator (tPA) and urokinase, but drugs must be given to patients within 3 hours of the onset of stroke symptoms. Unfortunately, just a tiny fraction of patients enter the emergency room within first three hours. For those who are not eligible for clot busters scientists designed mechanical blood clot retrievers. There are some retrievers' generations: first – MERCI (**M**echanical **E**mbolus **R**emoval in **C**erebral **I**schemia) and Penumbra; second – Solitaire and TrevoPro. Retrievers are effective but they remove clots fragmentally and fragments can embolize arteries. To avoid this adverse reaction scientist invented new generation of retrievers - Lazarus Funnel and ReCover which are close to get wide use in clinical practice.

KEYWORDS

Stroke, Blood Coagulation, Thrombectomy, Equipment

INTRODUCTION

Stroke, or cerebrovascular insult (CVI), is disturbed circulation that starves neurons of oxygen. It results in neurons death which in turn causes specific stroke signs and symptoms. Here are some of them: 1) Loss of consciousness; 2) Loss of body balance; 3) Inability to control or feel one side of the body; 4) Blindness in one eye; 5) Problems with understanding what goes around; 6) Inability to speak clearly; 7) Ear tingling.

There are two types of stroke: **1) ischemic** - caused by blood vessel occlusion that leads to ischemia distal to the obstruction;

2) hemorrhagic - caused by blood vessel rupture that result in the lack of oxygen all around the damaged area of brain.

These two types of stoke are treated in a different way. Let me draw your attention to the treatment for ischemic stroke.

Currently, it is available two main directions for stroke treatment. The aim is to provide revascularization and restore the blood flow. It can be reached by using thrombolytics such as tissue plasminogen activator (tPA), streptokinase or urokinase but drugs must be given to patients within 3 hours of the onset of stroke symptoms [1, 24-25]. However, a tiny fraction of patients with acute ischemic stroke is eligible for this kind of treatment due to the late enters to the hospitals [2]. Patients who don't meet the requirements for clot buster therapy have got a chance of good outcomes with designing mechanical tools that are used in surgery to remove thrombi in a blocked area. Unfortunately, this innovative treatment is used not worldwide: only the USA, Canada, Japan and west Europe do thrombectomy in the brain arteries. Moreover, many medical students and some doctors in Russia are not familiar with mechanical blood clot retrievers: how they work, what benefit is to use them, what the difference between retrievers' generations is. I hope the review will help to realize lots of useful and important data about mechanical blood clot retrievers.

MAIN BODY

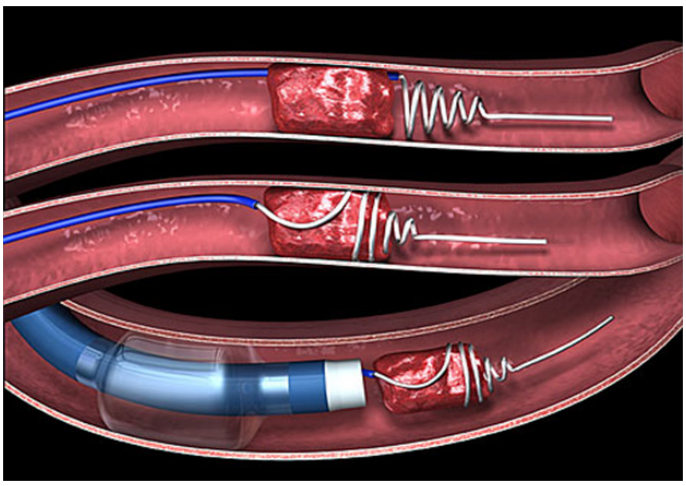
Retrievers' generations

There are some retrievers' generations which are different in many indicators. The first generation is MERCI (full name is Mechanical Embolus Removal in Cerebral Ischemia) and Penumbra;

The second one – Solitaire and TrevoPro. Retrievers are very effective but they remove clots fragmentary and fragments can embolize arteries. To avoid this adverse reaction scientist designed new generation of retrievers - Lazarus Cover and Lazarus ReCover.

