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Thrombectomy of symptomatic isolated occlusions of posterior cerebral arteries in segment P1 and P2 in acute stroke treatment

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Abstract

Background: Interventional stroke treatments for occlusions of the posterior circulation are established procedures. However, there are limited data on the treatment of isolated symptomatic P1 and P2 occlusions, which we have examined in this study.

Purpose: To investigate the mechanical thrombectomy of distal posterior occlusions

Material and Methods: Retrospectively, data from patients with isolated P1 and P2 occlusions treated with MT were evaluated. Successful reperfusions have been defined as modified thrombolysis in cerebral infarct (mTICI) Grade 2b–3. A good clinical outcome was defined as a 90-day modified Rankin score 0–2.

Results: All 79 treated patients were primarily aspirated. Stent retrievers were used secondarily in nine patients. Successful reperfusion was achieved in 95% of patients. Of the patients, 57% had a favorable clinical outcome after 90 days.

Conclusion: Mechanical thrombectomy with first line aspiration of symptomatic P1 and P2 occlusions is a safe and effective procedure.

Keywords

Acute stroke treatment, thrombectomy, posterior cerebral arteries, P1 and P2, distal occlusion

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Introduction

Mechanical thrombectomy in acute stroke due to large vessel occlusions (LVO) has been proven effective according to numerous clinical trials. These studies were exclusively restricted to LVOs of the anterior circulation. However, with growing experience and innovative endovascular tools, more distally located occlusions, whether in the anterior or posterior circulation, become accessible to mechanical thrombectomy. Reperfusion can be accomplished by traditional mechanical thrombectomy with a stent retriever or aspiration alone (1–9).

The permanent occlusion of distal intracranial arteries might cause relevant disability, depending on the related area of the brain (9–15). The potentially higher risk of vessel injuries after mechanical thrombectomy in smaller, more distally located lesions needs to be carefully weighted against the possible therapeutic benefit (3,10,11,16). Regarding the posterior circulation, several studies reported promising results after mechanical thrombectomy in basilar artery

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occlusions but little is known about the risks and benefits of mechanical reperfusion in more distally located occlusions of the posterior circulation (17–20).

The aim of the present study was to evaluate the safety and effectiveness of mechanical thrombectomy in isolated acute symptomatic occlusions of the posterior cerebral artery (PCA) in its proximal or distal segment (P1 and P2).

Material and Methods

We retrospectively analyzed our institutional database regarding mechanical thrombectomy. Of the 810 LVOs treated by mechanical thrombectomy between July 2014 and August 2019, 79 patients had acute isolated occlusions of the PCA in the P1 or P2 segment treated by mechanical thrombectomy. The present study was approved by the local ethics committee at Ruhr University Bochum, Germany.

Primary endpoints were a successful reperfusion defined by the modified Thrombolysis in Cerebral Infarction scale score (mTICI) of 2b–3. Secondary endpoints were functional independence defined by a modified Rankin Scale (mRS) of 0–2 and 0–1 at discharge and after 90 days. Further secondary endpoints included procedure related clinically relevant complications (Table 1 and Table 2). The time from groin puncture to reperfusion and that from onset of symptoms to reperfusion were analyzed retrospectively.

Patient selection

Inclusion criteria were isolated occlusions of the PCA in the P1 or P2 segment, age >18 years, and a relevant clinical deterioration caused by the occlusion (National Institute of Health Stroke Scale [NIHSS] score $\geq$6). Exclusion criteria were an intracranial hemorrhage and a pre-stroke mRS $>$ 3. Treatment decision was made on an individual interdisciplinary consensus. In eligible patients, intravenous thrombolysis was administered according to the guidelines of accordance with the National Society of Neurology. NIHSS and mRS scores were determined by a neurologist on admission, at discharge, and at the 90-day clinical follow-up.

Imaging evaluation

A cerebral computed tomography (CT) scan including CT angiography (CTA) was performed in all cases before the procedure. An additional CT scan was performed 24 h after the intervention to exclude intracranial hemorrhage. The postinterventional pc-Aspect score and mTICI scores were determined by two experienced neuroradiologists. In cases of disagreement, determination was made by consensus. Procedure-related complications, such as emboli in new territories (ENT) and vessel dissections of vessel perforations, were also recorded (21). Intracranial hemorrhages were considered to be symptomatic if the NIHSS score increased by at least 4 points (1,2,4–6,22).

