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# Mechanical Thrombectomy with Stent Retrievers in Acute Basilar Artery Occlusion

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## ABSTRACT

**BACKGROUND AND PURPOSE:** Basilar artery occlusion remains one of the most devastating subtypes of ischemic stroke. The prognosis is poor if early recanalization is not achieved. The purpose of this study was to evaluate the safety and technical feasibility of self-expanding retrievable stents in the endovascular treatment of acute basilar artery occlusion.

**MATERIALS AND METHODS:** Twenty-four patients with acute basilar artery occlusion were treated with Solitaire FR or Revive SE devices between December 2009 and May 2012. Additional treatment included intravenous and/or intra-arterial thrombolysis (21/24) and percutaneous transluminal angioplasty/permanent stent placement (7/24). Recanalization was assessed by means of the TIC1 score. Clinical outcome was determined at discharge (NIHSS), and at 3 months (mRS).

**RESULTS:** Median NIHSS score on admission was 24; median duration of symptoms was 254 minutes. Successful recanalization (TIC1 2b + 3) by thrombectomy only was achieved in 18 patients (75%). Intracranial stent deployment after thrombectomy caused by underlying atherosclerotic stenosis was performed in 7 patients. If these patients with intracranial stent placement are included, successful recanalization was achieved in 21 of 24 patients (87.5%). NIHSS improvement  $\geq 10$  points was reached in 54% of patients ( $n = 13/24$ ). Mortality during the first 3 months was 29% (7/24). After 3 months, 8 patients (33%) had a favorable clinical outcome (mRS 0–2).

**CONCLUSIONS:** In our series, application of self-expanding retrievable stents in acute basilar artery occlusion resulted in a high recanalization rate without procedural complications and good clinical outcome in one-third of patients.

**ABBREVIATIONS:** BAO = basilar artery occlusion; IAT = intra-arterial thrombolysis; MT = mechanical thrombectomy

Basilar artery occlusion (BAO), representing 20% of all ischemic strokes occurring in the posterior circulation, remains the stroke subtype with the highest mortality rate by far.<sup>1</sup> Severe neurologic and non-neurologic sequelae are caused by ischemic infarction of brain stem parenchyma, cranial nerve nuclei, and autonomic centers, with death and dependency rates exceeding 70% even after treatment.<sup>2</sup>

Regardless of treatment, recanalization of an occluded basilar artery is the single greatest predictor of good outcome.<sup>3</sup> The likelihood of a good outcome in nonrecanalized patients is approximately 13%.<sup>4</sup> There exists only limited data on the efficacy of different recanalization strategies to achieve complete recanalization of the occluded vessel segment.<sup>1</sup> Either intravenous or local

intra-arterial administration of thrombolytics has shown low rates of recanalization in approximately 60% of cases and consequently has been associated with poor clinical outcome. Given the poor results in achieving complete vessel recanalization by pharmacologic intravenous or local intra-arterial thrombolysis (IAT), more effective recanalization strategies are highly desirable, and many centers favor additional mechanical thrombectomy (MT). A variety of intra-arterial devices intended to disrupt, stent, or aspirate the thrombus has been reported for recanalization of basilar artery occlusions.<sup>5–10</sup> Recently, the appearance of self-expanding retrievable stents (stent retriever), which have increased recanalization rates to  $>90\%$  in the anterior circulation,<sup>11–14</sup> has brought up a promising alternative to all other therapeutic strategies. While an increasing number of studies has investigated the use of stent retrievers in anterior circulation, employment in acute BAO has been reported infrequently and in most studies with  $<20$  patients (Table 1).

We investigated a series of 24 patients with acute BAO thus far treated by stent retrievers and analyzed safety and efficacy data as well as clinical results.

