Primary Stent Retrieval for Acute Intracranial Large Artery Occlusion Due to Atherosclerotic Disease

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Background and Purpose  The goal of stent retriever–based thrombectomy is removal of embolic clots in patients with intracranial large artery occlusion. However, outcomes of stent retrieval may differ between acute arterial occlusions due to intracranial atherosclerotic disease (IAD) and those due to embolism. This case series describes the outcomes of stent retriever–based thrombectomy and rescue treatments in 9 patients with IAD-related occlusion.

Methods  Among patients who underwent endovascular treatment for acute intracranial large artery occlusion, those in whom stent retrieval was attempted as first-line treatment were included in this review. IAD was defined as significant fixed focal stenosis at the occlusion site, which was evident on final angiographic assessment or observed during endovascular treatment.

Results  Median number of stent retriever passes was 2 (range, 1-3), and temporary bypass was seen in all patients. Immediate partial recanalization (arterial occlusive lesion grade 2-3) was observed in 7 patients. Immediate modified thrombolysis in cerebral infarction grade 2b-3 was seen in 6 patients, but the lesions often required rescue treatment due to reocclusion or flow insufficiency. In terms of rescue treatments, angioplasty and intra-arterial tirofiban infusion seemed to be effective.

Conclusions  Our findings suggest that stent retrieval can effectively remove thrombi from stenotic lesions and achieve partial recanalization despite the tendency toward reocclusion in most patients with IAD-related occlusion. Further research into the use of rescue treatments, such as tirofiban infusion and angioplasty, is warranted.

Keywords  Cerebral infarction; Thrombectomy; Mechanical thrombolysis; Intracranial atherosclerosis; Intracranial embolism and thrombosis

Introduction

Intravenous recombinant tissue plasminogen activator (rtPA) infusion was the first approved treatment for acute ischemic stroke.1,2 However, this treatment has limited efficacy in patients with intracranial large artery occlusion, and only a subset of patients experience recanalization.3 In patients with underlying intracranial atherosclerotic disease (IAD), stenotic lesions tend to reocclude despite recanalization by intravenous rtPA.4 Notably, IAD is more common in Asian populations than in Western populations.5

Recently, randomized controlled studies of endovascular treatments for acute ischemic stroke due to intracranial large artery occlusion have demonstrated improved efficacy.6-10 One important factor in their success is the use of stent retrievers to remove clots. Stent retrievers were designed for thrombus, which...
can incorporate into the inner space of the stent. In situ thrombosis may occur when intracranial large artery occlusion is associated with IAD, but it has not been evaluated whether such occlusions can be removed via stent retrieval. Additionally, the underlying stenosis cannot be solved with stent retrieval and re-occlusion can often occur, so other rescue treatments may be required.

There are few reports of emergent thrombectomy using stent retrievers in patients with acute ischemic stroke and IAD-related occlusion. In the current study, a consecutive case series is presented, with a focus on procedural factors. In addition, several types of rescue treatment are introduced.

Methods

Patients who underwent endovascular treatment for acute ischemic stroke due to intracranial large artery occlusion at a Korean university hospital between July 2013 and May 2015 were screened. Only those who underwent endovascular treatment with the Solitaire flow restoration (FR) revascularization device (Covidien, Irvine, CA, USA) as the first-line method were included. IAD was defined as significant fixed focal stenosis at the occlusion site, which was evident on final angiographic assessment or observed during endovascular treatment. Significant stenosis was defined as (1) degree of fixed stenosis > 70%, or (2) any degree of fixed stenosis with either flow and perfusion impairment on angiography or an evident tendency toward re-occlusion even after sufficient treatment with stent retrieval. When angioplasty or stent insertion achieved full recanalization of intracranial stenosis, the case was classified as IAD. Patients whose final angiographic assessment showed complete recanalization with arterial occlusive lesion (AOL) grade 3 were excluded from this study because their stroke etiology was proved to involve embolism. Patients with an arterial occlusion etiology of moyamoya disease, dissection, or vasculitis also were excluded. Cases with vessel injury accompanied by an interventional procedure, and those in which the occlusion site was never recanalized because the underlying IAD could not be evaluated also were excluded from this study.

Patient outcome was analyzed according to the immediate effects of stent retrieval as the primary treatment method. Modified thrombolysis in cerebral infarction grade was used to evaluate reperfusion status. AOL grade was used to evaluate recanalization status of the occlusion site. Both of the above scales do not always correlate with each other. National Institutes of Health Stroke Scale score was used to evaluate neurologic severity on admission and at discharge. Modified Rankin Scale score was used to evaluate disability at 3 months. Procedural factors including operation duration, rescue treatment methods, and complications also were recorded.