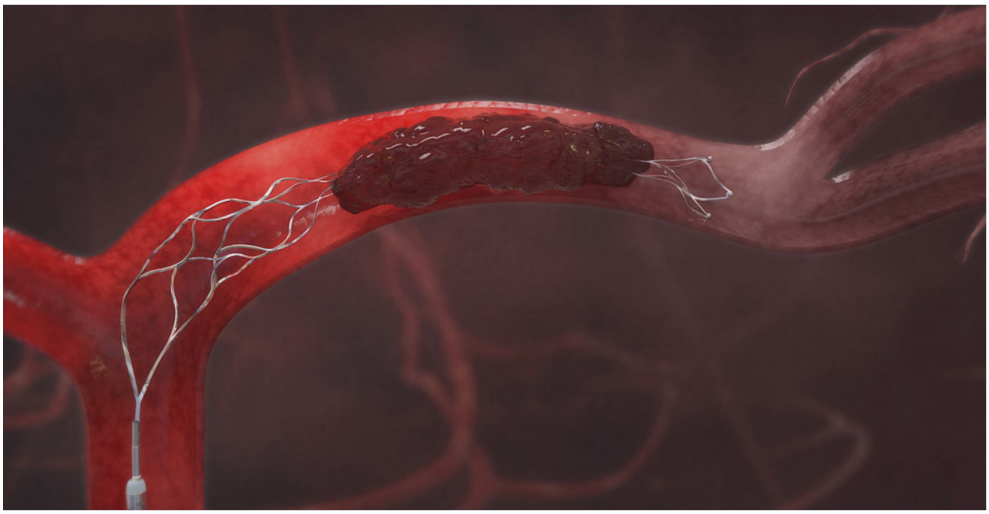
MERCI

The MERCI Retriever is a medical devised designed to remove emboli in cerebral arteries. It was the first devise improved by US Food and Drug Administration (FDA) in August 2004 to extract clots in patients who suffer from acute ischemic stroke [3].



Picture 1. MERCI is in the process of thrombectomy

Picture 2. Different Penumbra retrievers



Picture 3. Solitaire stent retriever is inside of thrombus

The retriever is a long thin wire with a spiral coil formed at the distal end. The process starts when a catheter is snaking into the affected vessel from the femoral artery. Then MERCI heads upward through the catheter to the affected site of the brain. While the retriever is in a catheter tube the distal coil keeps straightened to fit the catheter shape [4].

The retriever is then fed through the catheter. When the retriever emerges at the clot site, a surgeon pulls back a catheter, then the wire reforms, wrapping around the clot with tiny loops and the clot can be pulled from the brain artery. At this time the balloon is inflated to prevent blood flow that could hinder the retrieval process. To prevent breaking off the clot while pulling it out, a balloon at the proximal end is inflated to stop blood flow through the artery. Once the clot is pulled out, the balloon is deflated and the blood flow is restored [5].

Penumbra

The Penumbra System is the second FDA-approved device specifically designed for the purpose of re-canalization in acute brain ischemia [7]. The Penumbra is used for endovascular thromboaspiration. The system provides dual options: the first one is debulking thrombus, and the second - aspiration of clots that have appeared during the debulking.

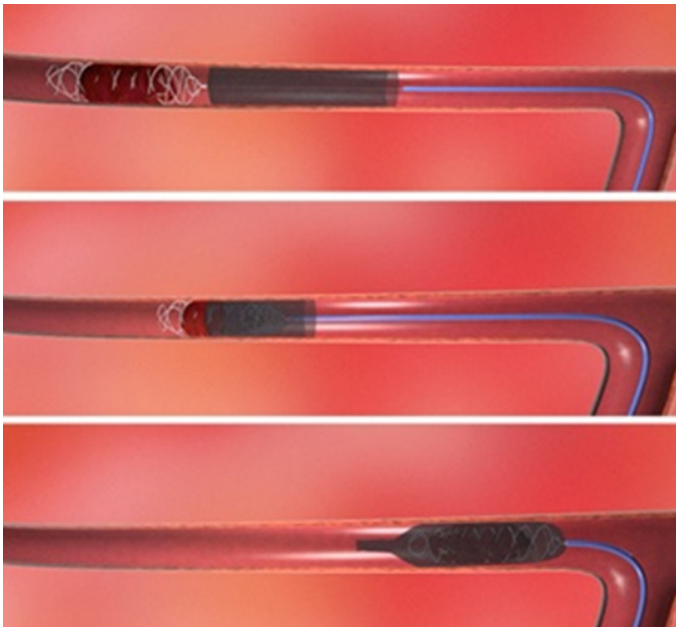
Mechanism pretty differs from MERCI system. Once the Penumbra system achieved an appropriate position which is proximal to the clot, an aspiration pump is turned on to start reduction and aspiration of the clot [8-10].

