

## Intracranial Stent Placement for Recanalization of Acute Cerebral Artery Occlusion

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**Abstract:** To retrospectively evaluate the feasibility, efficacy, and safety of intracranial artery recanalization for acute ischemic stroke (AIS) using a self-expandable stent. All patients treated with an intracranial stent for acute cerebral artery occlusion were included. Treatment comprised intraarterial thrombolysis, balloon angioplasty and stent placement. Recanalization result was assessed by follow-up angiography immediately after stent placement. Complications related to the procedure and outcome at 3 months were assessed. Twelve patients (median NIHSS 14, mean age 63 years) were treated with intracranial stents for AIS. Occlusions were located in the posterior vertebrobasilar circulation (n=6) and in the anterior circulation (n=6). Stent placement was feasible in all procedures and resulted in partial or complete recanalization (TIMI 2/3) in 92%. No vessel perforations, subarachnoid, or symptomatic intracerebral hemorrhages occurred. Three patients (25%) had a good outcome (mRS 0 to 2), 3 (25%) a moderate outcome (mRS 3), and 6 (50%) a poor outcome (mRS 4 to 6). Mortality was 33.3%. Intracranial stent placement for AIS management has an excellent recanalization rate. However, it is associated with high complication risks as our series showed. We believe that the decision to treat acute ischemic stroke with intracranial stent placement should be made after careful consideration of potential benefits and risks.

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### 1. Introduction

Various treatment modalities for AIS have gradually evolved during the past decade.[1-2] Among them, stents have been reported as an option for improvement of the recanalization rate and have shown excellent results with an acceptably low complication rate.[3-4] The authors have also used intracranial stents in failed cases of intraarterial thrombolysis (IAT) with pharmacologic and mechanical methods since 2004. We also experienced good results in terms of recanalization. But at the same time, we felt that stent should be selected as an option with care. Its use has often been accompanied by complications that could be directly and indirectly related to the stent. In this article, we summarize the radiologic and clinical outcomes of 12 patients with AIS treated with intracranial stents.

### 2. Methods

All patients treated at our department with intracranial stent placement for acute cerebral artery occlusion were retrospectively analyzed. Data had been collected prospectively and entered into our stroke database. Inclusion criteria for intracranial stent treatment were confirmed vessel occlusion by digital subtraction angiography (DSA), failed IAT, or contraindication to perform intravenous thrombolysis

(IVT) or IAT. Inclusion criteria for IAT were (1) clinical diagnosis of acute stroke established by a stroke neurologist; (2) baseline NIHSS score 4 to 24; (3) exclusion of hemorrhage by cranial Computed Tomography (CT) or Magnetic Resonance Imaging (MRI); (4) vessel occlusion correlating to neurological deficit confirmed by 4-vessel angiography; (5) initiation of treatment within 6 hours of symptom onset for hemispheric stroke and within 24 hours for vertebrobasilar stroke; (6) no clinical or laboratory contraindications for IAT; (7) for patients >80 years that their general condition before stroke did not advise against it.

### Intracranial Stent Placement Procedures

All procedures were performed with local anesthetics. A standard transfemoral approach was used, and a 6F guide sheath was placed in the lesion side of the common carotid artery and a 6F conventional guide catheter was placed coaxially into the ICA.

Dual oral antiplatelet agents (clopidogrel 300mg and aspirin 300mg) were given orally or through a nasogastric tube after confirming no intracranial hemorrhage on postprocedural brain CT. Clopidogrel (75 mg) and Aspirin (100 mg) were administered daily thereafter. IV heparin was not

administered during and after IAT. However, in case of cardiac embolic occlusion, low molecular heparin was added 24 hours after IAT, which was changed to oral warfarin several days later. Activated clotting time was not checked during IAT. Mechanical IAT was performed with microwires, microcatheters, and balloons (Gateway balloon, Boston Scientific company US). In all patients a self-expandable stent (Wingspan stent system, Boston Scientific) designed for intracranial use was applied. Stents were slightly oversized to allow proper adjustment to the vessel wall (2.5 to 4.5 mm diameter, 15 to 20 mm length). The stent catheter was navigated to the occlusion site using a road map, and the stent was placed during fluoroscopic control. Aspirin (300 mg) was administered intravenously immediately after stent placement. PTA was carried out before or after stent placement at the discretion of the operator. Recanalization result was assessed by DSA immediately after stent placement according to the Thrombolysis in Myocardial Infarction (TIMI) trial criteria: Grade 0, no recanalization; grade 1, minimal recanalization; grade 2, partial recanalization; grade 3, complete recanalization. 17 Thrombus formation or residual thrombus inside the stent lumen as well as side wall irregularities corresponding to residual atherosclerotic stenosis or fixated thrombotic material between stent and vessel wall were recorded. Dissection and vessel perforation were assessed. Flow in the lenticulostriate arteries (LA) after stent placement in the middle cerebral artery (MCA) was evaluated and perfusion of major branches (eg, M2 segments, cerebellar arteries, posterior cerebral artery) after recanalization of the main vessel was assessed.

