

A Suction Thrombectomy Technique: A Rapid and Effective Method for Intra-Arterial Thrombolysis

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Objective : During mechanical thrombolysis, to reduce procedure-related complications and time, the authors have performed a simple suction thrombectomy technique. In this article, the authors describe the technical details and clinical outcomes of this technique.

Materials and Methods : From January 2013 to December 2013, 14 consecutive acute ischemic stroke (AIS) patients with large cerebral arterial occlusions in the middle cerebral artery (MCA; n = 7), internal cerebral artery (ICA; n = 5), basilar artery (BA; n = 1), and a tandem lesion (ICA and MCA; n = 1) were treated using this technique. The proximal part of the occluding clot was aspirated or captured and retrieved as one piece using a large bored microcatheter by applying negative suction pressure using a 50 mL syringe.

Results : Overall recanalization rate was 85.7% (12 patients). In the 8 patients in whom this technique was used alone, the recanalization rate was 87.5% (7 patients). The median procedural duration was 30 minutes (range 17-112) in these 7 patients. Distal embolism did not occur. Two patients developed post-procedural intracerebral hemorrhages and one was symptomatic. His modified Rankin Scale (mRS) score at 90 days was 4.

Conclusion : This technique is a feasible, fast, and safe method for treatment of AIS.

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INTRODUCTION

The impact of timely recanalization is critical in the treatment of acute ischemic stroke (AIS), especially for large vessel occlusion (LVO).⁷⁾¹²⁾ When considering thrombolysis methods, mechanical thrombolysis has been actively preferred because of the low efficacy of pharmacological thrombolysis.²⁾⁴⁾¹⁰⁾¹³⁾ Various mechanical devices have been used, including wires, microcatheters, balloons, stents, and capture or aspiration devices. High recanalization rates and early recanalization

were achieved with mechanical thrombolysis, but this method also has limitations. For example, mechanical disruption of the thrombus could lead to migration of the fragmented emboli into distal arteries that are more difficult to open. Squeezing or pushing out the thrombus to the vessel walls with balloons or stents can work¹¹⁾¹⁴⁾ but is often associated with complications.³⁾⁶⁾¹¹⁾ Theoretically and practically, removal of the occluding thrombi from the cerebral arteries is the best method for treatment of acute stroke. The Merci device is one of the devices used for this

purpose. However, high recanalization rates have not been reported for the Merci device.¹³⁾ The Penumbra System, another device for removal of thrombi, does have high recanalization rates.¹⁾ However, it requires steps for fragmentation of thrombi.

In this article, we describe the details and outcomes of a suction thrombectomy technique. It is very simple; placement of a large bore microcatheter at the proximal part of the thrombi, application of negative pressure using a syringe. The thrombi are sucked out as fragments or captured at the catheter tip by the negative pressure and withdrawn as a single piece.

MATERIAL AND METHODS

From January 2013 to December 2013, 16 consecutive acute stroke patients with intracranial large arterial occlusions in the middle cerebral artery (MCA; n=7), internal cerebral artery (ICA; n = 5), basilar artery (BA; n = 1), and a tandem lesion (ICA and MCA; n = 1) were treated by the suction thrombectomy technique. This technique failed due to vessel tortuosity in 2 of these patients.

Our intra-arterial mechanical thrombolysis (IAMT) criteria were similar to those of other IAMT trials.¹⁾⁶⁾¹³⁾ Patients who met the following criteria were included: (1) clinical symptoms of AIS; (2) intracranial large arterial occlusion (LAO) visible on brain magnetic resonance (BMR) angiograms or brain computed tomography (BCT) angiograms; (3) examination within 8 hours of onset; and (4) within a time window of 3 h, the patients exhibited no response on BMR angiograms to intravenous tissue plasminogen activator (tPA) treatment. Patients who had intracranial hemorrhages (ICH), broad infarctions (middle cerebral artery territory $\geq 1/3$), or severe brain edema were excluded.

The etiology of the AIS was classified according to the Trials of Org 10172 in Acute Stroke Treatment (TOAST) classification system. At an initial examination and at a periprocedural examination, the presence of neurological deficits was evaluated by a

stroke neurologist according to the National Institutes of Health Stroke Scale (NIHSS). Follow up BCT or BMR images were evaluated within 24 h of the thrombolytic therapy. If an intracranial hemorrhage was suspected, BCT was performed immediately after the procedure. A symptomatic hemorrhage was defined as neurological deterioration greater than or equal to 4 points on the follow-up NIHSS score compared to that of the initial examination and a hemorrhage visible on follow up imaging. Functional disability was assessed using a modified Rankin Scale (mRS) and clinical outcome was tested by mRS at 90 days. Good long-term outcome was defined as an mRS score ≤ 2 at 90 days. Recanalization was assessed and scored using the Thrombolysis in Cerebral infarction (TICI) scale. We regarded TICI grades 2 and 3 as recanalization and complete recanalization was defined as TICI grades 2b or 3.