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**Table 1: Comparison of baseline stroke severity and outcome variables between this study and others with the use of a stent retriever in acute basilar artery occlusion**

	N(BAO)/N (Total)	NIHSS Initial	Successful Recanalization (TICI 2b–3), %	sICH, %	mRS 0–2 After 90 Days, %	90-Day Mortality, %
Roth et al <sup>23</sup>	8/22	19	87.5	12.5	37.5	50
Miteff et al <sup>24</sup>	10/26	31	100 (TIMI 3 in 33) <sup>a</sup>	10	20	33
Costalat et al <sup>25</sup>	16/50	?	81 (TICI 3)	6.3	44	25
Dorn et al <sup>26</sup>	24/108	16	77.9	NA	NA	47.8 <sup>b</sup>
Mordasini et al <sup>27</sup>	14/14	21	100	0	29	36
Espinosa et al <sup>28</sup>	18/18	20	94	0	50	22
Mourand et al <sup>29</sup>	31/31	38	74	16	35	32
Study group	24/24	24	87.5	8	33	29

**Note:**—N indicates number of patients; NA, not available; sICH, symptomatic intracerebral hemorrhage.

<sup>a</sup> TIMI (Thrombolysis In Myocardial Infarction) grade 2 or 3; <sup>b</sup> at discharge.

## MATERIALS AND METHODS

Approval for prospective data collection of all interventional procedures reported in this study was given by the institutional review board. Patient informed consent for study inclusion was obtained from the patients or their legal representatives.

On the basis of the prospectively collected thrombolysis in stroke data base in Heidelberg since 1998, we analyzed angiographic and clinical data of patients with acute ischemic stroke caused by BAO undergoing endovascular stroke treatment with stent retrievers between December 2009 and May 2012. In our institution, the Solitaire FR Revascularization Device (Solitaire FR; Covidien, Dublin, Ireland) became available in March 2009 and the Revive SE thrombectomy device (Revive SE; Codman & Shurtleff, Raynham, Massachusetts) in October 2010 for endovascular stroke treatment.

On admission, a stroke neurologist performed physical neurologic examinations and detailed assessment of the NIHSS score. Cranial CT including CT angiography or multimodal stroke MR imaging including dynamic susceptibility contrast perfusion, DWI, and time-of-flight MR angiography was performed in all patients immediately after physical evaluation. Thereafter, intravenous thrombolysis with rtPA (0.9 mg/kg body weight for 40 minutes) was administered as bridging therapy in patients with no contraindications to rtPA. Patients who received intravenous thrombolysis in a tertiary institution and were referred to us for further endovascular therapy were also included in this study.

After the interventional procedure, patients were observed for at least 24 hours in a neurologic intensive care unit, and follow-up CT or MR imaging was routinely performed at 20–36 hours after treatment, or earlier if neurologic deterioration occurred. Postinterventional NIHSS and mRS were assessed by detailed physical examinations performed by an independent stroke neurologist at discharge. MR spectroscopy at 3 months was obtained during a standardized telephone follow-up or an outpatient visit. As a common definition of good outcome, an mRS score of 0–2 was adopted and for poor functional outcome a score of 3–6 was adopted.<sup>15</sup> Stroke etiology was classified according to TOAST criteria.<sup>16</sup>

## Procedure

All interventions were performed by board-certified consultant neurointerventionalists on a biplanar system (Artis zee Biplane; Siemens, Erlangen, Germany) under general anesthesia. Using transfemoral access, a 6F guiding catheter (Envoy; Codman &

Shurtleff or Neuron; Penumbra, Alameda, California) was placed into the dominant or most accessible vertebral artery. During the study period, mechanical thrombectomy was performed with the use of Solitaire FR or Revive SE. A microcatheter (Prowler Select Plus, Codman & Shurtleff; or Rebar 27, Covidien) with a 0.014-inch microwire (Transcend; Stryker, Kalamazoo, Michigan) was carefully advanced through the thromboembolic occlusion under fluoroscopic control. Angiographic runs were subsequently performed through the microcatheter to document the correct position of the microcatheter tip at least 0.5 cm beyond the distal end of the thrombus. Under fluoroscopic control, the stent retriever was advanced through the microcatheter across the vessel occlusion with the distal stent markers beyond the distal end of the occlusion. The stent was deployed/unsheathed completely by pulling back the microcatheter over the proximal marker, and angiographic runs were performed to control for flow restoration. The duration of stent deployment before its retrieval/thrombectomy maneuver varied between 1–5 minutes if thrombectomy/mechanical recanalization was the only aim (21/24 patients). If additional intra-arterial local administration of rtPA was performed, longer deployment times of up to 20 minutes were reached (3/24 patients). To perform the mechanical recanalization/thrombectomy maneuver, the microcatheter was withdrawn with the deployed/unsheathed stent retriever at fixed distance from the microcatheter tip under simultaneous aspiration with a 20-mL syringe at the guide catheter. In the case of persistent occlusion or incomplete vessel recanalization, the device was cleaned and reinserted for repeated thrombectomy.

