



Effectiveness of Anchoring with Balloon Guide Catheter and Stent Retriever in Difficult Mechanical Thrombectomy for Large Vessel Occlusion

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Objective : A distal navigation of a large bore aspiration catheter during mechanical thrombectomy (MT) is important. However, delivering a large bore aspiration catheter is difficult to a tortuous or atherosclerotic artery. We report the experience of anchoring with balloon guide catheter (BGC) and stent retriever to facilitate the passage of an aspiration catheter in MT.

Methods : When navigating an aspiration catheter failed with a conventional co-axial microcatheter delivery, an anchoring technique was used. Two types of anchoring technique were applied to facilitate distal navigation of a large bore aspiration catheter during MT. First, a passage of aspiration catheter was attempted with a proximal BGC anchoring technique. If this technique also failed, another anchoring technique with distal stent retriever was tried. Consecutive patients who underwent MT with an anchoring technique were identified. Details of procedure, radiologic outcomes, and safety variables were evaluated.

Results : A total of 67 patients underwent MT with an anchoring technique. Initial trial of aspiration catheter passage with proximal BGC anchoring technique was successful for 35 patients (52.2%) and the second trial with distal stent retriever anchoring was successful for 32 patients (47.8%). Overall, navigation of a large bore aspiration catheter was successful for all patients (100%) without any procedure related complications.

Conclusion : Our study showed the usefulness of anchoring technique with proximal BGC and distal stent retriever during MT, especially in those with an unfavorable anatomical structure. This technique could be an alternative option for delivering an of aspiration catheter to a distal location.

Key Words : Ischemic stroke · Intervention · Reperfusion · Stent · Thrombectomy.

INTRODUCTION

A mechanical thrombectomy (MT) was established as a standard treatment for patients with acute ischemic stroke (AIS) caused by large vessel occlusion (LVO)⁵. Techniques of

MT are evolving, and there are three main strategies of MT, including stent retriever, contact aspiration, and combined strategy (stent retriever with simultaneous aspiration)^{8,10,33}. A large bore aspiration catheter plays an important role in all these MT strategies. It could increase the suction force for clot.

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It also could act as a distal accessible intermediate catheter to aid distal delivery of microcatheter and stent retriever^{9,18,21}. However, there are some cases in which delivery of large bore aspiration catheter is difficult and challenging due to atherosclerotic or tortuous vessel status. Several methods such as using a compliant balloon catheter, application of larger co-axial catheter, and anchoring with stent retriever have been introduced for a smooth navigation of a large bore aspiration catheter^{13,25,35}.

Another cornerstone device for MT is a balloon guide catheter (BGC). It can increase suction effectiveness, thereby facilitating clot removal and minimizing the chance of distal emboli with a temporary proximal flow arrest^{11,17,19}. New generation BGCs such as 8F (FlowGate2, FG2; Stryker Neurovascular, Fremont, CA, USA) and 9F Concentric (Stryker Neurovascular) have various applications in MT with improved accessibility due to good trackability and smooth navigation. BGC with a balloon anchoring technique could be useful for cases with unfavorable anatomy of aortic arch or common carotid artery (CCA)²².

The objective of this study was to report our experience of using an anchoring technique with BGC and stent retriever to facilitate the passage of a large aspiration catheter in MT. The first attempt was made with proximal BGC anchoring. Serial distal stent retriever anchoring was then performed to deliver the aspiration catheter to a distal lesion. For a better recanalization rate or a far distal lesion approach, navigation of a large bore aspiration catheter to a distal lesion is important. We described technical details, feasibility, outcome, and safety concerns of anchoring technique with BGC and stent retriever for navigation of a large bore aspiration catheter.

