ORIGINAL RESEARCH

Emergency Intracranial Stenting in Acute Stroke: Predictors for Poor Outcome and for Complications

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Background—Stent-retriever thrombectomy is the first-line therapy in acute stroke with intracranial large vessel occlusion. In case of failure of stent-retriever thrombectomy, rescue stent angioplasty might be the only treatment option to achieve permanent recanalization. This study aims at identifying predictors for poor outcome and complications in a large, multicenter cohort receiving rescue stent angioplasty.

Methods and Results—We performed a retrospective analysis of patients with large vessel occlusion who were treated with rescue stent angioplasty after stent-retriever thrombectomy between 2012 and 2018 in 7 neurovascular centers. We defined 2 binary outcomes: (1) functional clinical outcome (good modified Rankin Scale, 0–2; and poor modified Rankin Scale, 4–6) and (2) early symptomatic intracerebral hemorrhage. Impacts of clinical, radiological, and interventional parameters on outcomewere assessed in uni- and multivariable logistic regression models. Two hundred ten patients were included with target vessels located within the anterior circulation (136 of 210; 64.8%) and posterior circulation (74 of 210; 35.2%). Symptomatic intracerebral hemorrhage occured in 22 patients, 86.4% (19 of 22) after anterior and 13.6% (3 of 22) after posterior circulation large vessel occlusion. Good functional outcome was observed in 44.8% (73 of 163). A higher National Institutes of Health Stroke Scale on admission (adjusted odds ratio, 1.10; P=0.002), a higher premorbid modified Rankin Scale (adjusted odds ratio, 2.02; P=0.049), and a modified Thrombolysis in Cerebral Infarction score of 0 to 2a after stenting (adjusted odds ratio, 23.24; P<0.001) were independent predictors of poor functional outcome.

Conclusions—Use of rescue stent angioplasty can be considered for acute intracranial large vessel occlusion in cases after unsuccessful stent-retriever thrombectomy. Likelihood of symptomatic intracerebral hemorrhage is higher in anterior circulation stroke. **(*J Am Heart Assoc*. 2020;9:e012795. DOI: 10.1161/JAHA.119.012795.)**

Key Words: intracranial stenosis • retriever • stenting • thrombectomy • thrombus

Stent-retriever thrombectomy (SRT) is the first-line therapy in acute stroke with intracranial large artery vessel occlusion (LVO) of the anterior circulation.[1–5] The superiority of SRT compared with best medical treatment has been proven in several randomized, multicenter trails.[6–8] In these studies, patients treated with SRT achieved high rates of recanalization with modified Thrombolysis in Cerebral Infarction (mTICI) grades 2b or 3 up to 88%.[9] Despite an initially successful recanalization, patients may develop immediate reocclusion of the target vessel. In the majority of these cases, the underlying pathology is intracranial atherosclerotic disease,[10,11] which is much more prevalent in Asian populations.[11,12]

Acute reocclusion or high-grade stenosis after unsuccessful SRT is associated with poor functional outcome.[13] Potential rescue strategies include angioplasty (PTA), PTA with drug

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Clinical Perspective

What Is New?

- In case of unsuccessful recanalization of intracranial vessels in acute stroke, rescue stenting using self-expandable stents can achieve permanent recanalization.

What Are the Clinical Implications?

- Rate of good functional clinical outcome is high, and rate of symptomatic intracerebral hemorrhage is acceptable; therefore, rescue stenting should be considered rather than leaving the patient with a nonrecanalized vessel.

eluting balloon,[14] and rescue stent angioplasty (RSA)[13–16] with self-expandable stents or balloon-mounted stents.[17]

The best currently available evidence for endovascular treatment of intracranial atherosclerotic disease is based on the SAMMPRIS (Stenting and Aggressive Medical Management for Preventing Recurrent stroke in Intracranial Stenosis) study and the VISSIT (Vitesse Intracranial Stent Study for Ischemic Stroke Therapy) study,[18,19] showing the superiority of best medical treatment over elective intracranial stenting. Lately, mostly small retrospective studies reported consistently on improved functional outcomes after RSA for cases where initial thrombectomy attempts fail or high-grade stenosis increases the risk for acute reocclusion.[15,20–26] Accordingly, Chang et al reported significantly better outcomes after RSA versus medical treatment representing the largest study (n=50) on RSA.[15,27]

