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Outcome after Thrombolysis for Acute Isolated Posterior Cerebral Artery Occlusion

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Key Words
Acute ischemic stroke · Thrombolytic therapy · Posterior cerebral artery · Percheron artery

Abstract
Background: To date, there is limited data on intra-arterial thrombolysis (IAT) and intravenous thrombolysis (IVT) for isolated posterior cerebral artery (PCA) occlusion. We aimed to evaluate recanalization, outcome and quality of life in patients who undergo thrombolysis for isolated PCA occlusion. ***Methods:*** Analysis of 9 patients treated with IAT and 9 patients treated with IVT with short-term (3 months) outcome and long-term (median 23 months) outcome after IAT. ***Results:*** 9 of 546 patients treated with IAT (4 women and 5 men; median age 66 years) had isolated PCA occlusion. Median baseline National Institute of Health Stroke Scale (NIHSS) score on admission was 9. Eight patients presented with visual field defects and variable additional symptoms. One patient suffered bithalamic infarction. Median time to treatment was 5.8 h. Recanalization was complete in 2, partial in 2, minimal in 2, and not achieved in 3 patients. Recanalization tended to be better when the microcatheter was placed in or close to the thrombus. We observed no major complications, and 3 months outcome was favorable (modified Rankin Scale score 0–2) in 67% of the patients after IAT. During the same period, 9 patients with PCA occlusion were treated with IVT with 89% favorable clinical outcomes at 3 months. At long-term follow-up after IAT, neuropsychological domains were more severely impaired than other neurologic functions. ***Conclusion:*** IAT is a feasible treatment of isolated PCA strokes. Clinical outcome was favorable in the majority of patients after IAT and IVT. No major complications were observed. Further studies are needed to compare IAT and IVT for isolated PCA stroke.

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Infarcts in the territory of the posterior cerebral artery (PCA) are common. They may cause visual field defects, sensorimotor disturbances, and a variety of neuropsychological and psychiatric symptoms, sleep disorders, and pain [1, 2]. Given the broad clinical spectrum, diagnosis of PCA stroke is often difficult. Many PCA stroke patients present late, when the time window for intravenous thrombolysis (IVT) has already elapsed. Guidelines consider intra-arterial thrombolysis (IAT) as safe and ef-

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ficacious for the treatment of middle cerebral artery (MCA) stroke within 6 h after symptom onset and for basilar artery occlusion up to 12 h after symptom onset [3]. However, it is unknown whether IAT is safe and efficacious for the treatment of acute isolated occlusion of the PCA.

The aims of the present study were, therefore, to evaluate safety, vessel recanalization, outcome and quality of life (QOL) in patients who undergo IAT for an acute isolated occlusion of the PCA. Furthermore, outcomes of patients undergoing IVT for isolated PCA occlusion are described.

Methods

Patient Selection and Workup

This study is based on the Bernese Stroke Registry. We prospectively recorded patients with acute isolated PCA occlusion who underwent IAT or IVT. All procedures were in accordance with institutional guidelines. All patients were examined immediately after admission by a neurologist, and the deficit was scored using the National Institutes of Health Stroke Scale (NIHSS) score [4]. Demographic data, time of symptom onset, and previous medical history [history of coronary artery disease, atrial fibrillation, transient ischemic attack (TIA), or ischemic stroke] were recorded. The following stroke risk factors were assessed: hypertension, diabetes, current cigarette smoking, dyslipidemia, coronary artery disease, previous TIA or stroke, and a family history of TIA or stroke. After clinical evaluation, patients underwent a standard investigation protocol in the emergency department including blood tests, electrocardiography, cranial computed tomography (CT), and/or magnetic resonance imaging (MRI). Status of extra- and intracranial vessels was primarily assessed noninvasively by CT angiography (CTA) and/or magnetic resonance angiography (MRA).

Angiography and Intra-Arterial Thrombolysis

Angiography and IAT were performed with the informed consent of the patient or his family as soon as possible after CT or MRI. All patients underwent four-vessel diagnostic angiography to assess the cerebral blood vessel status prior to IAT. IAT was performed if: (1) diagnosis of ischemic stroke was established; (2) baseline NIHSS score was ≥4 points or if isolated hemianopia or aphasia were present; (3) there was no hemorrhage on cranial CT or MRI; (4) cerebral digital subtraction angiography (DSA) showed a vessel occlusion correlating with the neurological deficit; (5) treatment (local infusion of urokinase or mechanical recanalization) could be initiated within 6 h from symptom onset; (6) no individual clinical or laboratory finding contraindicated thrombolysis, and (7) in elderly patients (aged over 75 years), if the general condition before stroke did not advise against it. Time from symptom onset to thrombolysis, placement of microcatheter, method of thrombolysis [intra-arterial fibrinolytic therapy with urokinase (Urokinase HS Medac, Wedel, Germany) with or without mechanical recanalization techniques including clot retrieval, angioplasty or stenting], urokinase dose and duration of urokinase infusion were recorded. Time to treatment was defined as interval from symptom onset to the beginning of local infusion of urokinase of mechanical recanalization.

Diagnostic angiography included DSA of the carotid arteries bilaterally to visualize collaterals to the vertebrobasilar system via the posterior communicating arteries. Origin and size of both vertebral arteries (VAs) were documented by DSA of both subclavian arteries. DSA of the vertebrobasilar system was performed by selective contrast injection into the origin of the dominating VA which was then also used for the endovascular approach directly after diagnostic angiography. The degree of vessel recanalization was quantified according to the Thrombolysis in Myocardial Infarction (TIMI) classification [5].