Endovascular procedure

All procedures were performed under general anesthesia. After puncture of the common femoral artery, a long sheath was placed in the dominant vertebral artery (Neuron Max 088; Penumbra, Inc., Alameda, CA, USA). A combination of a 3.8-F and a 5.0-F or 6-F catheter or a 3.8-F aspiration catheter alone was navigated towards the occlusion (3MAX; Penumbra, Inc.) and 5MAX (Penumbra Inc.) or Sofia 5-F or 6-F (Microvention, Tustin, CA, USA). The most distally located aspiration catheter was then attached to the aspiration pump and aspiration was conducted for at least 2 min, while in the majority of cases manual aspiration via the second catheter was performed (ADAPT technique). The combination of aspiration catheters was then carefully removed under continuous aspiration. If unsuccessful, the described procedure was repeated up to three times. In case of failure to reperfuse the artery thereafter, a stent retriever (pRESET 3×20; phenox, Bochum, Germany) was applied as a bail-out strategy.

Statistical analysis

Descriptive statistics included the number of observations, mean $\pm$ SD, and median and interquartile range (IQR) for continuous variables, and counts and percentages for discrete variables. Statistical analysis was performed using SAS version 9.4 (SAS Institute, Cary, NC, USA).

Results

Between July 2014 and December 2018, 79 patients (35 men, 44 women; mean age $= 72.8 \pm 11.6$ years; age range = 40–92 years) with acute ischemic stroke caused by isolated occlusions of the PCA P1 or P2 segment were treated by mechanical thrombectomy (Fig. 1). In three patients with an acute occlusion of the PCA, mechanical thrombectomy was not carried out due to a pre-existing clinical deficit before the onset of symptoms of more than 3 points on the mRS scale. The mean NIHSS score on admission was 12 (IQR = 4–14) and IV thrombolysis was performed in 54.0% (43/79) of all patients before mechanical thrombectomy. No spontaneous recanalization after IV thrombolysis was observed. The baseline clinical and procedural data of all patients are listed in Table 1. Of the patients, 71% (56/79) was treated by a single aspiration; in 20.0% (16/79), two attempts were necessary while in 9.0% (7/79)