MATERIALS AND METHODS

Study population

This study was approved by the local Institutional Review Board of each participating center (IRB No. VC20RISI0067). Each institution's stroke database between March 2017 and February 2021 was retrospectively reviewed to the LVO patients who underwent MT with an anchoring technique for delivery of large bore aspiration catheters. Anchoring technique was used in cases with failed navigation of an aspiration catheter with a standard co-axial technique using a micro-

catheter and a microwire. Among 442 patients who underwent MT, a total of 67 cases were enrolled. Almost all patients had either tortuous vasculature or atherosclerotic carotid arteries. Inclusion criteria were as follows: 1) AIS by LVO in anterior circulation, including distal intracranial carotid artery (ICA), middle cerebral artery (MCA, M1, or M2), and anterior cerebral artery (ACA) established with computed tomography angiography; 2) neurologic deficits; and 3) MT with suction aspiration alone or a combined approach. Patients who underwent MT with simple stent retriever were excluded. Stroke etiology was classified with TOAST criteria. Intravenous tissue plasminogen activator (IV t-PA, alteplase) was administered to cases within 4.5 hours after stroke onset at a maximum dose of 0.9 mg/kg in accordance with the European Cooperative Acute Stroke Study (ECASS) III trial^{1,6}. Radiologic results were evaluated according to the Thrombolysis in Cerebral Infarction (TICI) grading system. Successful recanalization and first-pass reperfusion were defined as TICI grade of 2b or 3 and TICI 2b or 3 with the first pass, respectively.

Endovascular procedure

Enrolled patients and flow sheet for application of anchoring technique during MT are summarized in Fig. 1. Under consciousness sedation with dexmedetomidine (Precedex), a direct aspiration first pass technique (ADAPT) with a large bore aspiration catheter was tried as the primary method of MT^{26,27}. In all cases, a tri-axial system was applied with an 8F BGC (FG2), an aspiration catheter, coaxially over a Synchro microwire (Stryker Neurovascular) and an Excelsior 18 or 27 microcatheter (Stryker Neurovascular). The largest caliber aspiration catheter that the vessel could accommodate was selected for each case, usually an AXS Catalyst 6 (CAT6; Stryker Neurovascular) or a 5MAX ACE (Penumbra). Occasionally, delivery of aspiration catheter failed with a conventional co-axial microcatheter, due to anatomical obstacles such as tortuosity of extra and intracranial vasculature, plaque formation or ulceration of vessel, and impediment of ophthalmic artery orifice. In this situation, the proximal anchoring technique was tried with balloon inflation of the BGC located in the proximal ICA to push the aspiration catheter. With the large bore aspiration catheter at the face of the thrombus, dual aspiration was applied with a 50 mL syringe at the BGC and aspiration pump at the aspiration catheter⁷. If distal delivery of the aspiration catheter failed even with a proximal BGC an-