Results

Patients and revascularization treatments

Among 53 patients who underwent endovascular treatment with the Solitaire FR device as the first-line method, IAD-related occlusion was observed in 9 (8 men, 1 woman; median age, 63 years; range, 57-77 years) (Table 1). Three lesions were observed to affect posterior circulation (2 in the basilar artery [BA] trunk, 1 in the vertebral artery), while the other lesions affected anterior circulation (all in the M1 segment of the middle cerebral artery [MCA]). None of the lesions had any cardioembolic source. Six patients underwent intravenous rtPA infusion prior to endovascular treatment. A stent retriever was the primary device for endovascular treatment, and the Solitaire FR device was applied in all cases. A balloon guide catheter was used concomitantly, which was inflated in all cases with anterior circulation occlusion.

Table 1. Baseline characteristics and immediate effects of stent retrieval

| Case No. | Sex | Age (year) | Cardioembolic potential | NIHSS score on admission | Occlusion site on CTA | IV rtPA No. of passes | Temporary bypass | Immediate mTICI grade | Immediate AOL grade | Thrombus removal |
|----------|-----|------------|-------------------------|--------------------------|-----------------------|----------------------|-------------------|---------------------|-------------------|----------------|
| 1        | M   | 61         | None                    | 4                        | VA                    | Yes                  | 2                 | Yes                 | 0                 | 0               | Yes*             |
| 2        | M   | 73         | None                    | 18                       | M1 of MCA             | Yes                  | 1                 | Yes                 | 3                 | 2               | Yes              |
| 3        | M   | 56         | None                    | 9                        | M1 of MCA             | Yes                  | 3                 | Yes                 | 3                 | 2               | Yes              |
| 4        | M   | 57         | None                    | 30                       | BA trunk              | No                   | 3                 | Yes                 | 2a                | 1               | Yes*             |
| 5        | M   | 57         | None                    | 28                       | BA trunk              | Yes                  | 2                 | Yes                 | 3                 | 2               | Yes              |
| 6        | M   | 63         | None                    | 18                       | M1 of MCA             | No                   | 2                 | Yes                 | 2b                | 2               | Yes              |
| 7        | F   | 83         | None                    | 17                       | M1 of MCA             | No                   | 1                 | Yes                 | 3                 | 2               | Yes              |
| 8        | M   | 81         | None                    | 16                       | M1 of MCA             | Yes                  | 1                 | Yes                 | 3                 | 1               | Yes              |
| 9        | M   | 68         | None                    | 9                        | M1 of MCA             | Yes                  | 2                 | Yes                 | 3                 | 2               | Yes              |

*New distal artery occlusion was seen after stent retrieval was attempted.
AOL, arterial occlusive lesion; BA, basilar artery; CTA, computed tomography angiography; IV, intravenous; MCA, middle cerebral artery; mTICI, modified thrombolysis in cerebral infarction; NIHSS, National Institutes of Health Stroke Scale; rtPA, recombinant tissue plasminogen activator; VA, vertebral artery.
Immediate effects of stent retrieval and rescue treatments

Median number of stent retriever passes was 2 (range, 1-3). Temporary bypass was seen in all patients when the stent retriever was deployed. Following thrombectomy, immediate reperfusion (modified thrombolysis in cerebral infarction grade 2b-3) was seen in 7 patients, and immediate partial recanalization (AOL grade 2-3) was seen in 6. On angiography, the thrombi were somewhat removed in all patients; however, most removed clots were very small or not visible in the stent. Table 2 shows the rescue treatment types and methods, while Table 3 shows the procedural and clinical outcomes. Angioplasty was the most commonly used rescue treatment (in 5 patients) (Figure 1), while intra-arterial tirofiban infusion was performed in 2 patients. Two patients did not undergo immediate rescue treatment; however, one patient (patient No. 9) required a second emergent procedure after showing severe neurologic deterioration 5 hours after the first procedure. He underwent angioplasty and tirofiban infusion, which resulted in successful recanalization and improved modified Rankin Scale score.

Outcomes of patients with BA trunk occlusion

Both patients with IAD-related occlusion affecting the BA trunk had very poor outcomes. In both cases, the stenotic lengths were > 10 mm. In patient No. 4, the lesion was repeatedly reoccluded despite several stent retrieval trials and partial recanalization after angioplasty. Computed tomography (CT) angiography showed that the BA was reoccluded 5 hours later, and a second emergent procedure was performed. The patient’s consciousness level improved, but he still demonstrated locked-in syndrome 3 months after presentation. In patient No. 5, the lesion was repeatedly reoccluded during stent retrieval trials, so successive angioplasty was performed. Despite those efforts, blood flow remained stagnant at the stenotic site. Thus, a Wingspan stent (Stryker, Kalamazoo, MI, USA) was deployed, and poststenenting angioplasty was performed. Although the patient’s recanalization and reperfusion grades improved, as did his consciousness level, he remained locked-in at 3 months.