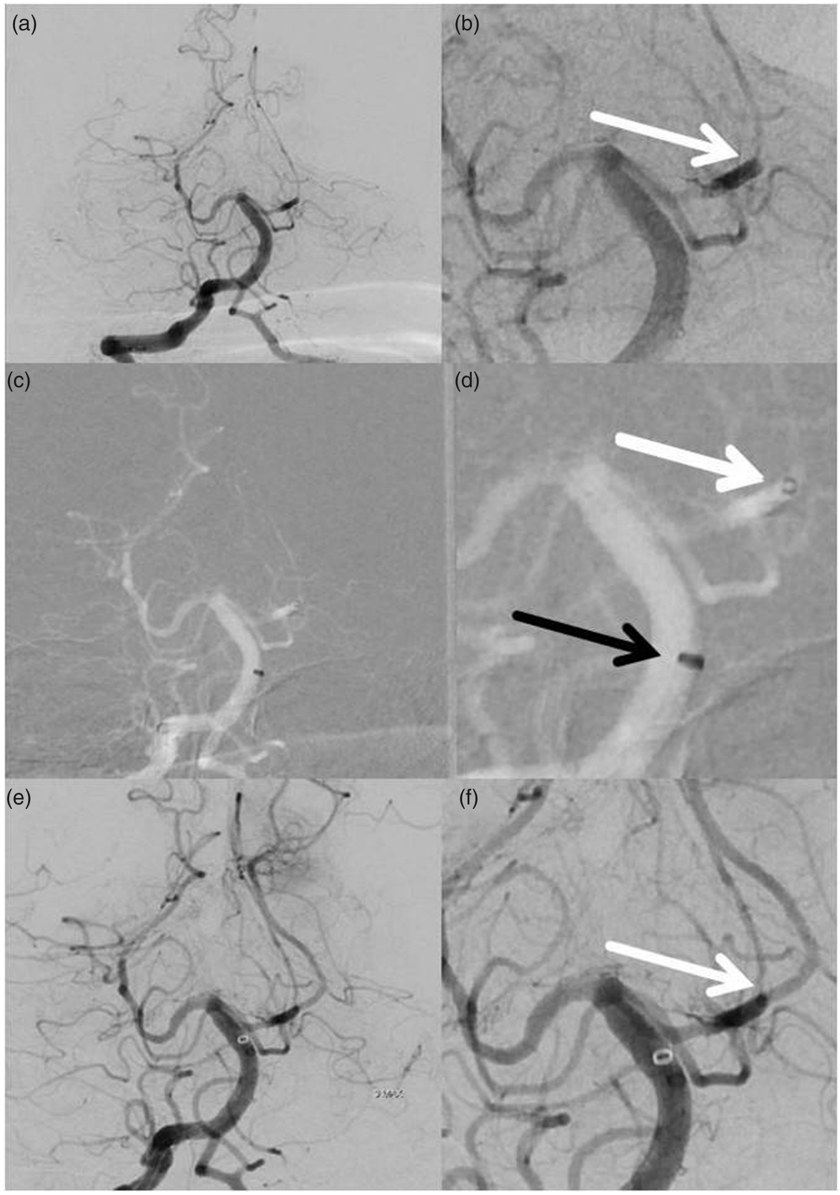

Fig. 1. Angiography (a, b) before, (c, d) during, and (e, f) after aspiration of an isolated posterior cerebral artery occlusion in Segment P2 with 3MAX. (b) The white arrow indicates left PCA occlusion in segment 2. (d) The white arrow indicates the position of the 3MAX tip in front of the occlusion/ADAPT. The black arrow indicates the position of Sofia tip in the basilary artery. (f) White arrow indicates reperfused segment P2 of the left PCA.

three maneuvers were performed. The overall success rate (TICI 2b–3) in the entire series was 95.0% (75/79), while in 80.0% (63/79) a mTICI 3 revascularization was accomplished. Aspiration alone without a stent retriever was performed in 89% (70/79) of patients. A stent retriever as bail-out was applied in 11.4% (9/79) after ADAPT maneuvers failed. Neither ENTs nor dissections of the afferent artery following the revascularization were detected on the final angiogram. The mean NIHSS decreased from 12 to 3 (IQR = 0–5) ($P < 0.001$, admission vs. discharge). The mean mRS score of 4.3 ± 0.8 on admission decreased to 1.8 ± 0.7 at discharge ($P < 0.001$). At 90 days, 57.0% of patients (45/79) were functionally independent (mRS 0–2). Of the patients, 52.0% (41/79) had an mRS of 0–1 at the 90-day follow-up. Symptomatic intracranial hemorrhages were not detected, while 5.0% (4/79) of the patients experienced a minor asymptomatic subarachnoid or intracerebral hemorrhage. No distal emboli or emboli to a new territory were observed (Table 2 and Table 3).

Table 1. Baseline characteristics.

Characteristics	All patients (n = 79)
Age (years)	72.8 ± 11.6 (40–92)
Women	44/79 (56)
Baseline NIHSS	12 (4–14)
Baseline NIHSS P1	14 (8–14)
Baseline NIHSS P2	6 (4–8)
Number of P1 occlusions	60 (79)
Number of P2 occlusions	19 (79)
Baseline mRS score	4.3 ± 0.8 (3–5)
Baseline mRS score P1 (mean±SD)	4.7±0.7 (range 3–5)
Baseline mRS score P2	3.1 ± 0.9 (3–5)
pc-Aspect pre-interventional	8 (6–10)
Time from symptom onset to door (min)	63 (51–76)
Time from groin puncture to recanalization (min)	47 (25–98)
IV thrombolysis	43/79 (54)
Time from symptom onset to IV thrombolysis (min)	92.4 (84–112)
Time from IV thrombolysis to recanalization (min)	67 (35–108)

Values are given as n (%), mean ± SD or median (IQR).
mRS, modified Rankin Scale; mTICI, modified Thrombolysis In Cerebral Infarction; NIHSS, National Institutes of Health Stroke Scale.