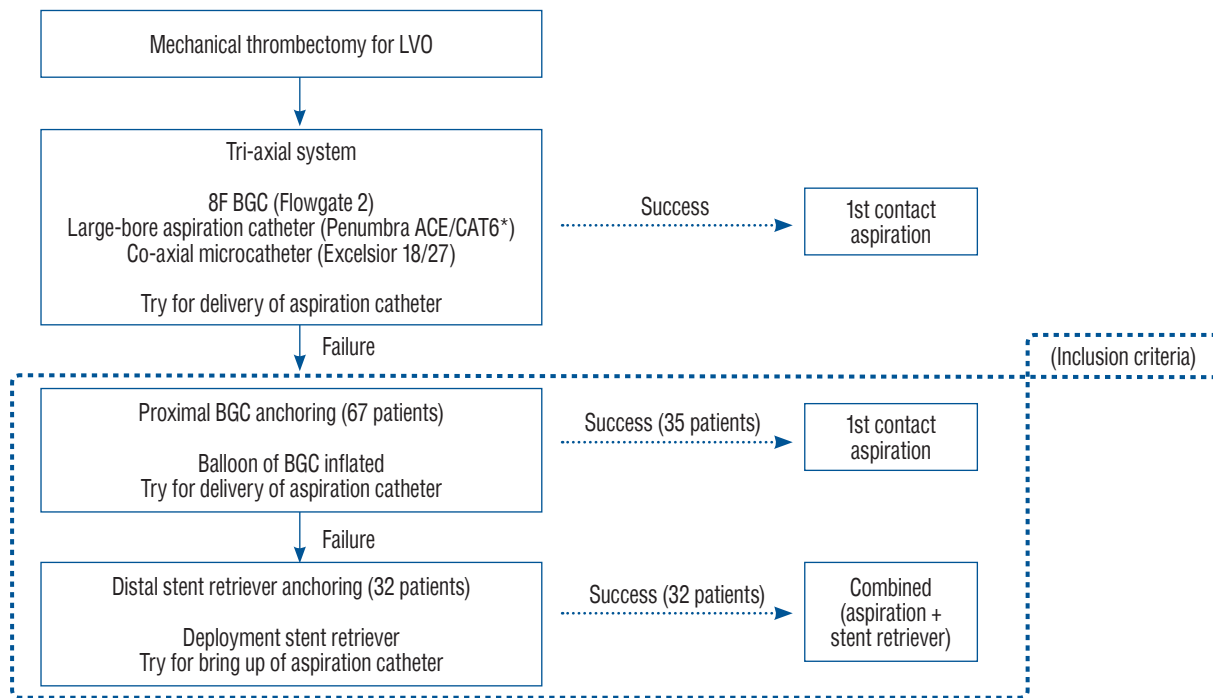


Fig. 1. Flow sheet for detailed application of anchoring technique during mechanical thrombectomy, and summary of enrolled patients. *AXS Catalyst 6 (Stryker Neurovascular, Mountain View, CA, USA). LVO : large vessel occlusion, BGC : balloon guide catheter.

choring technique, a combined approach MT with a distal stent retriever anchoring technique was applied to navigate the aspiration catheter at the occlusion site. After 3 minutes of waiting post stent deployment to promote stent clot integration, the aspiration catheter and stent retriever were slowly removed as a single unit³¹. At this time, the same dual aspiration technique was used for the BGC and the aspiration catheter⁷.

Anchoring technique with proximal balloon guide catheter

A proximal BGC anchoring technique was applied when we failed to navigate the aspiration catheter with the conventional microcatheter co-axial method. Application of the proximal BGC anchoring technique for a patient with M1 occlusion is presented in (Fig. 2). Sometimes for various reasons, including diffuse tortuosity of vasculature, the orifice of the ophthalmic artery, atherosclerosis, and plaque ulceration may prevent the navigation of a large bore aspiration catheter to the occlusion site. Under such situations, we inflated the balloon of BGC at the proximal cervical ICA in order to have a strong support by anchoring BGC and to get a stable guiding system. The aspiration catheter was then withdrawn slightly and pushed gently

to the distal lesion.

Anchoring technique with distal stent retriever

If placing the large bore aspiration catheter at the target artery failed, even with proximal BGC anchoring technique, we switched to the combined approach MT and tried an additional anchoring technique with a distal stent retriever. Anchoring technique with distal stent retriever is presented in (Fig. 3). In patient with a left M2 occlusion, navigation of an aspiration catheter (CAT6; Stryker Neurovascular) to the left MCA was difficult, due to diffuse tortuosity of cervical and cavernous ICA. Initially, CAT6 delivery through the proximal BGC anchoring technique was tried. However, it was not successful. Furthermore, the co-axially Excelsior 18 (Stryker Neurovascular) microcatheter could not reach the occluded M2 segment because of a short working length of the microcatheter and the proximal location of CAT6. A Trevo XP Provue (Stryker Neurovascular) stent retriever was then delivered through the microcatheter and deployed at M1 which was a more proximal lesion than the real-occlusion site of M2. Subsequently, the Trevo stent-retriever was gently pulled back. Simultaneously, CAT6 was pushed to the distal location. Sup-