Technical details

The endovascular procedure was performed using a femoral artery approach under local anesthesia with the occasional addition of the sedative medications midazolam and propofol for uncooperative patients. After determining occlusion site and extent, a large bored suction catheter (Penumbra System 4.1 Fr, Penumbra Inc, Alameda, CA, USA) was advanced to the proximal portion of the thrombi under the guidance of a microwire or a coaxial microcatheter system (Excelsior-10, Boston Scientific, CA, USA). If the suction catheter could not be advanced smoothly over the acute angle of the carotid siphon at the cavernous segment of the ICA, the suction catheter tip was retrieved, steam-shaped and reinserted. After placing the suction catheter proximal to the thrombi, in most cases, a microcatheter (Excelsior-10) was advanced through the thrombi distally over the microwire and selective angiography was performed in order to measure length of whole clot and visualize distal vessels. If the microcatheter was not able to pass smoothly through the thrombi because of its consistency, we did not try to advance it by force. With experience, we have realized that passing through the

thrombi and confirming the distal part of the thrombi is not an essential part of the suction thrombectomy.

As a next step, we slowly advanced the suction catheter in order to wedge it to the proximal part of the thrombi. For that, we needed to insert the catheter tip into the proximal several millimeters of the clot.

In most cases, placing the catheter tip into the clot was easy when the thrombi were located in a straight vessel part like in the M1 or in the supraclinoid ICA. However, when the thrombi began at a curved vessel like the intradural ICA bifurcation or the carotid siphon, we tried not to cause the suction catheter tip to be wedged to the vessel wall. In these cases, either of the two methods was used. The first one involves placement of the suction catheter tip 1-2 mm proximal to the thrombi (not into the thrombi) and then aspirating it with the ipsilateral common carotid artery occluded manually or by using a balloon guiding catheter. The second method involves insertion of the catheter tip up to the straight part of the clot after passing the curved part.

The suction or aspiration process was performed using 50 mL syringes. We aspirated the syringe manually in some cases and with devices in others. We designed a gun-like aspiration device (Fig. 1; Aspiration Gun, Taesung, Seoul, Korea) to hold a 50 mL syringe. By pulling the gun handle, we were able to apply neg-

ative suction pressure through the suction catheter. We were also able to control the suction pressure by use of a teeth-like locking system.

We started aspiration from 2-3 mm proximal to the clot. The negative pressure was moderate with the aspiration gun handle pulled to approximately 3/4 of the maximum. We then slowly advanced the catheter tip to the thrombi while maintaining the suction pressure. We could see aspirated blood. If the catheter tip was wedged to the thrombi, the aspirated blood suddenly stopped. At that time, we pulled the aspiration gun handle to the maximum. In many cases, thrombi were easily caught by the suction catheter tip, and in those cases, we slowly withdrew the catheter and the thrombi together. In many cases, the whole thrombi could be successfully removed as one piece. During this process, we were able to check whether or not the catheter tip held tight to the thrombi by simply checking for the presence of constant aspirated blood in the syringe. If present, it meant that the catheter tip did not hold the thrombi. The negative pressure was then released and the suction catheter was readvanced to catch the thrombi again.