Discussion

Acute occlusions of distally located arteries can be associated with severe clinical symptoms according to the dependent brain territory. Therefore, mechanical thrombectomy in small arteries with successful recanalization might have a significant clinical impact. To date, there is proven clinical evidence for endovascular revascularization in LVOs of the anterior circulation. However, numerous studies on mechanical thrombectomy in locations different from the clinical trials (posterior circulation and distally located occlusions) demonstrated promising clinical and angiographic results (23–28). The benefit of mechanical thrombectomy in distal cerebral artery occlusions of the anterior circulation has been studied before (9,26,29). We sought to evaluate the safety and efficacy of this procedure in the subgroup of distally located acute occlusions of the posterior circulation (PCA P1 and P2 segment) The clinical presentation of an acute PCA occlusion varies from minor symptoms as visual disturbances to a significant degree of severity including permanent hemiparesis (26).

Studies evaluating the clinical benefit of endovascular recanalization therapy in acute basilar artery

Table 2. Procedure and Outcome.

Procedure and outcome	All patients (n = 79)
Time from symptom onset to groin puncture (min)	102 (93–132)
Time from symptom onset to door (min)	63 (51–76)
Time from groin puncture to recanalization (min)	47 (25–98)
Time from symptom onset to IV thrombolysis (min)	92.4 (84–112)
pc-Aspect post-interventional	7 (5–10)
Mortality at 90 days	6/79 (8)
Good functional outcome at 90 days, mRS 0–2	45/79 (57)
Good functional outcome P1 at 90 days, mRS 0–2	26/60 (43)
Good functional outcome P2 at 90 days, mRS 0–2	18/19 (95)
Good functional outcome at 90 days, mRS 0–1	41/79 (52)
Good functional outcome P1 at 90 days, mRS 0–1	23/60 (38)
Good functional outcome P2 at 90 days, mRS 0–1	13/19 (68)
90 days mRS score	1.0 ± 0.5 (1–2)
90 days mRS score P1	1.2 ± 0.7 (1–2)
90 days mRS score P2	0.6 ± 0.4 (1–2)
Symptomatic ICH	0/79 (0)
Asymptomatic ICH	4/79 (5)
Vessel dissection	0/79 (0)
Vessel perforation	0/79 (0)
Major groin complication	0/79 (0)
Distal emboli	0/79 (0)

Values are given as n (%), mean ± SD or median (IQR).
ICH, intracranial hemorrhage; mRS, modified Rankin Scale; mTICI, modified Thrombolysis in Cerebral Infarction; NIHSS, National Institutes of Health Stroke Scale.

Table 3. Outcome depending on the mRS.

Characteristics	Total	mRS 3–6	mRS 0–2	mRS 0–1	Mortality
Age (years)	72.8 ± 11.6	75.4 ± 7 [0.611]	71.9 ± 14 [0.221]	68.6 ± 13 [0.398]	76.7 ± 5 [0.399]
Women (%)	56	57 [0.435]	52 [0.291]	55 [0.344]	51 [0.593]
Baseline NIHSS	12	13 [<0.05]	11 [<0.05]	12 [<0.05]	14 [<0.05]
Baseline NIHSS P1	14	12 [<0.05]	13 [<0.05]	14 [<0.05]	16 [<0.05]
Baseline NIHSS P2	6	7 [<0.05]	6 [<0.05]	6 [<0.05]	5 [0.272]
Baseline mRS score	4.3 ± 0.8	4.9 ± 0.4 [<0.05]	3.5 ± 0.5 [<0.05]	3.2 ± 0.3 [<0.05]	4.8 ± 0.4 [<0.05]
Baseline mRS score P1	4.7 ± 0.7 (3–5)	4.9 ± 0.3 [1]	3.5 ± 0.6 [0.403]	3.0 ± 0.5 [<0.05]	3.8 ± 0.6 [0.392]
Baseline mRS score P2	3.1 ± 0.9 (3–5)	3.3 ± 0.5 [1]	2.7 ± 0.6 [0.338]	2.5 ± 0.6 [<0.05]	3.3 ± 0.5 [0.590]
pc-Aspect pre-interventional	8 (6–10)	6 [<0.05]	7 [0.545]	10 [1]	6 [<0.05]
Time from symptom onset to door (min)	63 (51–76)	60 (51–70) [1]	58 (53–73) [0.563]	65 (55–76) [1]	64 (53–74) [0.544]
Time from symptom onset to groin puncture (min)	102 (93–132)	119 (101–132) [<0.05]	110 (99–125) [<0.05]	96 (93–124) [<0.05]	101 (97–126) [1]
Time from groin puncture to recanalization (min)	47 (25–98)	49 (27–91) [1]	61 (25–86) [1]	44 (32–98) [0.734]	56 (28–95) [0.776]
IV thrombolysis (n/N)	43/79	14/79 [0.425]	9/79 [0.232]	10/79 [0.404]	10/79 [0.309]
Time from symptom onset to IV thrombolysis (min)	92.4 (84–112)	97.7 (84–105) [0.987]	85.3 (85–112) [0.272]	94.3 (87–109) [0.395]	93.8 (85–110) [0.528]
pc-Aspect post-interventional	6	6 [1]	5 [0.435]	6 [0.393]	7 [0.589]
Asymptomatic ICH	4/79	0 [0.655]	2/79 [0.335]	2/79 [0.593]	0 [0.332]