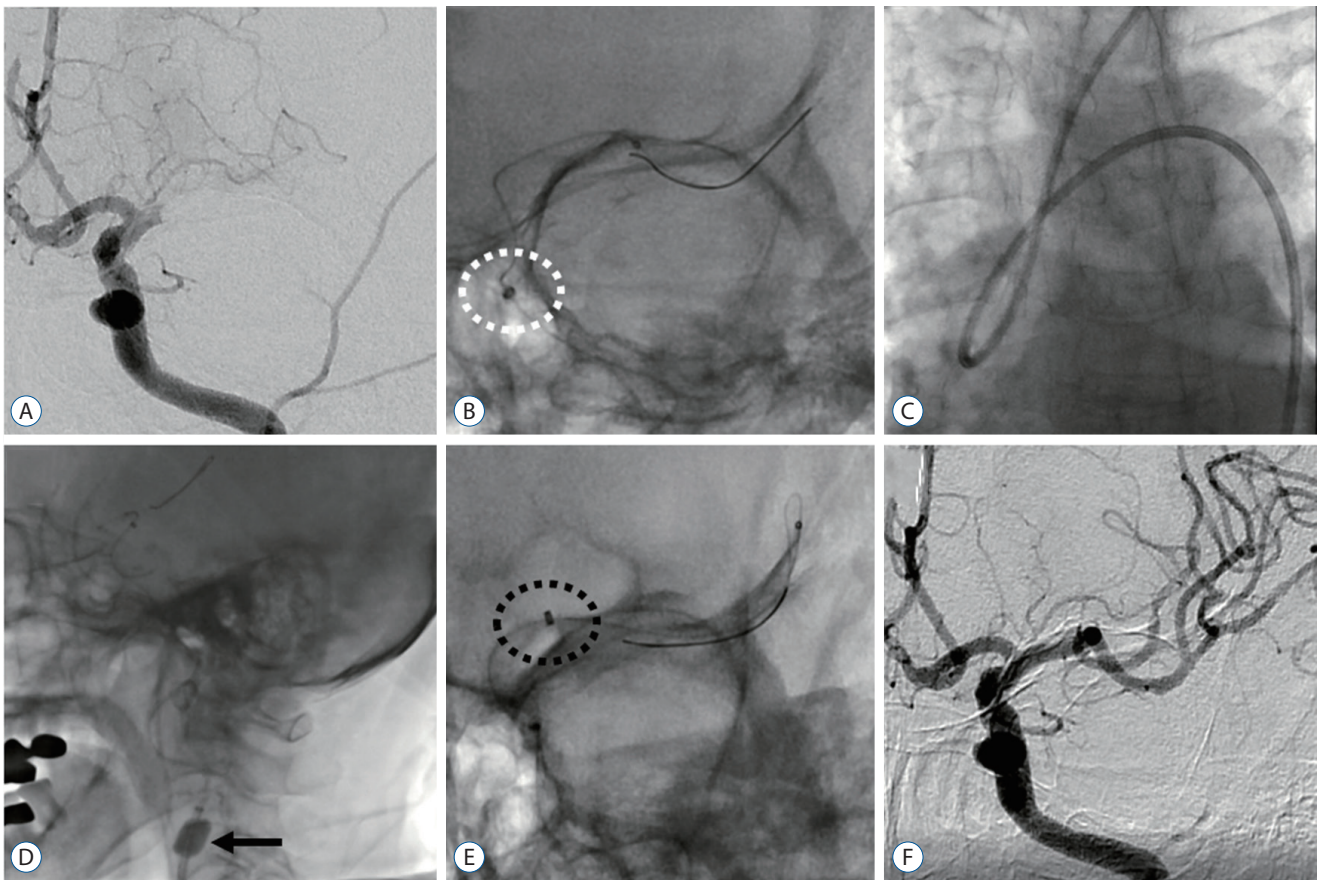


Fig. 2. Representative case of anchoring technique with proximal balloon guide catheter (BGC) for distal delivery of aspiration catheter during aspiration thrombectomy. A : An 84-years old male with proximal M1 occlusion. B : With an 8F BGC (FlowGate2, FG2; Stryker Neurovascular, Fremont, CA, USA) guiding, a Penumbra 5MAX ACE reperfusion catheter (Penumbra Inc., Alameda, CA, USA) was delivered under guidance of a co-axial Excelsior 27 (Stryker Neurovascular) microcatheter and a synchro 2 microwire (Stryker Neurovascular). However, the tip of the Penumbra 5MAX (white dot circle) could not pass the orifice of the ophthalmic artery. C : A push of the Penumbra 5MAX for distal delivery induced herniation of the FG2 BGC to the aortic arch. D : In the next trial, BGC was re-positioned at cervical ICA and balloon of FG2 BGC was inflated (black arrow). E : The Penumbra 5MAX catheter (black dot circle) was easily navigated past the orifice of ophthalmic artery to M1 when we pushed it in the inflation state of FG2 BGC balloon. F : Angiography after aspiration thrombectomy revealing a recanalization status of M1 and an intact internal carotid artery.

ported by the anchored stent retriever at M1, CAT6 could be easily engaged to the left M1. Then, the Trevo stent retriever was re-captured so that the microcatheter with microwire could pass the M2 occlusion site. After second deployment of the Trevo stent retriever at the real occlusion site, MT with combined approach was performed.