RESULTS

The clinical and neuroradiological characteristics

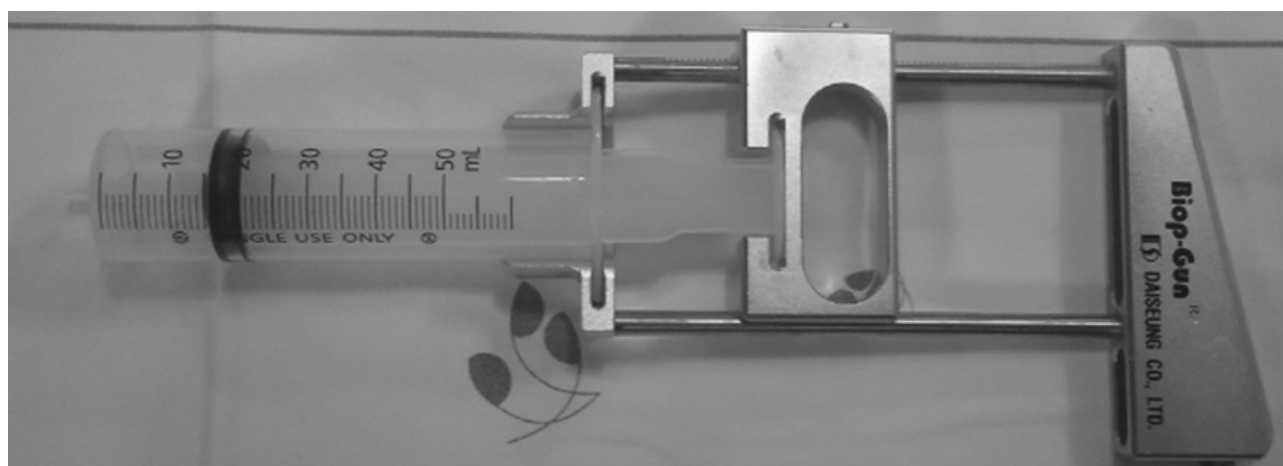


Fig. 1. Aspiration gun.

and outcomes of the 14 cases are summarized in Table 1. The mean age was 70 years (range: 45-93 years). The mean interval from the onset of symptoms to femoral arterial puncture was 5.9 hours (range: 3.6-12.8 hours). The initial median NIHSS was 17.5 (range: 9-35) and the immediate post-procedural NIHSS was 16 (range: 2-35). Seven of the 14 patients (50%) underwent intravenous tPA before intra-arterial thrombolysis (IAT) according to our protocol.

The occluded vessels were divided as follows: M1 in 7 patients (50%), ICA in 5 (3 extradural and 2 intradural ICA) (35.6%), 1 ICA (extracranial lesion) and M1 (7.1%), and 1 BA (7.1%). Based on the TOAST classification, large-artery atherosclerosis was present in 6 patients (42.9%), cardioembolism in 7 patients (50%), and the etiology was undetermined in 1 (7.1%). Adjuvant intraarterial thrombolytic agents including urokinase (UK) and/or tirofiban were administered in 7 patients. Carotid stent was applied in 1 case with a concomitant severe cervical carotid stenosis.

The median procedural time (the time from arterial

puncture to procedural end) was 85 minutes (range: 17-242 minutes). In 8 cases, suction thrombectomy was performed alone. Seven of these cases were recanalized with complete recanalization in 6 of the 7 patients. The median procedural time of these 7 cases was 30 min (range: 17-112 min). Overall, the recanalization rate was 85.7% (12 of 14 cases). There was no distal embolism in the recanalization cases.

There were 2 failed cases. In these cases, we were not able to advance the suction catheter to the occlusion site due to vessel tortuousness. These 2 cases were finally recanalized by local infusion of urokinase and balloon angioplasty, respectively.

Post-procedural hemorrhage was detected in 2 patients. One patient with symptomatic subarachnoid hemorrhage finally improved. His mRS score at 90 days was 4. The other case of small intracerebral hemorrhage was asymptomatic. No hemorrhagic complication occurred in the 8 cases treated by the current technique alone. There were no cases of mortality.

Good long-term outcomes (mRS 0-2) at 90 days were

Table 1. Summary of the characteristics of the patients and the clinical results after the procedure

Pt No	Age	Sex	From onset to femoral puncture (hours)	Procedure duration (minutes)	Location	TOAST	IVtPA	UK	Initial NIHSS	Post procedure NIHSS	TICI grade	Symptomatic hemorrhage	mRS at 90 days	Cause of failure
1	65	M	10h27	30	MCA	LAA	Y		13	4	3		2	
2	45	M	2h17	17	MCA	LAA	Y		20	8	2B		1	
3	81	F	3h15	150	ICA	CE	Y		18	18	1		4	T
4	75	M	10h38	206	MCA	Un	N	10k	12	18	0	SAH	4	T
5	59	M	8h19	26	MCA	LAA	N		12	8	2A		2	
6	93	F	3h15	25	MCA	CE	Y		21	16	3		3	
7	50	F	3h	40	MCA	CE	Y		10	2	2B		0	
8	71	F	6h	70	ICA	CE	N		20	17	2B		4	
9	70	M	7h49	242	ICA	CE	N	10k	19	19	2A		4	
10	81	F	2h25	100	MCA	CE	Y	10k	9	2	2B		2	
11	84	F	12h48	173	ICA	LAA	N	20k	11	14	2A		4	
12	66	F	4h28	60	BA	CE	N	50k	35	35	2B		5	
13	71	M	3h11	112	ICA&MCA	LAA	N		23	16	3		2	
14	65	M	4h28	125	ICA	LAA	N	6k	17	16	2A	ICH	5	