As a supplement to thrombectomy, we used intra-arterial rtPA if distal branch occlusions persisted. If there was an underlying stenosis or insufficient recanalization, we eventually performed additional balloon angioplasty and permanent endovascular stent placement (Solitaire FR or Enterprise; Codman & Shurtleff). The maximum dose of intra-arterial rtPA was 21 mg. Other periprocedural medications in selected patients (12/24) included an IV bolus of 500 mg of aspirin or 5000 U of heparin or tirofiban (administered intravenously, at an initial rate of 0.4 µg/kg per minute for 30 minutes and continued at 0.1 µg/kg per minute for 24 or 48 hours). If permanent stent deployment was performed, postprocedural medication with 100 mg of aspirin and 300 mg of clopidogrel (subsequently 75 mg for 3 months) was initiated.

The extent of recanalization was classified according to the TICI grading scale.<sup>17</sup> TICI grades 2b and 3 were rated as sufficient

recanalization, whereas TIC1 grades 0–2a were rated as insufficient recanalization. Assessment of angiographic images was performed in consensus by 2 board-certified interventional neuroradiologists (M.M., S.S.) with more than 5 years of training.

The following time points were recorded for analysis: onset of symptoms, first angiogram, and achievement of final recanalization result. Time intervals from symptom onset to the first angiogram and procedure time to final recanalization (time to recanalization) were calculated. Furthermore, images were evaluated regarding level and length of the occlusion (in millimeters, by use of CTA or MRA), posterior circulation ASPECTS (by use of CT angiography source images or MR imaging DWI), and number of stent deployments necessary for recanalization.<sup>18</sup> Postprocedural hemorrhage was rated according to PROACT II criteria.

### Statistics

Categorical data in contingency tables were analyzed by use of the Fisher exact test. Nonparametric pair-wise comparisons were performed with the use of the Wilcoxon test (procedure “rank sum” for unmatched data). Statistical analyses were performed by use of PASW Statistics, Version 18.0 (IBM, Armonk, New York). Statistical significance was assumed at an  $\alpha$  level of  $P < .05$  (2-sided). To test the effects of age, admission NIHSS score, time from symptom onset, and recanalization status on outcome, univariate logistic regression analyses were calculated (“logistic” procedure of STATA 12; StataCorp, College Station, Texas).

### RESULTS

Between December 2009 and May 2012, endovascular therapy was performed on 31 patients for BAO. Of these, 7 patients were excluded because of endovascular treatment technique with either exclusive local intra-arterial thrombolysis or primary stent placement for high-grade basilar artery or distal vertebral artery stenosis. Twenty-four patients (17 male, 7 female; median age, 70; range, 33–83 years) underwent MT. In this group, 63.3% had hypertension, 50.0% had hypercholesterolemia, 33.3% had atrial fibrillation, 33.3% had a history of previous TIA or stroke, 23.3% had diabetes, 23.3% were current smokers, and 20% had coronary artery disease. Stroke etiology was categorized in accordance with TOAST classification: large-vessel disease in 7 (29.2%) patients, cardioembolic cause in 11 (45.8%) patients, both (large-vessel disease and cardioembolic) in 4 (16.7%) patients, and undetermined in 2 (8.3%) patients.

The site of BAO was partial basilar tip (1/24; 4.2%), distal to anterior ICA offspring to basilar tip (13/24; 54.2%), midbasilar without basilar tip (6/24; 25%), proximal basilar artery with 1 vertebral artery (2/24; 8.3%), and proximal basilar artery with both vertebral arteries (2/24; 8.3%). The median length of the occluded basilar artery segment was 17 mm (minimum, 5 mm; maximum, 50 mm).