RESULTS

A total of 67 patients underwent MT with an anchoring technique. Navigation of a large bore aspiration catheter was successfully done for all patients. The mean age of patients

was 71.4 years (standard deviation [SD], 13.2 years). There were 31 female patients (46.3%). Age distribution was as follows : ≥ 80 years ($n=25$, 37.3%), 60–79 years ($n=33$, 49.3%), and <60 years ($n=9$, 13.4%). Detailed co-morbidity is summarized in (Table 1). There were 38 patients (56.7%) with left hemisphere stroke. IV t-PA was applied in 23 patients (34.3%) before MT. Cardio-embolic origin stroke occurred in 33 patients (49.3%). Twenty-one patients (31.3%) showed atherosclerotic thrombus. The etiology of AIS was undetermined for 13 patients (19.4%). All of lesions were located in the anterior circulation, including 38 (56.7%) in the M1, 10 (14.9%) in the M2 segment, 17 (25.4%) in distal ICA, and two (3.0%) in the ACA. Regarding procedure details, BGC was applied in all 67

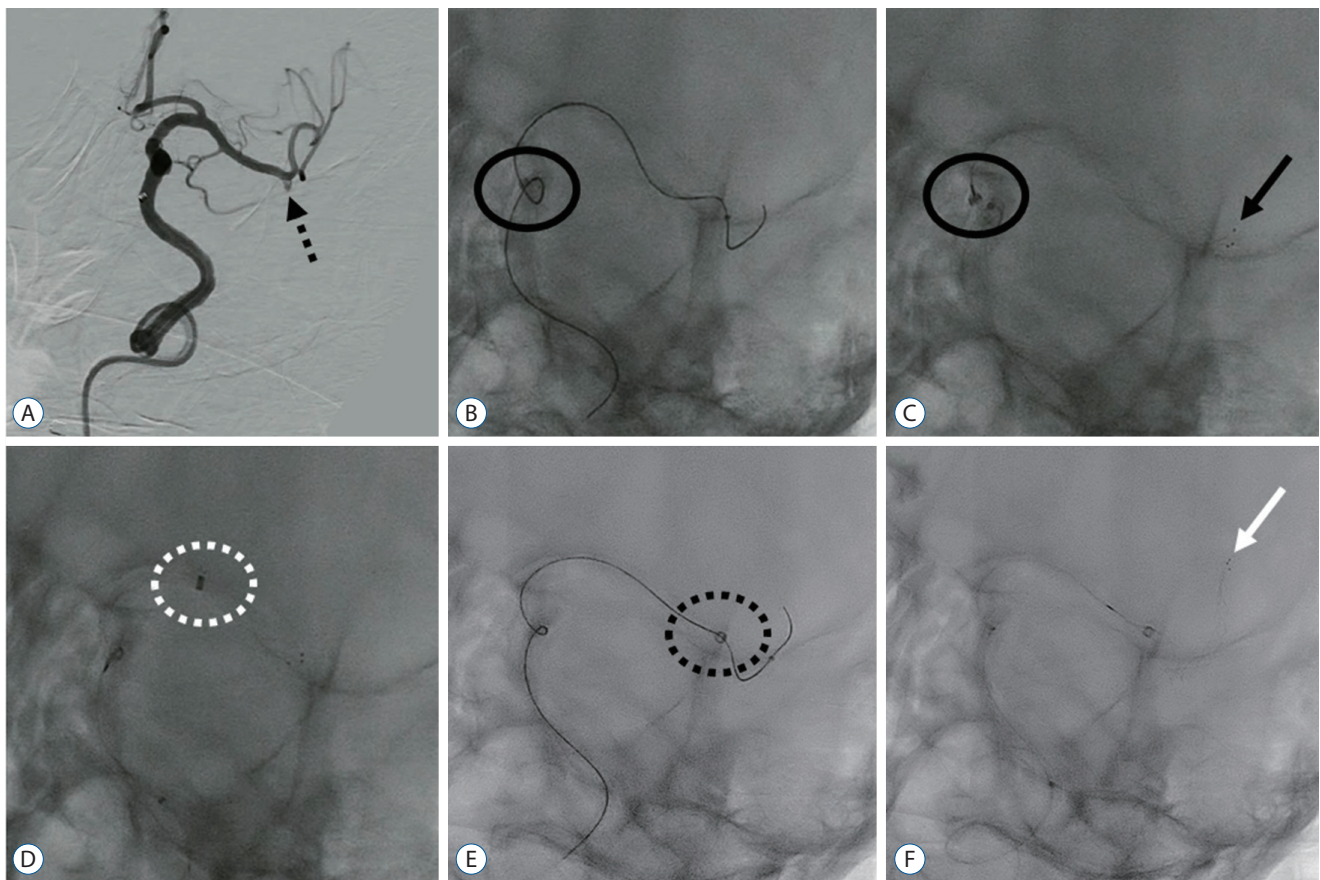


Fig. 3. Demonstration of anchoring technique with distal stent retriever during combined approach thrombectomy. A : Initial angiography of an 85-year-old female showing left proximal M2 occlusion status (black dot arrow) with diffuse tortuosity of proximal and distal ICA. B : Under guidance of a co-axial Excelsior 27 (Stryker Neurovascular, Fremont, CA, USA) microcatheter and a synchro 2 microwire (Stryker Neurovascular), the tip (black circle) of 6F aspiration catheter (AXS Catalyst 6, CAT6; Stryker Neurovascular) could not pass the ophthalmic segment of internal carotid artery (ICA). C : A 4 × 30 mm sized Trevo XP Provue (Stryker Neurovascular) stent retriever (black arrow) was deployed at left M1. D : The Trevo stent retriever was then gently pull back and straightening of the