We analyzed patient data from 7 neurovascular centers to identify predictors of poor outcome after RSA in the largest patient-level pooled analysis to date. We hypothesized that we would be able to identify predictors, both for poor outcome and hemorrhage, in the postinterventional phase after RSA that would help in selecting patients and informing future trial design.

Methods

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Study Population

Patients with acute ischemic stroke caused by intracranial LVO of the anterior and posterior circulation, who received RSA between February 2012 and October 2018, were identified from the databases of 7 tertiary stroke centers. The study was approved by the responsible ethics committee (Aerztekammer Nordrhein, Duesseldorf, Germany), and therefore no informed consent from every individual could be waived. As inclusion criteria, we defined (1) evidence of intracranial large vessel occlusion, (2) absence of intracranial hemorrhage, and (3) acute reocclusion or persistent high-grade stenosis after SRT. Patients with missing recanalization at any time during the procedure were excluded. Differentiation between high-grade stenosis, residual clot, or dissection as the cause for high-grade stenosis or reocclusion was not made. Patients with extra-/intracranial tandem lesions were excluded.

All anonymized patient data were entered in the databases of the participating centers. Data from 41 of 210 patients have been published already.[13,23]

Baseline Characteristics

Patient data were evaluated regarding demographics, premorbid disability (modified Rankin Scale [mRS] score), and stroke severity on admission using the National Institute of Health Stroke Scale (NIHSS). NIHSS scoring was performed exclusively by experienced neurologists, both on admission and on the following days on the stroke unit.

Administration of intravenous recombinant tissue plasminogen activator was recorded. If available, time intervals between onset and imaging time to groin puncture, as well as procedural data, such as final endovascular revascularization, were documented.

Intracranial anterior circulation LVO was defined as occlusion of: (1) internal carotid artery (carotid T), (2) anterior cerebral artery, (3) the first segment of the middle cerebral artery (M1), and (4) the second segment of the middle cerebral artery (M2). Intracranial posterior circulation LVO was defined as occlusion of the: (1) basilar artery and (2) intracranial segment of the vertebral arteries.

Interventional and Postprocedural Parameters

Interventional data, including type of stent-retriever, number of thrombectomy maneuvers, as well as the stent design (balloon or self-expanding), were evaluated. The recanalization result was graded by the mTICI (modified Thrombolysis in Cerebral Infarction) score.[28] Time to first PTA of the intracranial target vessel as well as the antiplatelet regimes were recorded.

Complications, including the occurrence of symptomatic intracranial hemorrhage (sICH) resulting in a deterioration of ≥4 NIHSS points and postinterventional stent occlusion and restenosis, were recorded. NIHSS score on admission and at discharge from the hospital as well as the mRS after 90 days were documented. A final mRS score of 0 to 2 was defined as "good functional clinical outcome."

Endovascular Revascularization

Endovascular treatment was performed as a state-of-the art stent-retriever–based procedure using common guiding and balloon guiding catheters. Numbers of retrieval maneuvers as well as the PTA and intracranial stenting after unsuccessful thrombectomy were left to the interventionalist's decision.

Statistical Analysis

Univariable distribution of metric variables is described by median and interquartile range (IQR). For categorical data, absolute and relative frequencies are given. The Mann–Whitney *U* test or χ^2 test was used to compare 2 independent samples on a metric or categorical outcome, respectively. We defined 2 binary outcomes: (1) sICH occurrence in the immediate postinterventional phase (yes/no) and (2) functional clinical outcome (good [mRS 0–2] and poor [mRS 4–6]). Impacts of clinical, radiological, and interventional parameters on outcome were assessed in uni- and multivariable logistic regression models.