Solitaire

The Solitaire is a self-expanding stent made with plenty of thin wires. Solitaire is a combination of a stent (a tube used to expand narrowed blood vessels)

and a retriever (a trap-device used to remove any kind of emboli) [11-13]. This combination allows the Solitaire to be extremely effective in opening up intracranial vessels in acute ischemic stroke [14].

Thrombectomy starts when a guidewire is placed into the femoral artery and directed up into the blocked brain artery. Guidewire should be placed distal of thrombus. A microcatheter is then fed up to and through the blockage. Next step is to pull out guidewire and place The Solitaire through the microcatheter. Pulling back the microcatheter, solitaires is expended in the area of the clot and grasp it. The clot is disrupted and can be pulled out by the device [15].



Picture 4. Lazarus Recover while pulling out the clot

Lazarus Funnel

Stent retrievers have created dramatically growth in acute stroke therapy but they remove clot fragmentary and these emboli can obturate arteries [16].

To decrease this possible unfavorable reaction scientist invented new generation of retrievers. Lazarus Effect is a name of a company that designed new innovative retrievers for thrombectomy. Two devices (Lazarus Cover and Lazarus ReCover) have already got CE-marked and widely use in European countries, however, Lazarus Effect official site says that these devices are not available for sale in the United States [17-18]. Moreover, the company gives a data that three new retrievers are under development (Lazarus Lynx, Lazarus Funnel and Lazarus Locket) [18]. All these devices are a combo of stent retriever and a funnel which prevent artery embolization [19].

Clinical trials

MERCI vs Solitaire

Most popular devices in clinical use are MERCI and Solitaire. 113 patients with acute ischemic stroke admitted to hospital within 8 hours of stroke symptoms took part in clinical trials. The researches randomly divided patients into two groups. The first group was treated with MERCI, the second one –with Solitaire.

According to the Solitaire with the Intension for Thrombectomy (SWIFT) trial published online in Lancet in August 2012, Solitaire was totally better than MERCI [22].

The results showed that:

1. Solitaire was effective in 61% of patients (it opened blocked vessels without causing symptomatic bleeding in or around the brain) vs 24% in the Merci group.

2. Mortality rate three months after a stroke was lower in the Solitaire group (17,2%) than in the Merci group (38,2%);

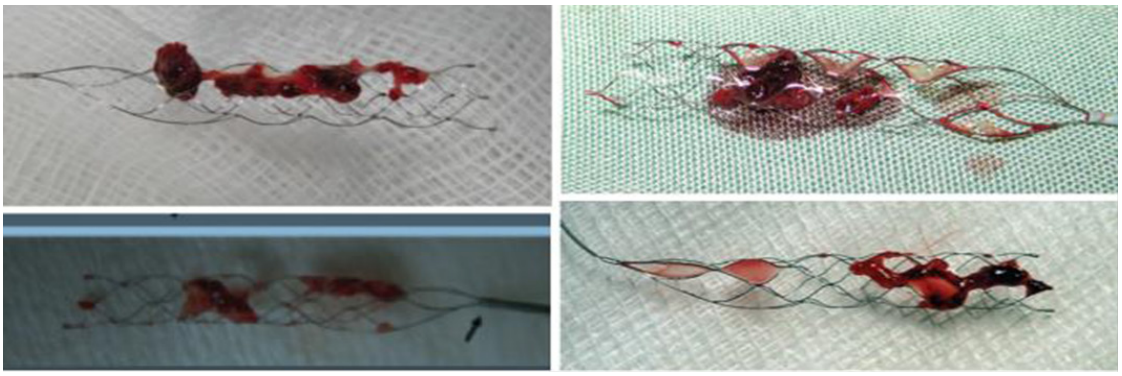
3. 11% of the MERCI group had bleeding in the brain compared with 2% in the Solitaire group.