catheter was observed. The CAT6 catheter (white dot circle) was pushed forward, passing the ophthalmic segment and engaging the left M1. E : After re-capture of the Trevo stent retriever, an Excelsior 27 microcatheter and a synchro 2 microwire could be pass the occluded left M2 segment. CAT6 catheter was advanced to distal M1 (black dot circle). F : Trevo stent retriever (white arrow) could be deployed to sufficiently cover the occlusion site of M2.

patients with the proximal BGC anchoring technique with 8F FG2. The ratio of simple aspiration to combined technique was 44.8% (30 patients) to 55.2% (37 patients). In all of 67 cases, aspiration catheter was used (Penumbra 5MAX : CAT6=39 : 28). The distribution of stent retriever for distal stent retriever anchoring technique in combined approach was Solitaire : Trevo XP=16 : 21. The proximal BGC anchoring technique was used in all 67 patients. Successful navigation of large bore aspiration catheter to occlusion site with only the proximal BGC anchoring technique was achieved in 35 patients (52.2%). For the remaining 32 patients, additional anchoring technique with a distal stent retriever was applied. All cases with a distal stent retriever anchoring technique were successful to bring

up the aspiration catheter. Therefore, success rate was 100% when a combination of proximal BGC and distal stent retriever anchoring technique was used to navigate the large bore catheter. Successful recanalization was achieved in 65 patients (97.0%), and first-pass reperfusion rate was 55.2% (37 patients). There was no anchoring technique-related complication, such as vessel dissection or perforation. Six patients (8.9%) had transient vasospasm at the proximal BGC anchoring site. However, all vasospasms spontaneously improved within a few minutes (Table 1).

