Interventional Acute Ischemic Stroke Therapy With Intracranial Self-Expanding Stent

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Background and Purpose—Rapid and safe recanalization of occluded intracranial arteries in acute ischemic stroke (AIS) is challenging. Newly available self-expanding intracranial atherosclerotic stents (SEIS), which can be deployed rapidly and safely, make acute stenting an option for treating AIS. We present the feasibility of this technique.

Methods—A retrospective analysis evaluated procedural protocols and clinical response to treatment in patients with AIS treated with SEIS. Descriptive statistics are presented with initial and follow-up National Institutes of Health Stroke Scale and modified Rankin Score.

Results—Nine patients with AIS underwent acute SEIS placement. There was successful deployment of the Neuroform (n = 4) and Wingspan (n = 4/5) stents in the M1/M2 (n = 5) and M3 (n = 1) middle cerebral artery segments, intracranial internal carotid artery (one of 2), and intracranial vertebrobasilar junction (one). Mean time of SEIS deployment from AIS onset was 5.1 hours. Complete (Thrombolysis in Cerebral Ischemia/Thrombolysis in Myocardial Ischemia 3) and partial/complete (Thrombolysis in Cerebral Ischemia/Thrombolysis in Myocardial Ischemia 2 or 3) recanalization occurred in 67% and 89%, respectively. One intracranial hemorrhage (11%) and one acute in-stent thrombosis (successfully treated with abciximab and balloon angioplasty) occurred. Stroke-related mortality occurred in 3 of 9 (33%) patients and survivors had modified Rankin Score ≤2. Follow-up angiography (mean, 8 months; range, 2 to 14 months) in 4 of 9 patients showed no stent restenosis.

Conclusions—This preliminary experience with SEIS in refractory AIS demonstrated the technical feasibility and high rate of recanalization with acute stenting. Long-term safety and strategies to limit in-stent thrombosis and optimize periprocedural management are crucial before initiating future randomized efficacy studies with SEIS in AIS refractory to standard therapy. (Stroke. 2008;39:2392-2395.)

Key Words: stroke ■ Neuroform ■ Wingspan ■ stenting ■ therapy ■ interventional ■ intracranial stent ■ acute stroke therapy

Interventional management of acute ischemic stroke (AIS) has evolved since the National Institute of Neurological Diseases and Stroke intravenous AIS thrombolysis trial.1 Expanding the time window beyond 3 hours with intra-arterial alone or in combination with intravenous thrombolysis is safe and may be effective.2–7 However, chemical thrombolysis is limited by the low rate of complete recanalization and increased rate of intracranial hemorrhage (ICH). The Interventional Management of Stroke (IMS)-II (combined intravenous/intra-arterial recombinant tissue plasminogen activator with or without EKOS ultrasound microcatheter) and PROACT-II (intra-arterial prourokinase) trials demonstrated a 36.4% and 19% complete recanalization rate (Thrombolysis in Cerebral Ischemia [TICI]/Thrombolysis in Myocardial Ischemia [TIMI] 3), respectively.2,3 The Merci clot retrieval system (Concentric Medical) has been studied in a series of trials and been shown to have a 54% rate of TIMI 2/3 recanalization rate.8 Until recently, intracranial stenting was limited to off-label use of balloon-mounted stents designed for cardiac circulation. These stents are poor tools for treating intracranial disease because they are rigid, making navigation in the tortuous intracranial circulation difficult.9 The recently available self-expanding intracranial stents (SEIS) allow acute stenting as an option in AIS that is refractory to conventional management.10–12 We present our experience in the feasibility of SEIS for the treatment of AIS.

Methods

After obtaining Institutional Review Board approval, the neurointerventional database at Medical College of Wisconsin was reviewed from July 2005 to October 2007 and patients with AIS in whom stent-assisted recanalization was performed were identified. Patients or their legal representatives gave prior informed consent for chemical or mechanical thrombolysis, including clot retrieval devices, angioplasty, and/or stenting.
SEIS was performed in AIS within 8 hours of symptom onset with a National Institutes of Health Stroke Scale score ≥10 and cranial CT imaging without ICH or clear early cerebral infarction more than or equal to one third of the vessel distribution with angiographic occlusion (length 14 mm) amenable to SEIS (at least 3-mm landing zone pre- and postclot).