4. 58% of the Solitaire group had good mental and motor functioning at 90 days, compared with 33% in the MERCI group. (Fig.1)

Solitaire vs Lazarus proximal Funnel and Lazarus distal Funnel

A cerebral flow model was used as in vitro simulator thrombectomy procedures to estimate efficacy of Lazarus Funnel. There were three cohorts: control is Solitaire retriever + guide catheter; proximal Funnel placement + control; and distal Funnel placement + control [23].

Successful re-canalization was more effective on 25% and reduction in distal emboli on 20% when proximal Funnel was used; and a 200% increase in successful re-canalization and a 60% reduction in emboli using distal Funnel [23]. (Fig.2)



Picture 5.Devices with fragments of thrombus

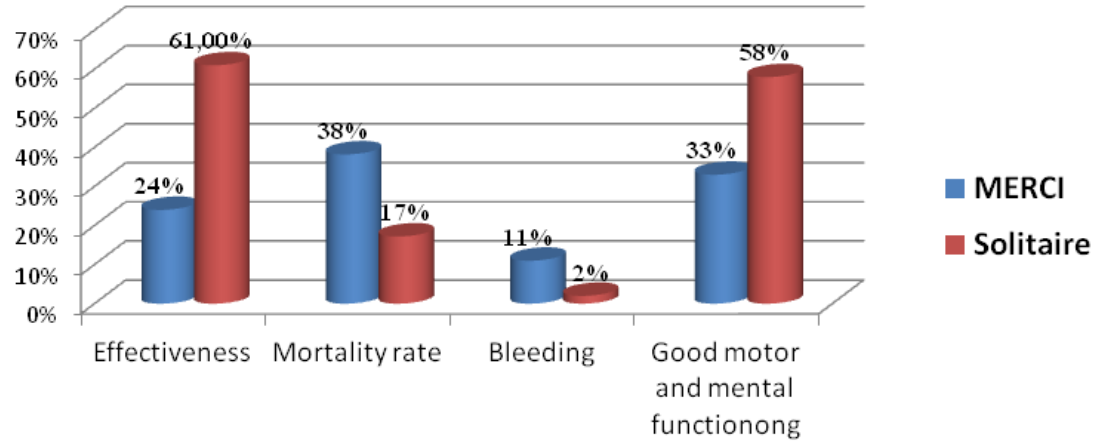


Fig.1 Comparison outcomes and effectiveness In MERCI and Solitaire groups

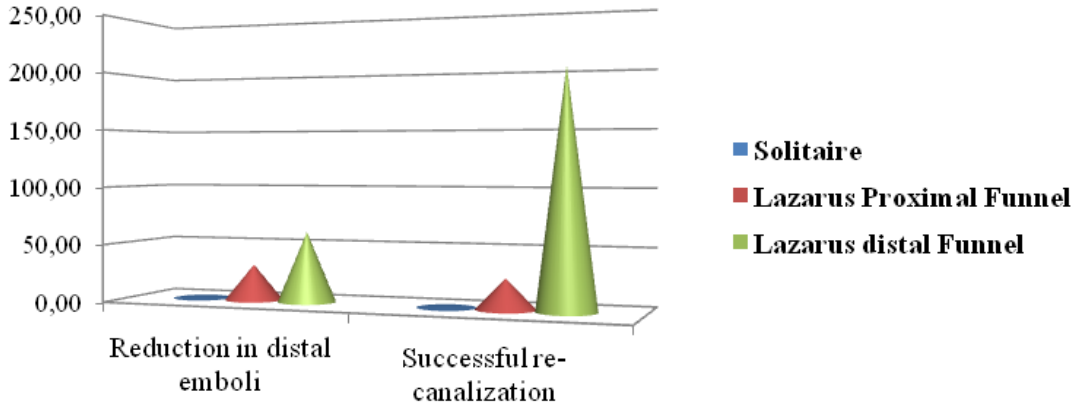


Fig.2 Efficacy of Lazarus distal Funnel and Lazarus Proximal Funnel

CONCLUSION

We can see that devices for thrombectomy in acute ischemic stroke play a great role in a quick and an effectual rehabilitation. Patients treated with Solitaire stents had better revascularization rate, clinical outcome and lower complication rate than patients treated with the Merci retriever. The Lazarus Funnel resulted in a significant increase in re-canalization and significant reduction in distal emboli without increase in time to re-canalization.