Multivariable model building was performed using a step-wise variable selection procedure: In a first step, all factors were fitted together by a step-wise forward selection (inclusion: *P* value of the score test ≤0.05 and exclusion: *P* value of the likelihood ratio test >0.1). Then, the factors of the model from step 1 were fitted together with all pair-wise interactions in a second block using step-wise forward selection (inclusion: *P* value of the score test ≤0.05 and exclusion: *P* value of the likelihood ratio test >0.1). Given for selected variables are odds ratios (ORs) with 95% CI and *P* value of a likelihood ratio test. For nonselected variables, the *P* value of score test is displayed. Odds were calculated as ratio of the probability for poor outcome to the probability of good outcome. Because of partially missing data of Alberta Stroke Program Early CT Score at the end of the procedure, these variables were not included into logistic regression models. No adjustment for multiple testing was performed, and analyses are regarded as explorative. Local, unadjusted $P<0.05$ was considered as statistically noticeable.

Statistical analyses were performed in SPSS (version 24; IBM Corporation, Armonk, NY) and in SAS software (version 9.4; SAS Institute Inc, Cary, NC).

Results

Baseline Characteristics

A total of 210 patients fulfilled the inclusion criteria and were included for further analysis. The total amount of thrombectomies performed in the participating centers in this time period was 4751, resulting in a percentage for RSA of 4.4%.

In the stenting group, median age of patients was 67 years (IQR, 59–75), and 84 (40%) patients were female. Median NIHSS score on admission was 13 (IQR, 3–14) and the premorbid mRS 0 (IQR 0–1). Detailed baseline characteristics are listed in Table 1. The M1 segment of the middle cerebral artery was occluded in 85 patients (40.5%) and the basilar artery in 46 (21.9%). Median time between computed tomography to groin puncture was 99 minutes (IQR, 60–137). Intravenous recombinant tissue plasminogen activator was administered in 66 of 210 patients (31.4%) before the recanalization procedure.

Interventional Data

In 201 of 210 patients (95.7%), a self-expanding stent was implanted and in 9 (4.3%) a balloon-expanding stent. The most commonly used clot-retrieving device was the Solitaire FR Stent (80 of 210 patients [40%]). The numbers of SRT maneuvers before stenting ranged from 1 to 17, with a median of 2 (IQR, 1–3). The final run after PTA/stenting confirmed a successful recanalization (mTICI 2b/3) in 174 (82.9%); thereof, a successful recanalization was observed in 106 (77.9%) of the anterior circulation LVO and in 68 (97.1%) of the posterior circulation LVO.

For RSA, the Acclino/Acclino flex/Credo stent (Acandis GmbH, Pforzheim, Germany) was placed in 61 of 201 (29%), the Solitaire AB Stent (ev3/Medtronic, Irvine, CA) in 45 of 201 (31%) patients, the Wingspan Stent (Stryker) in 8 of 201 (3.8%), the Neuroform (Stryker) in 65 of 201 patients (20.0%), and others (eg Leo Stent [Balt, Montmorency, France], Coroflex Blue Ultra Stent [B. Braun, Berlin, Germany], the Enterprise Stent [Codman Neuro, Raynham, MA], and Pharos® Stent [Codman]) in 31 of 201 patients (14.8%).

There was not a standard protocol for antiplatelet therapy regime. All patients received at least monoantiaggregation or a GpIIb/IIIa antagonist in the acute setting. Detailed data for antiaggregation were available in 150 patients. In this group, 124 patients (82%) received a GpIIb/IIIa antagonist, mainly eptifibatide (109 cases), Tirofiban (12 cases), and Abxicimab (3 cases). GpIIb/IIIa antagonists were continued until the control computed tomography scan 24 hours after the procedure. After that, mono- or double antiaggregation was continued depending on each center's decision.