Twenty-one patients (87.5%) received intravenous rtPA as bridging therapy before endovascular therapy, with a median dose of 50 mg (minimum, 36 mg; maximum, 90 mg), and local intra-arterial thrombolysis as an adjunctive therapy was given in 6 patients (25%), with median dose of 18 mg (minimum, 13 mg; maximum, 21 mg).

The median time interval from symptom onset to first angio-

gram was 254 minutes (range, 125–827 minutes), and median procedure time from first angiogram to recanalization was 77 minutes (range, 30–324 minutes).

Nine patients were treated with Solitaire FR, 12 patients with Revive SE, 2 patients with both devices, and in 1 patient delivery of the stent retriever was technically not feasible due to tortuous anatomy of aortic arch or right vertebral artery. The median number of passes for Solitaire FR or Revive SE was 2 (range, 1–10).

Initial TIC1 score before recanalization was 0 in 22 patients and 1 in 2 patients. After MT, successful recanalization defined as TIC1 score 2b or 3 was achieved in 18 patients (75%; TIC1 2b in  $n = 9$ ; TIC1 3 in  $n = 9$ ). Two of 24 patients were recanalized partially according to TIC1 2a. Additional intracranial stent deployment after MT due to an underlying atherosclerotic stenosis was performed in 7 patients. In 3 of these patients, the TIC1 score subsequently improved from 0–2b ( $n = 1$ ), from 1–2b ( $n = 1$ ), and from 2a–2b ( $n = 1$ ). In the remaining 4 patients, the TIC1 score did not differ from previous MT [TIC1 2a ( $n = 1$ ); 2b ( $n = 1$ ); 3 ( $n = 2$ )]. Overall, after MT alone or in combination with intracranial stent placement, successful recanalization was achieved in 21 of 24 patients (87.5%; TIC1 2b in  $n = 12$ ; TIC1 3 in  $n = 9$ ). Extracranial stent placement was performed in 2 patients (in 1 patient with a severe 90% atherosclerotic stenosis in V1 and in another patient with dissection in V2 caused by the guiding catheter). Table 2 gives an overview of the patient angiographic and treatment data.

Asymptomatic postprocedure hemorrhage (HI1) occurred in 1 patient, and symptomatic intracranial hemorrhage (PH2) with lethal consequence appeared in another patient.

After stent retrieval, thromboembolic occlusion of a previously unaffected artery was observed in 4 of 24 (16%) patients (P2/P3 segment,  $n = 1$ ; PICA,  $n = 2$ ; superior cerebellar artery,  $n = 1$ ). Severe vasospasm was detected in 2 patients, which resolved after intra-arterial administration of nimodipin.

Among all patients, median NIHSS score on admission was 24 (range, 7–42) and at discharge, 5 (range, 0–28), keeping in mind the impreciseness of this score in vertebrobasilar strokes and the arbitrary values in intubated patients. NIHSS improvement  $\geq 10$  points was reached in 54% of patients ( $n = 13/24$ ). Mortality at discharge was 25% ( $n = 6$ ) and at 3 months 29% ( $n = 7$ ), respectively. After 3 months, 8 patients (33%) had a favorable clinical outcome (mRS 0–2), 4 patients (17%) were mRS 3, two patients (8%) were mRS 4, and 3 (13%) patients were mRS 5. Table 3 shows the outcome and complications of the treated patients. The strongest predictor of favorable outcome, with an odds ratio of 3.51 ( $P = .10$ ; CI: 0.65–18.9), was recanalization status after thrombectomy as graded by the TIC1 scale. With an odds ratio of 0.58, the NIHSS score on admission also was a strong predictor of outcome with a trend toward statistical significance in this small sample ( $P = .081$ , CI: 0.31–1.06). Older patients tended to have worse outcome with an odds ratio of 0.93 (CI: 0.85–1.00;  $P = .067$ ). Interestingly, time from symptom onset to endovascular treatment (range, 2 hours, 5 minutes to 13 hours, 47 minutes) did not exert a strong influence on outcome (odds ratio = 0.99;  $P = .21$ ; CI: 0.98–1.00).