Modified Rankin Scores (mRS), ICH, mortality, and vessel recanalization data were collected. Recanalization was assessed by 2 of the authors (OOZ and BFF), who were unaware of the study design at the time of interpretation using the accepted TICI/TIMI grading systems.13

Intervention
After the clot was identified, a 2000-unit heparin intravenous bolus followed by a 450-unit/hr intravenous infusion was administered throughout the procedure (IMS-III protocol). Stent placement was attempted after standard AIS intervention failure (no recanalization after 1 hour of chemical thrombolysis; mean dose, 9 mg; range, 6 to 15 mg; one Merci device use; or 70% residual stenosis or residual clot after angioplasty). The lesion length was estimated as the distance between the vessel cutoff on base catheter angiography and the beginning of the normal vessel distal to the clot on microcatheter angiography. The stent diameter was sized 0.5 to 1.0 mm greater than the diameter of the proximal parent vessel. Prestent angioplasty was performed using Gateway balloon (Boston Scientific, Freemont, Calif) with an undersized balloon (80% of the proximal vessel and not exceeding the distal vessel diameter) or a Hyperglide balloon (EV3, Plymouth, Minn). Poststenting angioplasty was performed if residual stenosis was ≥70%.

After crossing the occlusion with the stent, a single 10-mg abciximab intravenous bolus was administered. If the immediate postprocedure CT scan was negative for hemorrhage, a load of 300 to 600 mg clopidogrel orally or through a nasogastric tube and 300 to 600 mg aspirin by rectum was administered.

Results
The 9 patients’ mean age was 69±9 years. The median admission National Institutes of Health Stroke Scale score was 18 (Table 1).

Occlusion sites were the middle cerebral artery/M1 (n=3), M1/M2/M3 middle cerebral artery segment (n=3), vertebrobasilar junction (n=1), and combination of internal carotid artery (ICA) terminus and ICA bifurcation and middle cerebral artery/M1 (n=2).

Neuroform stents were used in 4 of 9 (44%) lesions and Wingspan stents in 5 of 9 (56%) lesions.

Intraprocedure glycoprotein (GP)-IIb/IIIa inhibitors were administered in 6 of 9 (67%) cases and after the cranial CT in 3 cases. Initial therapy was intra-arterial thrombolysis (6), intravenous/intra-arterial thrombolysis (one), and a Merci Clot retriever (one). Preangioplasty was performed in 4 Wingspan and one Neuroform cases. Postplasty was performed in all Neuroform cases and one Wingspan case for residual near occlusion.

Successful stent deployment across the clot occurred in 8 of 9 (89%) cases. The only technical failure occurred when the Wingspan stent could not track beyond the middle cerebral artery/ICA junction and was deployed in the proximal clot. Complete recanalization (TIMI 3) occurred in 6 of 9 (67%) patients, whereas TIMI 2 flow was seen in an additional 2 of 9 (22%) cases. One patient, who did not receive intraprocedural abciximab, developed an acute in-stent thrombosis 1 hour after placement. He responded to abciximab bolus and Hyperglide balloon angioplasty. One asymptomatic basal ganglia ICH occurred (11%; Figure).

![Figure](image_url)

Table 1. Baseline Clinical and Procedural Data

<table>
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<th>Patient No.</th>
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<th>Sex</th>
<th>Race</th>
<th>Occlusion Site</th>
<th>Initial Therapy</th>
<th>Stent Type</th>
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<th>Postplasty</th>
<th>Time to Stent, Hours</th>
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M indicates male; F, female; W, white; B, black; M1, M2, M3, segments of middle cerebral artery; VB, vertebrobasilar; IV, intravenous; IA, intra-arterial; w, Wingspan stent; N, Neuroform stent.