Symptomatic Intracerebral Hemorrhage

Of the 210 patients, 22 (10.5%) experienced an sICH in the immediate postinterventional phase. Median age differed statistically noticeably between patients with sICH (median, 74 [IQR, 65–88]) and no sICH (median, 66 [IQR 58–74]; $P<0.004$). Nineteen of 22 patients with sICH (86.4%) were treated for anterior circulation LVO whereas there were 3 patients with posterior circulation LVO ($P<0.025$; Table 1). A successful recanalization after RSA (mTICI 2b-3) was significantly more often observed in patients without sICH compared with patients with sICH (all $P=0.004$; Table 1). Logistic regression analysis was performed to assess the association between various clinical and interventional parameters and sICH in the postinterventional phase.

Table 1. Comparison of Baseline Demographic, Clinical, and Radiological Characteristics Between Patients With sICH and Without Intracranial Hemorrhage After Acute Stenting

Baseline Characteristics	All (n=210)	Without sICH (n=188)	With sICH (n=22)	*P* Value
Age (y), median (IQR)	67 (59; 75)	66 (58; 74)	74 (65; 88)	0.004
Female, n (%)	84 (40.0)	70 (37.2)	14 (63.6)	0.017
CT parameters, median (IQR)				
ASPECTS	9 (8; 10)	9 (8; 10)	8 (7; 9)	0.209
Clinical parameters, median (IQR)				
NIHSS on admission	13 (8;18)	12 (7; 18)	14 (12; 21)	0.032
Premorbid mRS	0 (0;1)	0 (0; 1)	0 (0; 2)	0.249
NIHSS at discharge	6 (3;14)	5 (2; 12)	20 (11; 32)	<0.001
mRS, 90 days	3 (1; 5)	2 (1; 5)	6 (5; 6)	<0.001
Occlusion type, n (%)				0.186
ICA	41 (19.5)	35 (18.6)	6 (27.3)	
ACA	1 (0.5)	1 (0.5)	0 (0)	
M1	85 (40.5)	73 (38.8)	12 (54.5)	
M2	8 (3.8)	7 (3.7)	1 (4.5)	
VA	29 (13.8)	26 (13.8)	3 (13.6)	
BA	46 (21.9)	46 (24.5)	0 (0)	
Anterior circulation (vs posterior circulation)	136 (64.8)	117 (62.2)	19 (86.4)	0.025
Procedure process and results				
Intravenous thrombolysis, n (%)	66 (31.4)	57 (30.3)	9 (40.9)	0.311
CT to groin puncture (min), median (IQR)	99 (60.0; 137.0)	98 (60.0; 135.8)	106.5 (75.3; 146.8)	0.629
Passes of retriever	2 (1;3)	2 (1;3)	2 (1;4)	0.829
mTICI after last stent-retriever/aspiration (TICI 2b/3), n (%)	68 (32.4)	65 (34.6)	3 (13.6)	0.285
mTICI in final run after RSA (TICI 2b/3), n (%)	174 (82.9)	160 (85.1)	14 (63.6)	0.004
Stent category, n (%)				
Self-expandable stents	201 (95.7)	179 (89.1)	22 (10.9)	
Balloon-expandable stents	9 (4.3)	9 (4.8)	0 (0)	
Stent type, n (%)				
Acclino flex	61 (29.0)	59 (31.4)	2 (9.1)	
Solitaire	45 (31.0)	37 (19.7)	8 (36.4)	
Neuroform	65 (29.0)	56 (29.8)	9 (40.9)	
Wingspan	8 (3.8)	7 (3.7)	1 (4.5)	
Others (Leo, Enterprise, coroflex, Pharos)	31 (14.8)	29 (15.4)	2 (19.4)	

ACA indicates anterior cerebral artery; ASPECTS, Alberta Stroke Program Early CT Score; BA, basilar artery; CT, computed tomography; ICA, internal carotid artery; INR, international normalized ratio; IQR, interquartile range; mRS, modified Rankin Scale; mTICI, modified Thrombolysis in Cerebral Infarction; NIHSS, National Institutes of Health Stroke Scale; RSA, rescue stent angioplasty; sICH, symptomatic intracranial hemorrhage, hemorrhagic transformation; TICI, thrombolysis in cerebral infarction; VA, vertebral artery.