| Table 2. Rescue treatments and procedure times |
|------------------------------------------------|
| Case No. | Rescue therapy | Angioplasty | Stenting | Tirofiban | Onset to puncture (minute) | Puncture to 1st deployment (minute) | 1st deployment to recanalization (minute) |
|---------|----------------|-------------|-----------|-----------|---------------------------|---------------------------------------|------------------------------------------|
| 1       | Yes            | Yes         | -         | -         | 173                       | 53                                    | 48                                       |
| 2       | Yes            | Yes         | -         | -         | 381                       | 68                                    | 29                                       |
| 3       | Yes            | Yes         | -         | -         | 287                       | 33                                    | 69                                       |
| 4       | Yes            | Yes         | -         | -         | 392                       | 39                                    | 59                                       |
| 5       | Yes            | Yes         | Yes       | -         | 203                       | 66                                    | 84                                       |
| 6       | No             | -           | -         | -         | 352                       | 29                                    | 33                                       |
| 7       | Yes            | -           | -         | Yes       | 698*                     | 30                                    | 48                                       |
| 8       | Yes            | -           | -         | Yes       | 154                       | 40                                    | 38                                       |
| 9       | No             | -           | -         | -         | 313                       | 31                                    | 31                                       |

*Patient had wake-up stroke; therefore, onset time was last normal time before sleep. Endovascular treatment was determined by institutional diffusion-perfusion mismatch criteria.

| Table 3. Procedural and clinical outcomes after endovascular treatment |
|---------------------------------------------------------------------|
| Case No. | Final AOL grade | Final mTICI grade | ICH | SAH | Dissection | Stenotic degree on CTA within 10 days (%) | NIHSS score at discharge | mRS score at 3 months |
|----------|-----------------|-------------------|-----|-----|------------|------------------------------------------|-------------------------|----------------------|
| 1        | 2               | 2b                | -   | -   | -          | 40                                      | 0                       | 0                    |
| 2        | 2               | 2b                | -   | -   | -          | 20                                      | 16                      | 5                    |
| 3        | 2               | 3                 | -   | -   | -          | 80                                      | 3                       | 1                    |
| 4        | 2               | 3a                | -   | -   | -          | 100                                     | 30                      | 5                    |
| 5        | 2               | 2b                | -   | -   | -          | 0                                       | 28                      | 5                    |
| 6        | 2               | 2b                | -   | -   | -          | 70                                      | 10                      | 4                    |
| 7        | 2               | 3                 | -   | -   | -          | 90                                      | 1                       | 1                    |
| 8        | 2               | 3                 | -   | -   | -          | 90                                      | 8                       | 1                    |
| 9        | 2               | 3                 | -   | -   | -          | 100*                                    | 6                       | 1                    |

*Neurologic deterioration and reocclusion on repeat CTA were observed 5 hours after the emergent interventional procedure. The second immediate procedure including angioplasty was successful.
AOL, arterial occlusive lesion; CTA, computed tomography angiography; ICH, intracerebral hemorrhage; mRS, modified Rankin Scale; mTICI, modified thrombolysis in cerebral infarction; NIHSS, National Institutes of Health Stroke Scale; SAH, subarachnoid hemorrhage.
Discussion

In this study, we found that the effectiveness of stent retrievers for treating acute IAD-related occlusion was somewhat limited because of hidden stenosis. Despite this limited effectiveness, in situ thrombi could be removed well, and partial revascularization was achieved in most cases. These findings demonstrate that stent retrieval could work well as the primary endovascular treatment. Furthermore, degree and length of stenosis could be determined upon stent retriever deployment, which was helpful in the planning of subsequent rescue treatments.

The performance of stent retrievers for treating IAD-related occlusion, and even its frequency, has been rarely reported. In this study, we tried to describe the immediate effects of endovascular treatment in 9 patients. The proportion of IAD-related occlusion at our institution appears to be higher than that reported for non-Asian populations. Indeed, one Korean study showed that IAD-related occlusion accounted for 23% of acute ischemic stroke cases and endovascular treatment.15 In the current study, patients who had acute ischemic stroke due to intracranial large artery occlusion underwent endovascular treatment, and IAD-related occlusion was confirmed by transmembranical cerebral angiography in 17% of the cohort. As a comparison, in a French study, just 5.5% of patients treated with stent retrieval showed intracranial stenosis.13 Nevertheless, the findings regarding frequency should be interpreted with caution because these studies were not performed with prospective enrollment criteria. In addition, the definition of IAD might differ...
somewhat among studies.

IAD-related occlusion may result from in situ thrombosis in a stenotic lesion. When an inflammatory response occurs in unstable atherosclerotic plaque, platelets aggregate into a thrombus and ultimately occlude the vessel. Consisting with that reported in a previous study, presence of stenotic lesions have been reported to occur more often in those cases, the recanalization power might have been overestimated. Consequently, we plan to perform a further prospective multicenter study.

Conclusions

IAD-related occlusion was observed in 17% of patients who underwent stent retriever-based thrombectomy. This method successfully removed in situ thrombi and helped achieve immediate partial recanalization in most cases. While several types of rescue treatment are possible after stent retrieval, further multicenter trials are needed to identify the optimal methods.

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