Pt = patient; TOAST: the Trials of Org 10172 in Acute Stroke Treatment; IVtPA = intravenous tissue plasminogen activator; UK = urokinase; NIHSS = National Institutes of Health Stroke Scale; TICI = thrombolysis in cerebral ischemia; mRS = modified rankin scale; MCA = middle cerebral artery; ICA = internal cerebral artery; BA = basilar artery; LAA = large artery atherosclerosis; CE = cardiac embolism; Un = stroke of undetermined etiology; Y = yes; N = no; k = × 10³; SAH = subarachnoid hemorrhage; T = tortuous

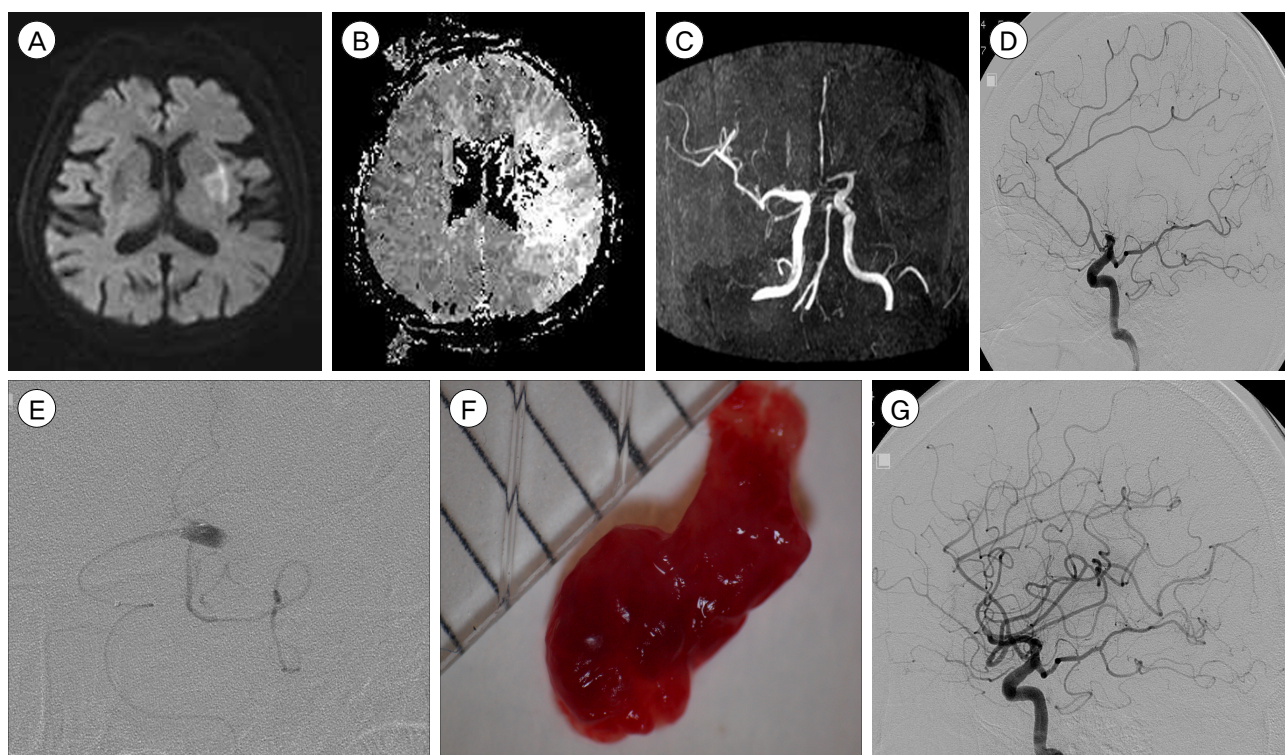


Fig. 2. A 93-year-old female with right-side hemiparesis. There was acute infarction in the left basal ganglia and the corona radiata on Diffusion magnetic resonance (MR) (A). Perfusion MR showed decreased perfusion decrease in the left middle cerebral artery (MCA) territory (B). Complete occlusion of the proximal M1 segment of the left MCA was found on brain MR angiogram (C). An angiogram showed occlusion of the proximal M1 (D). The suction catheter tip was wedged to the proximal part of the thrombus (E). The whole thrombus was retrieved as one piece (F). Post procedural distal subtractive angiogram showed complete recanalization of the occlusion site (G).

achieved in 6 of the 14 patients (42.9%). Of these, 6 cases were treated by suction thrombectomy alone.