In univariable logistic regression, higher age (*P*=0.007), female sex (*P*=0.021), and anterior circulation LVO (*P*=0.035) and an unsuccessful recanalization (mTICI of 0–2a) after RSA (*P*=0.007) were associated with presence of sICH after acute stenting (Table 2). Multivariable logistic regression analysis confirmed an unsuccessful recanalization (mTICI of 0–2a) after RSA as an independent predictor of sICH (adjusted OR, 4.16; *P*=0.007; e-value=3.496[29]; Table 3). Intravenous thrombolysis, premorbid mRS, NIHSS on admission, and number of SRT attempts were not independent predictors of sICH in the logistic regression analysis.

Functional Clinical Outcome After Acute Intracranial Stenting in Stroke Patients

Functional clinical outcome (mRS) after 90 days was only available in 163 of the patients (median, 3 [IQR, 1–5]).

Table 2. Univariable Analysis of Predictors of sICH in the Immediate Postinterventional Phase After Acute Stenting

	OR	95% CI	*P* Value
Age, y	1.06	0.02–1.10	0.007
Sex (ref: male)	0.34	0.35–0.85	0.021
NIHSS on admission	1.05	0.99–1.11	0.090
Premorbid mRS	1.37	0.93–2.02	0.109
Target vessel (ref: posterior circulation)	3.84	1.10–13.45	0.035
Intravenous thrombolysis (ref: no)	0.63	0.25–1.55	0.315
Passes of retriever	1.06	0.89–1.27	0.488
mTICI in final run after RSA	3.81	1.45–10.04	0.007

Given for selected variables are odds ratios (OR) with 95% CI and *P* value of likelihood ratio test. mRS, modified Rankin Scale; mTICI, modified Thrombolysis in Cerebral Infarction; NIHSS, National Institutes of Health Stroke Scale; RSA, rescue stent angioplasty; sICH, symptomatic intracranial hemorrhage, hemorrhagic transformation.

Seventy-three of 163 (44.8%) patients had a good functional clinical outcome (mRS 0–2) after 3 months. In-house mortality was 25 of 210 (11.9%); overall mortality after 3 months was 39 of 210 (18.5%). A higher NIHSS on admission, premorbid mRS, and NIHSS at discharge were significantly more often observed in patients with a poor outcome compared with patients with a good outcome (all $P<0.001$; Table 4). The number of retrieval maneuvers as an indirect parameter for procedure duration and complexity differed noticeably between patients with good (median, 2 [IQR, 1–3]) and poor functional outcome (median, 3 [IQR, 1–4]; $P<0.035$). A successful recanalization after RSA (mTICI 2b–3) was significantly more often observed in patients with good outcome compared with patients with poor outcome ($P<0.001$; Table 4).

Table 3. Multivariable Analysis of Predictors of sICH in the Immediate Postinterventional Phase After Acute Stenting

	OR	95% CI	*P* Value
Age, y	1.06	1.02–1.11	0.008
Sex (ref: male)	2.11	0.73–6.12	NS: 0.071
NIHSS on admission	1.04	0.96–1.12	NS: 0.288
Premorbid mRS	1.44	0.90–2.31	NS: 227
Target vessel (ref: posterior circulation)	3.31	0.66–16.58	NS: 0.71
Intravenous thrombolysis	1.55	0.53–4.56	NS: 0.482
Passes of retriever	1.00	0.79–1.26	NS: 0.662
mTICI in final run after RSA	4.16	1.49–11.06	0.007

Given for selected variables are odds ratios (OR) with 95% CI and *P* value of likelihood ratio test. mRS, modified Rankin Scale; mTICI, modified Thrombolysis in Cerebral Infarction; NIHSS, National Institutes of Health Stroke Scale; RSA, rescue stent angioplasty; sICH, symptomatic intracranial hemorrhage, hemorrhagic transformation.