Table 1. Demographic factors, procedure details, and outcomes of anchoring technique during mechanical thrombectomy

	Value (n=67)
Baseline characteristic	
Female	31 (46.3)
Age (years)	71.4±13.2
Age distribution	
≥80	25 (37.3)
60–79	33 (49.3)
<60	9 (13.4)
Hypertension	39 (58.2)
Diabetes mellitus	22 (32.8)
Atrial fibrillation	20 (29.9)
Coronary artery disease	12 (17.9)
Smoking	19 (28.4)
Prior stroke or transient ischemic attack	17 (25.4)
Left hemisphere stroke	38 (56.7)
Tissue-plasminogen activator	23 (34.3)
Stroke etiology	
Cardio-embolic	33 (49.3)
Atherosclerotic	21 (31.3)
Dissection	0 (0.0)
Undetermined	13 (19.4)
Occlusion site	
Middle cerebral artery M1	38 (56.7)
Middle cerebral artery M2	10 (14.9)
Distal internal carotid artery	17 (25.4)
Anterior cerebral artery	2 (3.0)
Procedure details	
Use of BGC	67 (100.0)
Aspiration only	30 (44.8)
Combined technique	37 (55.2)
Aspiration catheter (Penumbra 5MAX : CAT6*)	39 : 28
Stent retriever (Solitaire : Trevo XP)	16 : 21
Details of anchoring technique	
Proximal BGC anchoring	67 (100.0)
Success with only proximal BGC anchoring	35 (52.2)
Distal stent retriever anchoring application	32 (47.8)
Success rate of anchoring technique	67 (100.0)
Radiologic outcomes	
Successful recanalization [†]	65 (97.0)
First-pass reperfusion	37 (55.2)

Table 1. Continued

	Value (n=67)
Safety outcomes	
Peri-procedural	0 (0.0)
Arterial dissection	0 (0.0)
Vessel perforation	0 (0.0)
Vasospasm	6 (8.9)
Persistent vasospasm	0 (0.0)

Values are presented as number (%) or mean±standard deviation. *AXS Catalyst 6 (Stryker Neurovascular, Mountain View, CA, USA). [†]Successful recanalization : Thrombolysis in Cerebral Infarction (TICI) scores 2b or 3. BGC : balloon guide catheter

DISCUSSION

This study reported the effectiveness and safety of the anchoring technique with a proximal BGC and a distal stent retriever for distal delivery of a large bore aspiration catheter for cases with challenging vasculature during MT. With the development of thrombectomy devices, methods of MT can be divided into three main categories : conventional simple stent retriever, ADAPT as a contact aspiration, and combined approach with stent retriever and simultaneous aspiration, the so-called 'Solumbra technique'^{12,15,16}. In MT with contact aspiration and combined approach, a large bore aspiration catheter plays a pivotal role due to its potent and high power for clot suction. In addition, a large bore aspiration catheter is important even in a simple stent retriever technique because it acts as an intermediate catheter that can deliver multiple micro-devices to distal lesions and provide stability. Therefore, application of a large bore aspiration catheters with or without stent retrievers is an essential component of MT. However, access to the distal lesion of the large bore aspiration catheter is sometimes challenging due to various causes, including diffuse tortuosity of extra and intracranial vasculature, anatomical impediment of ophthalmic artery orifice, and plaque formation or ulceration. Such difficulty is more likely to occur in the elderly and Asian population, with a high ratio of intracranial atherosclerotic stenosis^{30,32}. The delivery of a large bore aspiration catheter may generate a "ledge effect", with a gap between the large diameter of the aspiration catheter and the smaller co-axial microcatheter^{4,26}. Several methods have been introduced to reduce this ledge effect in previous studies. A

larger caliber co-axial microcatheter, such as Excelsior XT-27 and 3MAX reperfusion catheter, double microwire application or buddy-wire technique, and shaping of aspiration catheter have been introduced to overcome the ledge effect with a reducing the gap^{20,28,35}. However, these methods need for additional devices or complexed handling, and passing a large co-axial device has difficulty in a tortuous vasculature with its risk. Therefore, the authors applied proximal BGC anchoring technique, which can provide system support with only the balloon inflation of the BGC itself without need for additional devices.