After dichotomization, by use of the posterior circulation ASPECTS score at a cutoff value of  $\geq 9$ , NIHSS score at discharge

**Table 2: Angiographic/treatment data**

Patient No.	TICI at Baseline	TICI at End Point	No. of Passes	Type of Device	Intracranial Stent Placement	IV rtPA	IA rtPA	Concurrent Medication
1	0	3	1	S	0	54	20	0
2	0	3	4	S	0	0	0	A
3	0	2b	4	S	0	55	20	T
4	0	2b	2	S	1	35	21	T
5	0	2b	2	S	1	41	13	T
6	0	2a	1	S	1	47	16	T
7	0	3	2	S	1	52	0	T
8	0	2b	1	R	0	50	16	T
9	0	3	4	R	0	45	0	0
10	0	0	0	0	0	50	0	0
11	0	2b	7	R	1	0	0	T
12	0	2b	3	R	1	67	0	T
13	0	2b	2	R	0	50	0	0
14	0	3	1	R	0	90	0	0
15	0	2b	1	R	0	43	0	H
16	0	3	2	R	0	69	0	0
17	0	2b	2	R	0	90	0	0
18	0	3	6	R, S	0	0	0	0
19	1	2b	2	S	0	50	0	0
20	0	2b	3	R	0	38	0	0
21	0	3	1	S	1	73	0	T
22	0	3	2	R	0	60	0	0
23	0	0	10	R, S	0	68	0	T
24	1	2b	4	R	0	60	0	0

**Note:**—"No. of Passes" refers to the number of passes needed for recanalization. A indicates aspirin; H, heparin; R, Revive SE; S, Solitaire FR; T, tirofiban; IA, intra-arterial.

**Table 3: Patient outcomes/complications**

Patient No.	NHIS at Baseline	NHIS at Discharge	mRS at Discharge	mRS at 90 Days	ICH	Complication
1	17	0	1	0	0	0
2	38	7	5	5	0	0
3	35	<sup>a</sup>	6	6	AS	0
4	19	1	2	5	0	OUA
5	26	<sup>a</sup>	6	6	0	OUA
6	38	17	4	4	0	0
7	16	2	2	3	0	0
8	39	<sup>a</sup>	6	6	S	0
9	42	22	5	6	0	0
10	40	<sup>a</sup>	6	6	0	0
11	21	28	5	5	0	VAS
12	7	<sup>a</sup>	6	6	0	OUA
13	22	2	3	2	0	D V2
14	30	5	3	3	0	0
15	27	1	1	2	0	D V1
16	22	4	3	2	0	0
17	10	6	4	2	0	OUA
18	37	8	4	3	0	D V1
19	12	3	3	2	0	D V2
20	21	15	5	4	0	0
21	30	4	3	2	0	0
22	24	0	0	0	0	VAS
23	—	<sup>a</sup>	6	6	0	0
24	17	10	4	3	0	0

**Note:**—AS indicates asymptomatic; D, dissection; OUA, thromboembolic occlusion of a previously unaffected artery; S, symptomatic; V1, V2, segment of the vertebral artery; VAS, vasospasm; —, absent.

<sup>a</sup> Deceased.

( $P = .03$ ), mRS at discharge ( $P = .004$ ), and mRS at 3 months ( $P = .02$ ) were significantly better in patients with ASPECTS  $\geq 9$ . Mortality in patients with ASPECTS  $\geq 9$  was significantly lower: 9% versus 29%,  $P = .034$ .