In univariable logistic regression, higher age (P=0.002), higher NIHSS on admission (P=0.001), higher premorbid mRS (P=0.001), higher number of retrievals (P=0.029), and an unsuccessful recanalization (mTICI of 0–2a) after RSA ($P<0.001$) were associated with a poor functional outcome in the postinterventional phase after acute stenting (Table 5). Multivariable logistic regression analysis identified higher NIHSS at admission (adjusted OR, 1.10; P=0.002; e-value=1.275), higher premorbid mRS (adjusted OR, 2.02; P=0.002; e-value=2.195), and an unsuccessful recanalization (mTICI of 0–2a) after RSA (adjusted OR, 23.24; $P<0.00$; e-value=9.113) as independent predictors of poor functional outcome after acute stenting (Table 6).

Discussion

This analysis of data from 7 centers worldwide is the largest published series for acute RSA so far, allowing, for the first time, the identification of predictive factors for functional clinical outcome. The study population was broad and representative of daily clinical practice, including patients with anterior and posterior circulation, low NIHSS, and long duration from symptom onset to presentation at the hospital.

In our study, good outcome was observed in 73 of 163 (44.8%) patients with recorded outcomes at 90 days. Even if all patients without recorded outcomes were defined as poor outcome, the rate of good outcome would still be 35%. This is considerably better than the rates of 7% to 22% in cohorts with reocclusion or persistent occlusion reports without RSA.[15,22,23,30] The rate of good functional clinical outcome in our analysis is also substantially better than in patients without recanalization (Thrombolysis in Cerebral Infarction 0/1) in the meta-analysis of the large thrombectomy randomized controlled trials.[31] These results are comparable with the data of a recent meta-analysis[32] of 160 patients treated with RSA, which showed 43% good functional outcome.

Placement of an intracranial stent requires antiplatelet therapy, which might increase the risk of intracranial bleeding in acute stroke. The rate of sICH in our analysis (11%) was somewhat higher than in the aggregated thrombectomy studies without intracranial stenting of 4.4%,[7] but comparable with the 12% in the meta-analysis of Wareham et al.[32] In the MR CLEAN[1] (Multicenter Randomized Clinical Trial of Endovascular Treatment for Acute Ischemic Stroke in the Netherlands) trial, the rate of sICH was 7.7% in the interventional group. Behme et al[33] reported a hemorrhage rate of 9% in emergency stenting of the internal carotid artery in tandem lesions, where an antiplatelet therapy was also administered.

A standard of antiplatelet therapy for acute intracranial stenting does not exist.[34] In our study, GpIIb/IIIa antagonists were used in most of the cases. The minority of cases were

Table 4. Comparison of Baseline Demographic, Clinical, and Radiological Characteristics Between Patients With Good (mRS 1–2) and Poor (mRS 3–6) Functional Clinical Outcome After Acute Stenting

Baseline Characteristics	Functional Independent (mRS 1–2; n=73)	Poor Outcome (mRS 3–6; n=90)	*P* Value
Age (y), median (IQR)	63 (54; 72)	69 (62; 77)	0.001
Female, n (%)	28 (38.4)	39 (43.3)	0.521
CT parameters, median (IQR)			
ASPECTS	9 (8; 10)	8 (7; 9)	0.072
Clinical parameters, median (IQR)			
NIHSS on admission	11 (6; 16)	15 (11; 20)	<0.001
Premorbid mRS	0 (0; 0)	0 (0; 2)	<0.001
NIHSS at discharge	2 (0; 5)	14 (10; 23)	<0.001
Occlusion type, n (%)			0.314
ICA	17 (23.3)	16 (17.8)	
M1	29 (39.7)	39 (43.3)	
M2	1 (1.4)	4 (4.4)	
VA	7 (9.6)	15 (16.7)	
BA	19 (26.0)	16 (17.8)	
Anterior circulation (vs posterior circulation)	47 (64.4)	60 (66.7)	0.760
Procedure process and results			
Intravenous thrombolysis, n (%)	26 (35.6)	29 (32.2)	0.649
CT-to-groin puncture (min), median (IQR)	103 (66.3; 166.0)	92.5 (53.0; 132.5)	0.273
Passes of retriever	2 (1;3)	3 (1;4)	0.035
mTICI after last stent-retriever/aspiration (TICI 2b/3), n (%), 63 missings	26 (35.6)	19 (21.1)	0.119
mTICI in final run after RSA, n (%)	70 (95.9)	63 (70.0)	<0.001
Stent category, n (%)			
Self-expandable stents	68 (93.2)	88 (97.8)	0.147
Balloon-expandable stents	5 (6.8)	2 (2.2)	
Stent type, n (%)			
Acclino flex	15 (20.5)	20 (22.2)	
Solitaire	15 (20.5)	12 (13.3)	
Neuroform	21 (28.8)	27 (30.0)	
Wingspan	2 (2.7)	6 (6.7)	
Others (Leo, Enterprise, coroflex, Pharos)	15 (20.5)	12 (13.3)	