Illustrative case, case 7

A 93-year-old female presented with a sudden onset right-side hemiparesis and a drowsy consciousness within a 3.15 hour window. Her initial NIHSS was 21. Diffusion magnetic resonance (MR) showed acute infarction in the left basal ganglia and the corona radiata (Fig. 2A). Perfusion MR showed decreased perfusion in the left MCA territory (Fig. 2B) and MR angiogram demonstrated complete occlusion of the proximal M1 segment of the left MCA (Fig. 2C).

With the diagnosis of AIS due to LVO, we performed an emergency IAT. An angiogram showed occlusion of the proximal M1 (Fig. 2D). A suction catheter was advanced to the thrombus under the guidance of a wire and a coaxial microcatheter. The entire length

of the thrombi was visualized on selective angiography. The suction catheter tip was wedged to the proximal part of the thrombus (Fig. 2E). Then, forced aspiration was applied by pulling the handle of the aspiration gun in order to capture the thrombus. The catheter and thrombus were withdrawn slowly. The whole thrombus was retrieved as one piece (Fig. 2F). Complete recanalization of TICI grade 3 was achieved (Fig. 2G). The procedural time was 25 min from femoral puncture to end of the procedure. The immediate post-procedural NIHSS score improved to 16. Her mRS score at 90 days was 0.

DISCUSSION

The current IAT method is a technique for thrombus retrieval in acute cerebral stroke. The procedural de-

tails are very simple and involve placement of a large bore tube (a 4-Fr suction catheter) proximally to the thrombi or wedging it into the thrombi and then applying negative pressure by pulling on a 50 mL syringe. We were able to control the negative pressure by using a simple device to hold the syringe, the so-called aspiration gun. Thrombi may be broken and fragmented by the negative pressure that could be easily aspirated. In many other cases, the clot was well caught by the catheter and retrieved easily as one piece under the condition that we maintained continuous negative pressure by the aspiration gun. In most cases, we did not use balloon-mounted guiding catheters to control the proximal blood flow. In over half of our cases, no thrombolytic drug infusion was necessary.

Pathologic findings of the thrombi in our cases demonstrate the sticky characteristics of thrombi. Grossly, the retrieved clots had an elastic consistency, and they were not easily fragmented by manual manipulation. Histologically, multiple layers of components of acellular fibrin appeared to play a role in keeping the clot as one unit. Fibrin holds blood cells, which are mainly red blood cells and other fibrin components together. Thus, they were not easily torn or broken, so that retrieving the thrombi as one piece by catching the proximal part was possible.

We have used the reperfusion catheter of the Penumbra System as a suction catheter.¹⁵⁾ We think this catheter is suitable for this purpose because it has a large lumen that is enforced by metal braiding that protects the catheter lumen from collapsing under the strong negative pressure. Other helpful characteristics of this catheter are the minimal difference between the proximal and distal inner-luminal diameters, which is important in terms of providing sufficient negative pressure. A malleable distal tip, which is necessary when a clot is located in a curved vessel, is also helpful. Compared to other devices and techniques such as the Merci (Concentric Medical, CA, USA) and the original Penumbra system¹¹³⁾, we believe that the current technique is simpler. The only special devices necessary for this technique are a large-bore catheter

and 50 mL syringes.

AIS, caused by LVO, is particularly morbid and neurological outcome is dependent on timely recanalization.¹³⁾ Thus, we believe that a short procedural time is important. In our study, the median procedural time was just 30 min (range: 17-112 min) in the successful cases. Now, this technique has become the first line of treatment for IAT in our practice because of the relatively high recanalization rate and the short procedural duration.

Aspiration thrombolysis has proved to be effective in terms of reducing distal emboli in the cardiac intervention field.⁸⁾⁹⁾ Considering our results with very low distal emboli, the current technique seems to have a low risk of embolism during the procedure. With respect to the suction technique, it seems that there is a possibility that vessel perforation or dissection may occur by sucking on the vessel medial wall. However, in our experience, there were no complications related to this technique. Placing the catheter tip at the straight part of the vessel appears to be important.

The current trial has some limitations, including the retrospective collection of data, a small number of cases, a single-center experience, and a short follow-up period. Thus, a prospective, large, long-term follow-up and multi-center study is required in order to prove the efficacy and safety of the current technique.

CONCLUSION

The suction thrombectomy technique outlined in this paper is a simple, time-saving, beneficial, and safe method for treatment of AIS with LVO. Thus, the current technique is worthy of consideration as a rapid and effective treatment option among various thrombolytic methods for recanalization of LVO in AIS.

Disclosure

The author report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

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