Values are given as n (%), mean ± SD or median (IQR). Values in square brackets are *P* values. Multiple regression of factors associated with mRS 0–2, mRS 0–1, and mortality.
ICH, intracranial hemorrhage; mRS, modified Rankin Scale; mTICI, modified Thrombolysis in Cerebral Infarction; NIHSS, National Institutes of Health Stroke Scale.

occlusions indicate a promising safety and effectiveness profile comparable to that proven for LVOs in the anterior circulation. However mechanical thrombectomy in basilar artery occlusions is more complex compared to the anterior circulation and the rate of complications seems to be slightly higher (3,10,23–25,30–32). The way up via the vertebral arteries leads to more dissections because of the small vessel diameter and tortuosity.

Some authors highlight the role of magnetic resonance imaging in the detection of acute ischemic stroke in the posterior circulation and in the decision making for endovascular recanalization (31,33). However, our clinical standard is based plane CT in combination with CTA mainly for time-saving reasons. Technical innovations in thrombectomy devices follow the general trend of miniaturization in neuroendovascular medicine. Aspiration catheters and stent retrievers are nowadays smaller and more flexible, which makes catheterization of distally located lesions easier and safer (9,26,29,34–39).

Our angiographic success rate (mTICI 2b–3) achieved by aspiration alone is comparatively high with a promising safety profile (absence of ENTs/distal emboli or dissections in the affected arteries), a fact that is most probably related to the high rate of aspiration alone (ADAPT) in our series (40).

Stent retriever thrombectomies were only applied in bail-out situations when aspiration alone failed. Nevertheless, our overall complication rate with stent retrievers in the treatment of LVOs is likewise comparatively low (39).

We observed a good clinical outcome in 57% of the patients at 90 days besides the promising angiographic results detected in our series. As in other studies, we believe that these results justify the endovascular recanalization of acute symptomatic occlusions in the PCA territory (26,41–43). A comparison with populations regarding the anterior circulation shows comparable success rates and clinical results (22,26,43,44).

The present study has some limitations. First, the main limitation of this study is the retrospective design. Second, the decision for endovascular therapy made on an individual interdisciplinary decision without predefined inclusion criteria and results were analyzed without an independent assessment. However, the comparatively high sample size in this highly selective subgroup might help to identify the value of mechanical thrombectomy in the PCA territory. Only patients with severe clinical symptoms were treated by modified thrombolysis, so this could be a bias in comparison to the outcome of conservative treated occlusion of the PCA (45).

In conclusion, we were able to demonstrate that mechanical thrombectomy with primary aspiration (ADAPT) in acute symptomatic occlusions in the PCA territory is safe and effective, with results similar to those known for the anterior circulation. Further studies might help to identify the benefit of endovascular recanalization therapy in PCA occlusions without severe clinical symptoms (NIHSS < 6). Furthermore, the role of stent retrievers in distal occlusions of the posterior circulation should be investigated in comprehensive prospective studies.

Declaration of conflicting interests

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