ASPECTS indicates Alberta Stroke Program Early CT Score; BA, basilar artery; CT, computed tomography; ICA, internal carotid artery; IQR, interquartile range; mRS, modified Rankin Scale; mTICI, modified Thrombolysis in Cerebral Infarction; NIHSS, National Institutes of Health Stroke Scale; RSA, rescue stent angioplasty; TICI, thrombolysis in cerebral infarction; VA, vertebral artery.

treated with antiplatelet drugs acetylsalicylic acid, dipyridamol, or clopidogrel as sole or combined therapy. For intracranial stenting, the decision for double antiplatelet therapy or GpIIb/IIIa antagonist administration is based on experience with acute stenting not only in stenosis treatment, but also on aneurysm treatment, including implantation of braided stents and flow diverters. For the acute stroke setting, it is unclear which antiplatelet therapy offers the best balance between bleeding and stent occlusion risk. A main finding of this study is the significant difference in hemorrhage rate between anterior (N=19; 11%) and posterior circulation (N=3; 4.1%).

We did not observe any technical complications explaining the higher rate of sICH in the anterior circulation. Data in the literature for sICH in posterior circulation stroke thrombectomy without stenting vary between 4% and 9%.[35,36] There are no larger series of posterior circulation RSA to compare with our study.

Table 5. Univariable Analysis of Predictors of Poor Clinical Outcome (mRS 3–6 at 90 Days) After Acute Stenting (n=151)*

	OR	95% CI	*P* Value
Age, y	1.04	1.02–1.07	0.002
Sex (ref: male)	1.22	0.65–2.30	0.521
NIHSS on admission	1.08	1.04–1.14	0.001
Premorbid mRS	2.14	1.35–3.34	0.001
Target vessel (ref: posterior circulation)	1.10	0.58–2.12	0.760
Intravenous thrombolysis	1.16	0.61–2.23	0.649
Passes of retriever	1.22	1.02–1.46	0.029
mTICI in final run after RSA	15.0	3.42–65.64	<0.001

Given for selected variables are odds ratios (OR) with 95% CI and *P* value of likelihood ratio test. mRS, modified Rankin Scale; mTICI, modified Thrombolysis in Cerebral Infarction; NIHSS, National Institutes of Health Stroke Scale; RSA, rescue stent angioplasty.
*Forty-seven missing mRS values.

Table 6. Multivariate Analysis of Predictors of Poor Clinical Outcome (mRS 3–6 at 90 Days) After Acute Stenting (n=151)*

	OR	95% CI	*P* Value
Age, y	1.04	1.00–1.06	0.016
Sex (ref: male)	0.79	0.34–1.84	NS: 0.661
NIHSS on admission	1.10	1.03–1.16	0.002
Premorbid mRS	2.02	1.32–3.36	0.002
Target vessel (ref: posterior circulation)	0.59	0.23–1.49	NS: 0.375
Intravenous thrombolysis	0.54	0.22–1.32	NS: 0.199
Passes of retriever	1.23	0.96–1.67	NS: 0.269
mTICI in final run after RSA	23.24	4.65–116.06	<0.001

Given for selected variables are odds ratios (OR) with 95% CI and *P* value of likelihood ratio test. mRS, modified Rankin Scale; mTICI, modified Thrombolysis in Cerebral Infarction; NIHSS, National Institutes of Health Stroke Scale; NS, not significant; RSA, rescue stent angioplasty;
*Forty-seven missing mRS values.