Figure. Example of acute stenting cases before and after stenting: Case A developed acute in-stent thrombosis with resolution postballoon angioplasty and GP-IIb/IIIa inhibitor. Case D developed a small asymptomatic basal ganglia bleed.
Mortality occurred in 3 of 9 (33%) patients due to a large ischemic stroke. The location of the thrombus in these patients was the carotid terminus (n=2) and proximal middle cerebral artery/M1 (n=1). Six patients (67%) had good clinical outcome (mRS=0 to 2, mean follow-up of 12.5 months; Table 2).

### Discussion

Limitations of chemical thrombolysis in AIS are low recanalization rate and high ICH rate,2–9 which often lead to poor clinical outcome.2,5 In the IMS-II trial, 55% of subjects with TICI/TIMI 2/3 flow had a 3-month favorable outcome as measured by mRS of 0 to 2 as compared with 27% with TICI/TIMI 0/1 flow (P=0.046).2

Although this is one of the largest SEIS experience in AIS, the limited sample size may hinder the validity of comparisons to other AIS trials. The success rate of deploying the stent with TIMI 2/3 flow was 89%. This compares to a recent multicenter study with 19 lesions treated with acute SEIS with TICI/TICI 2/3 of 79%.12 In comparison to that study, we used a Wingspan stent (greater radial force than the Neuroform stent) in 5 of 9 (56%) cases versus 3 of 19 (16%) lesions in their study. The Multi Mechanical Embolus Removal in Cerebral Ischemia (MERCI) trial showed the rate of TIMI 2/3 recanalization of 69%; however, that trial had a higher proportion of T occlusion.8 Our rate of recanalization may be related to the multimodality therapies, high rate of preangioplasty, and short time to stenting from symptom onset of 5.1 hours.

The ICH rate of 11% (n=1) in this study is similar to the previously reported rate in a AIS stenting series.12 This is also consistent with the 9% ICH rate in the Multi MERCI trial and the 10.9% and 9.9% in the PROACT-II and IMS-II trials, respectively.2,3,8 In this study, the only ICH that occurred was not symptomatic. The small GP-IIb/IIIa inhibitor dose and the short time to therapy may explain the low symptomatic ICH rate.

The study in-hospital mortality was 22% and 3-month mortality was 33%. The MERCI trial showed a 43.5% mortality rate at 3 months.8 The mortality rate in one acute stenting series was 7 of 19 (37%).12 The mortality rate in PROACT-II, IMS-II, and IMS-I was 25%, 16%, and 16%, respectively; and 27% and 24% in PROACT-II and National Institute of Neurological Diseases and Stroke placebo groups, respectively.2,3 Our 2 in-hospital mortalities were carotid T occlusion, which has a very poor outcome.5 Good clinical outcome (mRS ≤2) is seen in 6 of 9 (67%) with 4 of 6 patients regaining near baseline function (mRS ≤1).

Possible limitations of this technique include long-term stent patency requiring future follow-up, the use of GP-IIb/IIIa inhibitors, which may lead to an unacceptably high ICH rate, acute in-stent thrombosis, and the potential of perforator occlusion from displacing the thrombus after stent placement. To limit these possible complications, we adopted the following strategies: use of a small bolus dose of GP-IIb/IIIa at the time of stent deployment, immediate postprocedure cranial CT before antithrombotics, and tight blood pressure control in a Neurocritical Care Unit.

This study demonstrated that SEIS in AIS has an overall ICH rate of 11% with overall mortality rate of 33% with TIMI/TICI 2 and 3 recanalization rates of 67% and 89%, respectively. Sixty-seven percent of patients had a good clinical recovery (mRS ≤2) at 3 months.

This study, although limited by the small sample size and retrospective data collection, provides important feasibility and safety data to guide future prospective SEIS protocols in AIS refractory to current more established interventional therapy.

### Acknowledgments

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### Disclosures

None.

### References


### Table 2. Clinical and Angiographic Outcome

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<th>Follow-Up mRS</th>
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<td>Median</td>
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<td>17</td>
<td>6</td>
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</table>

NIHSS indicates National Institute of Health Stroke Scale.


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