## DISCUSSION

The first description of the use of IAT in BAO was published in the early 1980s.<sup>19</sup> Since that time, multiple series describing the use of

IAT in BAO have been published. A large meta-analysis that incorporated 10 studies including 316 patients reported an overall recanalization rate of 64% and overall mortality of 56%. The mortality was 87% in nonrecanalized patients and 37% in recanalized patients ( $P < .001$ ).<sup>20</sup> In the most recent and largest series to date, the data of 180 adult patients with angiographically confirmed basilar occlusion treated with IAT at 5 German stroke centers were retrospectively evaluated. Patients with partial or complete recanalization had a significantly better neurologic outcome than nonrecanalized patients ( $P < .001$ ), highlighting that complete or at least partial recanalization of the occlusion is essential for a favorable neurologic outcome. However, the overall recanalization rates of approximately 55% for IAT have remained low in these published series.<sup>21</sup> As a second major disadvantage of IAT, the time to recanalization is prolonged because it takes time to dissolve the thrombus after initial catheterization.<sup>12</sup> In accordance with these limitations, a previous meta-analysis showed that the overall proportion of patients achieving a favorable outcome after IAT remains low (good or favorable outcome in 24%).<sup>22</sup>

Therefore, various investigators have assessed the use of MT in small BAO case series ( $< 16$  patients with exception of the MERCI and Multi-MERCI trials) with different devices including simple clot disruption,<sup>5</sup> manual aspiration,<sup>6</sup> AngioJet catheter (Possis Medical, Minneapolis, Minnesota),<sup>7</sup> Amplatz Goose Neck Snare (Microvena, White Bear Lake, Minnesota),<sup>8</sup> Merci retriever (Concentric Medical, Mountain View, California),<sup>9</sup> and the Penumbra aspiration catheter.<sup>10</sup> In these studies, the successful recanalization rate varied between 50–100% and good clinical outcome ranged between 25–50%.

With the introduction of stent retrievers, which combine the advantages of temporary stent placement with immediate flow



restoration and thrombectomy with definite thrombus removal, increased recanalization rates of up to 100% have been reported.<sup>11–14</sup> However, only limited data about treatment of acute BAO with stent retrievers are presented in the literature (Table 1).<sup>23–29</sup>

Costalat et al<sup>25</sup> included 16 acute BAOs in their series of 50 patients with intracranial vessel occlusion and treated with the Solitaire FR. Successful recanalization (defined as TICI 3) was obtained in 81% (13/16), with a mean of 2.1 passes. One patient had a symptomatic intracranial hemorrhage. Good functional outcome (mRS of 0–2) at 3 months was achieved in 44% (7/16), and mortality rate was 25% (4/16).<sup>25</sup> Mordasini et al<sup>27</sup> presented a series with 14 acute BAOs treated with Solitaire FR. Successful recanalization (defined as TICI 2b or 3) was reached in all cases, with a mean of 1.3 passes. There was no symptomatic intracranial hemorrhage. At 3 months, good functional outcome (mRS 0–2) was observed in 28.6% (4/14) and overall mortality was 35.7% (5/14).<sup>27</sup> Espinosa de Rueda et al<sup>28</sup> treated 18 patients with Solitaire AB/FR or Trevo Pro (Stryker) with a mean of 1.7 passes. Successful recanalization (defined as TICI 2b or 3) was obtained in 94.4% (17/18) with good functional outcome (mRS 0–2) in 50% (9/17). No symptomatic intracranial hemorrhage was found, and mortality rate was 22.2% (5/17).<sup>28</sup>

In our series, we used 2 different stent retrievers. The first 9 patients were treated with the Solitaire FR and in the following 14 patients the Revive SE was used with changeover to the Solitaire FR in 2 cases. For both stent retrievers, the median number of passes was 2. In 1 of the 2 patients in which both devices (Solitaire FR after Revive SE) were used, successful recanalization was achieved only after the use of a slightly oversized Solitaire FR (6 mm in diameter) because the diameter of the basilar artery was very large, measuring nearly 5 mm. In the other patient, the basilar artery remained occluded despite 5 attempts with Revive SE, another 5 attempts with Solitaire FR, and even after eventual percutaneous transluminal angioplasty.

Thromboembolic events in previously unaffected proximal or distal portions of the posterior cerebral artery territories occurred in 2 patients distally (8%) and in 2 patients proximally (8%). Distal occlusion of previously patent branches is most likely to be explained by fragmentation and embolization of the clot during retrieval into the guiding catheter. This rate of embolism in our series is higher than what is reported for the anterior circulation.<sup>30</sup> One possible reason might be the different vessel anatomy in the posterior circulation, which is more tight and curved with possibly more tapering and deformation of the device while being withdrawn. To overcome this problem, we constantly attempted to advance the 6F guiding catheter as high/distal as possible so as to approach the deployed stent retriever as close as possible to optimize complete and effective aspiration of all thrombus material during retrieval. A potential drawback with this approach is possible vessel dissection occurring in 4 patients, emphasizing the application of a more flexible distal access catheter instead of stiffer guiding catheters.