A possible consequence of our finding could be that postinterventional management, and especially management of blood pressure, should be paid even more attention in anterior circulation stroke.

There was also a predominance of sICH in female patients, which did not reach significance in the multivariate analysis. Intravenous thrombolysis with PTA had no influence on the bleeding rate. Therefore, the decision for a stent should not be influenced by the administration of intravenous tissue plasminogen activator.

The more retriever passes performed, the worse the outcome. The number of retriever maneuvers reflects the overall procedure time and complexity. This might indicate that in cases of unsuccessful thrombectomy, the decision toward stenting should not be made too late. On the other hand, not every sticky clot should be stented, given that we have to consider the significant hemorrhage risk, especially in the anterior circulation. Recent research suggests that recanalization improves clinical outcome only if achieved with not more than 3 attempts.[22,37,38]

Concerning the interventional method used, there was 1 statistically significant finding. The use of the Acclino/Acclino flex stent (Acandis GmbH) was associated with a significantly lower rate of sICH (3.3% versus 14.3%; $P<0.01$). This stent is a new-generation self-expanding stent, which requires no exchange maneuver and can be delivered through a standard 0.017 microcatheter or the NeuroSpeed balloon directly. These features of easier delivery might increase the safety of the procedure. Moreover, other factors, from stent design such as the radial force, metal surface, and release mechanism, might play a role here. On the other hand, the stent has been available since 2014, and therefore the learning curve of the endovascular sites might be more advanced. However, the included sites were all very experienced in neurointerventions and acute stroke therapy.

Higher age, low Alberta Stroke Program Early CT Score, high NIHSS, and higher premorbid mRS were predictors for a poor outcome. These findings correlate with findings in other stroke treatment studies. Also, imaging to groin time plays a significant role for the outcome, as proven in other thrombectomy trials. From other studies, it is known that a longer procedural time decreases the chance for a good outcome.

Limitations

In our retrospective, multicenter analysis, a high number of data are missing such as Alberta Stroke Program Early CT Score and mRS outcome data of 47 patients at 90-days' follow-up. This drawback is attributable to the retrospective nature of our study. Several centers anonymized their results, and analyzing these variables to complete a full data set was not possible. We presumed a poor outcome for the 46 patients with missing follow-up mRS data. This might be too pessimistic given that of the 46 patients lost for 90-days' mRS follow-up (32%), 18 had had an NIHSS score at discharge of ≤4 points. It is unlikely that all of these patients had a poor neurological outcome.

The criteria for stenting were up to the interventionalist's decision, which could have caused a selection bias.

The antiplatelet regime in this study was not homogenous and partially unknown. Thus, we cannot conclude whether the preferred administration of GpIIb/IIIa antagonists is superior to other antiplatelet drugs (acetylsalicylic acid, dipyridamole, and clopidogrel) or newer, fast deliverable drugs like Ticagrelor. However, despite these limitations, we believe that this analysis allows us to draw valid and novel conclusions.

Conclusions

The rate of good outcome after intracranial rescue stenting after mechanical thrombectomy failure is considerably higher than reported for patients with persistent occlusions and comparable with that of patients treated with thrombectomy alone. A main predictor for good outcome was a low number of thrombectomy maneuvers before stenting. The observed hemorrhage rate is higher than that in regular thrombectomy procedures, but seems acceptable. Hemorrhage is more likely in the anterior circulation. Acute intracranial rescue stenting is a valid treatment option that deserves further study in prospective trials.

Disclosures

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