Nowadays, the BGC is an essential device for MT because it can increase suction effectiveness, facilitate clot removal, and minimize the occurrence of distal embolization^{11,17}. In early periods of BGC, there was a controversy over problems such as poor accessibility and vessel damage. However, recently introduced BGCs have shown improved accessibility with little vessel damage, even with its large (8F, 9F) luminal size. The authors previously reported the improved trackability and stability of BGC during MT with our initial experience of 8F FlowGate2 BGC³⁴. Sharashidze et al.²² have shown the proximal balloon anchoring with BGC in case with failure of pushing the guidewire into the ICA due to elongation of the arch and tortuosity of the CCA. Balloon inflation of BGC at left CCA enables the positioning of guidewire and co-axial catheter to the left ICA and serial tracing of BGC to the ICA²². Anchored BGC may provide a strong support to allow the advancement of the co-axial device to the distal lesion. A similar phenomenon was seen in our study. When the delivery of a large bore catheter with conventional microcatheter co-axial failed, anchored proximal BGC enabled the distal navigation of a large bore aspiration catheter in 52.2% of patients. This result might be due to the support and strong guidance with an inflated BGC. In the patient in Fig. 1, Penumbra 5MAX could not pass the ophthalmic segment and BGC was herniated by pushing the Penumbra 5MAX in a status with non-inflated balloon of BGC. However, inflation of BGC balloon enabled the passage of Penumbra 5MAX with a stable BGC status because of the strong support provided by anchored BGC with the inflated balloon. In addition, there was no significant complication related to balloon anchoring with proximal BGC. Therefore, the proximal BGC anchoring technique is a useful method that can be easily tried without showing any major complications in cases when distal delivery of a

large bore aspiration catheter is difficult.

Although proximal BGC anchoring technique was applied, distal navigation of a large bore aspiration catheter failed in 32 patients (47.8%) of our series. In this situation, we used the distal stent retriever anchoring technique for aspiration catheter delivery in 32 patients with a success rate of 100%. The anchoring technique with stent or compatible balloon have been introduced to straighten looped microcatheter for delivery of intra-cranial stent or flow diverter in large or giant aneurysm^{2,3,24,29}. Distally anchored stent could provide pulling force, enables straightening of micro-catheter and prevent herniation of devices. In previous studies, anchoring technique with stent retriever during MT has also been used to deliver a large bore aspiration catheter^{13,14,23}. Lin et al.¹³, have reported the ANchor TRACKing (ANTRACK) technique using either a compliant balloon catheter or a stent retriever to anchor in the distal vessels for distal delivery of a large bore catheter, leading to successful navigation of a large bore aspiration catheter in all seven patients with stent retriever anchoring without complications. The delivery of a large bore aspiration catheter with the distal stent anchoring technique has an advantage in that it can perform a combined approach thrombectomy with high rates of recanalization and first pass reperfusion^{15,33}. Furthermore, aspiration catheter could be delivered to distal lesion in cases with occlusion site located beyond M2 because the difference between the microcatheter and the aspiration catheter with hemostasis valve is only about 10 cm. Distal anchoring a stent retriever creates friction against the vessel wall and advances a large bore aspiration catheter. Applying a counter force to the stent-retriever can add a distal pulling force to the proximal pushing force.

This study has some limitations, including relatively small case numbers, its retrospective nature without randomization, and self-reported outcomes. A direct comparison between patients with application of the anchoring technique and those without application of such technique was not conducted. In addition, there might be a bias in device selection which was determined according to interventionists' preferences. However, our study was meaningful in that it suggested a useful technique for navigating a large bore aspiration catheter known to play an important role in MT. Large scale comparative studies are needed to validate the usefulness of anchoring technique during MT.

CONCLUSION

Our study demonstrated the effectiveness and safety of anchoring technique during MT. Proximal anchoring with BGC and distal anchoring with stent retriever could facilitate the navigation of large bore catheter to distal lesion without complications, and it increase the chance of successful recanalization. This technique is especially useful in passage of ophthalmic artery orifice, and the overcoming diffuse tortuous vasculature, atherosclerosis, and plaque ulceration.

AUTHORS' DECLARATION

Conflicts of interest

No potential conflict of interest relevant to this article was reported.

Informed consent

This type of study does not require informed consent.

Author contributions

Conceptualization : HJY, BTK, DSS; Data curation : HJY, DSS; Formal analysis : HJY; Methodology : HJY; Project administration : HJY, BTK; Visualization : HJY; Writing - original draft : HJY; Writing - review & editing : HJY, BTK, DSS

Data sharing

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