In our series with 24 patients, successful recanalization was achieved in 75%, which is lower than the reported rate in the anterior circulation. Together with additional intracranial stent placement, we found that our successful recanalization of 87.5% is in line with the previous data (Table 1). These numbers reflect

the higher incidence of a high-grade stenosis in the posterior circulation with consecutive atherothrombotic occlusions, caused by local thrombosis on the surface of ulcerated atherosclerotic plaques. The reported incidence in the literature of 35% of atherothrombotic lesions in patients with acute BAO is similar to our rate of 29%.<sup>3</sup>

After pretreatment intravenous thrombolysis with rtPA, no shift in occlusion site or recanalization rate was observed on pre-interventional DSA compared with initial CTA or MRA. Whether pretreatment intravenous thrombolysis helped with recanalization cannot be proved in the face of the low recanalization failure rate.

However, despite the high successful recanalization rate, favorable clinical outcome was limited. The proportion of patients who gained independence (mRS 0–2) after 3 months was 33% ( $n = 8/24$ ). Two patients discharged with mRS 2, 1 week after onset, had subsequent MCA infarction during the follow-up period with the result of mRS 3 and mRS 5, respectively. Applying the definition of good neurologic outcome according to the SWIFT study, 54% of patients ( $n = 13/24$ ) met the criteria for a good neurologic outcome.<sup>31</sup>

Some predictors influence clinical outcome independently from successful recanalization, such as high initial NIHSS/low Glasgow Coma Scale scores, age, thrombus volume, etiology, site of occlusion, time span from onset to recanalization, and brain stem DWI score or the posterior circulation ASPECTS.<sup>18</sup> In this study, NIHSS score on admission and age could be identified as predictors of outcome, however only with a trend toward statistical significance. This reflects one major limitation of our study, which is restriction to a single center and small sample size. Interestingly, time from onset to endovascular treatment did not exert a strong influence on outcome. This finding is in accordance with the observation that extended treatment windows of up to 12 hours in posterior circulation ischemic stroke are possible if irreversible extended brain stem infarction is ruled out by pretreatment DWI-MR imaging.<sup>32</sup> With the use of the posterior circulation ASPECTS in our series, patients with posterior circulation ASPECTS score  $\geq 9$  had a significantly better outcome (50%,  $n = 6/12$ , mRS 0–2 after 3 months) than patients with posterior circulation ASPECTS score  $\leq 8$  (17%,  $n = 2/12$ ), which reveals that extensive and irreversible brain stem damage obviously will indicate poor prognosis regardless of recanalization success.

In 2 of 24 patients in our series (8%), intracranial hemorrhage (HII,  $n = 1$ ; PH2,  $n = 1$ ; according to the PROACT II criteria) occurred with fatal outcome (mRS 6 in both; in 1 patient caused by PH2 and in the other patient caused by extensive brain stem infarction). Recanalization had been successful in both these patients (TICI 2b) and in both intravenous and intra-arterial lysis with rtPA, and, in addition, a standard dose rate of tirofiban had been given during and after the procedure. These observations in 2 cases of our series indicate that the risk of hemorrhage after recanalization/reperfusion might increase exceptionally with combined administration of intravenous/intra-arterial rtPA and glycoprotein IIb/IIIa antagonists and should therefore not be performed routinely in any interventional treatment of BAO.<sup>33</sup> However, the overall rate of intracranial hemorrhage compares favorably with the rates reported in other studies (Table 1).

## CONCLUSIONS

Treatment of acute BAO with stent retrievers is safe and technically feasible, with high rates of recanalization. However, although feasible and safe, endovascular treatment still must show superiority to intravenous thrombolysis alone. The results encourage further prospective trials to evaluate the potential clinical benefit in patients with acute BAO.

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