I truly believe in the near future this technique in acute ischemic stroke treatment will be used worldwide.

ACKNOWLEDGEMENTS

The author thanks MD-PhD Z.S.Manasova, Department of Pathological physiology, I.M.

Sechenov First Moscow State Medical University, Moscow, Russian Federation, for her advices and help.

REFERENCES

1. Mònica Millán, Laura Dorado, and Antoni Dávalos. Fibrinolytic Therapy in Acute Stroke. Curr Cardiol Rev. 2010 Aug; 6(3): 218–226.

2. 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; ECASS Investigators. Thrombolysis with alteplase 3 to 4.5 hours after acute ischemic stroke. N Engl J Med. 2008 Sep 25; 359 (13): 1317-29.

3. U.S. Department of Health and Human Services. Available from: http://www.fda.gov/ohrms/dockets/ac/04/questions/4022q1_Questions.pdf [accessed on July 27, 2015].

4. Medical Surgical Nursing: Assessment and Management of Clinical Problems. Wiley-Blackwell. 2009-2011: 1469-1470.

5. Smith WS, Sung G, Starkman S, Saver JL, Kidwell CS, Gobin YP. MERCI Trial Investigators. Safety and efficacy of mechanical embolectomy in acute ischemic stroke: results of the MERCI trial. Stroke. 2005; 36: 1432–1438.

6. Kidwell CS, Jahan R, Gornbein J, Alger JR, Nenov V, Ajani Z, et al; MR RESCUE Investigators. A trial of imaging selection and endovascular treatment for ischemic stroke. N Engl J Med. 2013; 368: 914–923.

7. Mikayel Grigoryan, Adnan I. Qureshi. Acute Stroke Management: Endovascular Options for Treatment. Semin Neurol. 2010; 30 (5): 469-476.

8. Penumbra Pivotal Stroke Trial Investigators. 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 Aug; 40 (8): 2761-2768.

9. Maxim Mokin, Ciprian N Ionita, Swetadri Vasan Setlur Nagesh, Stephen Rudin, Elad I Levy, Adnan H Siddiqui, Primary stentriever versus combined stentriever plus aspiration thrombectomy approaches: in vitro stroke model comparison. J Neurointerv Surg. 2015 Jun 30; 7 (6): 453-457.

10. Mokin M, Setlur Nagesh SV, Ionita CN, Mocco J, Siddiqui AH. Stent retriever thrombectomy with the Cover accessory device versus proximal protection with a balloon guidecatheter: in vitro stroke model comparison. J Neurointerv Surg. 2015 Feb 12.

11. Brekenfeld C, Schroth G, Mordasini P, Fischer U, Mono ML, Weck A, et al. Impact of retrievable stents on acute ischemic stroke treatment. AJNR Am J Neuroradiol. 2011; 32:1269–1273.

12. Helmi L Lutsep. Thrombolytic and newer mechanical device treatment for acute ischemic stroke. Expert Rev Neurother. 2006 Jul; 6 (7): 1099-1105.

13. Duan G, Feng Z, Zhang L, Zhang P, Chen L, Hong B, Xu Y, Zhao W, Liu J, Huang Q. Solitaire stents for the treatment of complex symptomatic intracranial stenosis after antithrombotic failure: safety and efficacy evaluation. J Neurointerv Surg. 2015 Jun 3.

14. Wainwright JM, Jahan R. Solitaire FR revascularization device 4×40: safety study and effectiveness in preclinical models. J Neurointerv Surg. 2015 Jun 22.