#### Management of post-procedure and follow-Up

After the intervention patients were transferred to the intensive care unit. Brain CT or MRI was performed in the first 24 hours after intervention as well as in case of neurological deterioration to exclude intracranial hemorrhage and to estimate brain edema. sICH was defined as clinical deterioration (4-point or greater increase in the NIHSS score or a 1-point deterioration in the level of consciousness) combined with space-occupying brain hematoma.<sup>15,18</sup> After exclusion of hemorrhage was made, long-term Aspirin (100 mg/d) was given and Clopidogrel (75 mg/d) was added for the next 30 days. Clinical outcome was assessed at 3 months observation according to the modified Rankin scale (mRS).<sup>19</sup> Outcome was stratified to “good outcome” (mRS 0 to 2), “moderate outcome” (mRS 3), and “poor outcome” (mRS 4 to 6).

### 3. Result

From May 2009 until July 2011, 12 patients (7 men and 5 women, mean age  $63 \pm 13$  years) were treated with intracranial stent placement for acute occlusion of cerebral artery in our hospital. Median NIHSS score at admission was 14 (range 5 to 38). In 11 patients 1 stent was placed, and in 1 patient two stents were delivered. Stent placement was feasible in all 13 stent procedures. Occlusion sites are given in the Table. All patients had collateral flow grade 2. We made the decision to place a stent in 4 patients in whom PTA had been unsuccessful. PTA was performed in a further 4 patients before and in 3 patients after stent placement. Partial or complete recanalization (TIMI 2 and 3) was achieved in 11/12 patients (91.6%). Median time from symptom onset to recanalization was 393 minutes (range 20 to 510 minutes.). Preservation of LA was possible in all stent placements in the middle cerebral artery (MCA). Occlusion of a major vessel branch at the site of stent placement persisted in 6 patients. Assessment of the dependent vessel branch territory by follow-up MRI or CT showed infarction in 3 of 6 patients (50%), whereas no infarction of this particular territory was noted in the remaining 3 patients. In 8 patients major branches at the site of the stent showed sufficient perfusion.

At 3 months follow-up 3 patients (25%) had a good outcome (mRS 0 or 1), 3 (25%) had a moderate outcome (mRS 3), and 6 (50%) had a poor outcome (mRS 4 to 6). Mortality was 33.3%.

### 4. Discussion

A recent meta-analysis of several stroke studies revealed a strong association of recanalization and good outcome after acute ischemic stroke.<sup>[1]</sup> IVT has been shown to improve patient outcome and is approved by the FDA and EMEA.<sup>[5]</sup> However, only a minority of patients admitted for acute stroke receive IVT.<sup>[6]</sup> IAT is also effective for vessel recanalization and is supposed to achieve higher recanalization rates than IVT.<sup>[7]</sup> On the other hand, application of thrombolytic drugs increases the risk of sICH.<sup>[8]</sup> These factors as well as failure of thrombolysis to achieve sufficient recanalization in a subgroup of patients led to the introduction of MT. The Merci Retriever System got FDA approval in 2004. However, recanalization rate remained at 46% to 57% with the Merci retriever and risk of SAH attributable to intracranial vessel perforation has increased.<sup>[9]</sup> Intracranial stent placement for recanalization of cerebral arteries has been performed in a limited number of acute stroke patients.<sup>[10]</sup> The present study confirms the high technical success rate using a self-expandable stent system introduced for treatment of atherosclerotic stenosis in the setting of

complete acute intracranial vessel occlusion.[11] No technical failure was encountered in our study. The stent catheter was navigated easily up to the intracranial vasculature and placed beyond the occlusion site. High recanalization rates of 79% to 90% after intracranial stent placement have been reported and are confirmed in the present study (92%).[11] Whereas Levy et al reported results obtained at 4 different clinical centers and used the Neuroform stent in a majority of patients, we report a single center experience with the more recently introduced Wingspan stent system. Compared to the Neuroform stent, the Wingspan stent has an improved delivery system, a higher radial force, and a higher number of struts. The improved delivery system increases stent safety and feasibility. The higher radial force and tighter struts are supposed to compress and fixate the thrombus more reliably.[12]

Mortality (33%) was similar to former studies (32% to in a quarter of the patients.[11] However, stenting was performed as a rescue therapy in patients with major artery occlusions after failure of other techniques. 40%), and a good outcome after 3 months was observed only in a quarter of the patients.

From our point of view important side branches like the LA can be preserved if the thrombus is passed on the ipsilateral side by the microwire and the stent. Stent expansion will fixate the thrombus at the contralateral wall. This technique was successfully performed in all 5 of our patients suffering MCA occlusion and can be translated to the BA and P1 segments with their perforating arteries as well. However, occlusion of major vessel branches (eg, M2 segment, superior cerebellar artery) at the site of stent placement persisted in 6 patients. Remarkably, no infarction occurred in the dependent vessel territory in half of those patients, pointing to a sufficient collateral circulation. In 3 patients follow-up MRI or CT revealed infarcts in the dependent vessel territory. These infarcts were apparent to some extent at MRI before the interventional treatment, and it remains uncertain whether they are related to the primary occlusive disease or to the stent placement.

In our experience care has to be taken if the deployed stent has to be passed repeatedly with other devices. As long as the stent is not covered by neointima, devices might get caught in the stent struts with subsequent complications. Hence stent placement was performed to reestablish sufficient cerebral blood flow with as little mechanical manipulation as possible, additional postdilatation was performed in only 25% of our patients. Before the introduction of stents for the treatment of atherosclerotic stenosis of intracranial vessels, PTA

performed alone for acute ischemic stroke yielded some success. However, when treating thrombus rather than atherosclerotic stenosis, reocclusion attributable to thromboaggregation and thrombus expansion might occur. In our study, all PTAs performed for vessel recanalization failed to establish sufficient flow.

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