15. Tennuci C, Pearce G, Wong J, Nayak S, Jones T, Lally F, Roffe C. Comparison of the Effectiveness of Three Methods of Recanalization ina Model of the Middle Cerebral Artery: Thrombus Aspiration via a 4F Catheter, Thrombus Aspiration via theGP Thromboaspiration Device, and Mechanical Thrombectomy Using the Solitaire Thrombectomy Device. Stroke Res Treat. 2011; 2011: 186424.

16. Chueh JY, Puri AS, Wakhloo AK, Gounis MJ. Risk of distal embolization with stent retriever thrombectomy and ADAPT. J Neurointerv Surg. 2014 Dec 24.

17. PR Newswire. Lazarus Effect ReCover™ Thrombectomy Device Receives CE Mark. Available from: http://www.prnewswire.co.uk/news-releases/lazarus-effect-recover-thrombectomy-device-receives-ce-mark-163575906.html [accessed on July 24, 2014].

18. Lazarus Effect. Available from: http://lazarus-effect.com [accessed on June, 2014].

19. Chueh JY, Kühn AL, Puri AS, Wilson SD, Wakhloo AK, Gounis MJ. Reduction in distal emboli

with proximal flow control during mechanical thrombectomy: a quantitative in vitro study. Stroke. 2013 May; 44 (5): 1396-1401.

20. Smith WS, Sung G, Saver J, Budzik R, Duckwiler G, Liebeskind DS, et al; Multi MERCI Investigators. Mechanical thrombectomy for acute ischemic stroke: final results of the Multi MERCI trial. Stroke. 2008; 39: 1205–1212.

21. Tsivgoulis G, Alleman J, Katsanos AH, Barreto AD, Kohrmann M, Schellinger PD, Molina CA, Alexandrov AV. Comparative efficacy of different acute reperfusion therapies for acute ischemic stroke: a comprehensive benefit-risk analysis of clinical trials. Brain Behav. 2014; 4 (6): 789-797.

22. Saver JL, Jahan R, Levy EI, Jovin TG, Baxter B, Nogueira RG, SWIFT Trialists. 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.

23. Fargen KM, Mocco J, Gobin YP. The Lazarus Funnel: a blinded prospective randomized in vitro trial of a novel CE-marked thrombectomy assist device. J Neurointerv Surg. 2014 Nov 6.

24. 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; Interventional Management of Stroke (IMS) III Investigators. Endovascular therapy after intravenous t-PA versus t-PA alone for stroke. N Engl J Med. 2013 Mar 7; 368 (10): 893-903.

25. Mazighi M, Serfaty JM, Labreuche J, Laissy JP, Meseguer E, Lavallée PC, et al; RECANALISE investigators. Comparison of intravenous alteplase with a combined intravenous-endovascular approach in patients with stroke and confirmed arterial occlusion (RECANALISE study): a prospective cohort study. Lancet Neurol.2009; 8: 802–809.

26. Khatri P, Abruzzo T, Yeatts SD, Nichols C, Broderick JP, Tomsick TA; IMS I and II Investigators. Good clinical outcome after ischemic stroke with successful revascularization is time-dependent. Neurology. 2009; 73: 1066–1072.

27. Tsivgoulis G, Alexandrov AV. Does “time is brain” also mean “time is clot”? Time dependency of tissue-type plasminogen activator-induced recanalization in acute ischemic stroke. Stroke. 2014 Sep; 45 (9): 2555-2556.

28. Choi JH, Park HS, Kim DH, Cha JK, Huh JT, Kang M. Comparative Analysis of Endovascular Stroke Therapy Using Urokinase, Penumbra System and Retrievable (Solitare) Stent. J Korean Neurosurg Soc. 2015 May; 57 (5): 342-349.

29. Turk AS, Spiotta A, Frei D, Mocco J, Baxter B, Fiorella D, Siddiqui A, Mokin M, Dewan M, Woo H, Turner R, Hawk H, Miranpuri A, Chaudry I. Initial clinical experience with the ADAPT technique: A direct aspiration first pass technique for stroke thrombectomy. J NeuroIntervent Surg. 2014; 6: 231-237.

.