According to our institutional guidelines, 250–500 mg of acetylsalicylic acid were administered intravenously to all patients immediately after thrombolysis, but anticoagulation was withheld for at least 24 h. A combination of acetylsalicylic acid and clopidogrel was not used.

Intravenous Thrombolysis

IVT was performed if: (1) diagnosis of ischemic stroke was established; (2) baseline NIHSS score was ≥4 points or if isolated hemianopia or aphasia were present; (3) there was no hemorrhage on cranial CT or MRI; (4) treatment could be initiated within 4.5 h of symptom onset; (5) no individual clinical or laboratory finding contraindicated thrombolysis, and (6) informed consent was given by the patient or his family. IVT consisted of systemic infusion of 0.9 mg tissue-type plasminogen activator (tPA)/alteplase (Actilyse; Boehringer Ingelheim, Basel, Switzerland) per kilogram bodyweight (maximum dose of 90 mg), of which 10% were administered as bolus injection and 90% as a continuous infusion over 60 min thereafter. Time from symptom onset to start of Actilyse infusion was recorded. According to our institutional guidelines, antiplatelet drugs and heparins were withheld for 24 h after IVT. Thereafter, antithrombotic medication (aspirin 100 mg) was started after exclusion of intracranial hemorrhage (ICH) by brain imaging. Recanalization was assessed by MRA or CTA the day after thrombolysis.

Stroke Subtype Classification

Stroke subtype was classified according to the Trial of Org 10172 in Acute Stroke Treatment (TOAST) criteria [6].

Identification and Classification of Intracranial Hemorrhage

Cranial MRI or CT was performed routinely within 24 h after thrombolysis or in case of any clinical deterioration. ICH was classified as 'symptomatic' if a parenchymal hematoma type 2 (according to the ECASS criteria) was accompanied by a 4-point or greater increase in the NIHSS score or if leading to death [7, 8].

Outcome

Short-term outcome was assessed 3 months after IAT or IVT using the modified Rankin Scale (mRS) and the NIHSS score [9]. Favorable outcome was defined as mRS score 0–2. Long-term follow-up after IAT was performed by a telephone interview (for mRS) and by a written questionnaire (see below) at a second time point ranging from month 10 to month 84 after stroke. QOL was assessed using the Stroke Specific Quality of Life (SSQOL) questionnaire [10]. The SSQOL is a disease-specific QOL scale which assesses twelve domains (energy, family role, language, mobility,

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Table 1. Clinical data of 9 patients undergoing IAT for acute PCA occlusion

Patient No.	Sex	Age years	Vascular risk factors	Clinical findings	NIHSS	TOAST
1	f	62	Hypertension, dyslipidemia	Somnolence, dysarthria, right hemianopia and hemiparesis	9	Cardioembolic
2	f	44	Coronary artery disease	Somnolence, right hemianopia and hemiparesis	9	Cardioembolic
3	m	66	Hypertension, dyslipidemia, smoking	Left hemianopia and hemiparesis	9	Unknown
4	m	57	Hypertension, dyslipidemia, coronary artery disease, atrial fibrillation	Aphasia, right hemianopia and hemiparesis	10	Cardioembolic
5	m	79	Hypertension, smoking, coronary artery disease, atrial fibrillation	Somnolence, left hemianopia and hemiparesis	15	Cardioembolic
6	m	56	Hypertension, dyslipidemia, coronary artery disease	Somnolence, right hemianopia	3	Cardioembolic
7	f	76	Hypertension, previous TIA	Dysarthria, left hemianopia and hemiparesis	17	Large artery atherosclerosis
8	m	74	Hypertension, dyslipidemia, atrial fibrillation	Right hemianopia	2	Cardioembolic
9	f	80	Hypertension, dyslipidemia, atrial fibrillation	Coma, right hemiparesis	21	Cardioembolic
Median		66			9	

TOAST = Trial of Org 10172 in Acute Stroke Treatment.

mood, personality, self-care, social roles, thinking, arm function, vision, and work). Each item is ranked on a 5-point Likert scale (range 1–5) with higher scores indicating better function. Domain scores are unweighted averages of the items included in that domain, and the summary SSQOL is an unweighted average of the twelve domain scores.

Results

Intra-Arterial Thrombolysis

From January 2000 to September 2009, 546 consecutive patients underwent IAT for the treatment of an acute ischemic stroke. Nine of these patients (4 women and 5 men, median age 66 years, range 44–80 years) underwent IAT for an isolated PCA occlusion after time window for IVT had already elapsed. Baseline characteristics are shown in table 1. Median NIHSS score on admission was 9 (range 2–21). Eight patients presented with dense visual field defects. One patient (IAT patient 9) suffered bilateral thalamic infarction due to an artery of Percheron occlusion (see case presentation below) and was comatose. Radiological findings are shown in table 2. Eight patients had unilateral PCA occlusions and 1 patient a bilateral P2 segment PCA occlusion. Median time from symptom onset to initiation of local urokinase infusion was 5.8 h (range 4.9–6.3 h). The microcatheter could be placed in or close to the site of occlusion in 4 patients, whereas urokinase was infused into the dominant VA in the remaining 5 patients. Mechanical recanalization techniques were used in 1 patient. Recanalization was complete (TIMI 3) in 2 patients, partial (TIMI 2) in 2, minimal (TIMI 1) in 2, and 3 arteries remained completely occluded (TIMI 0). In 3 out of 4 patients with microcatheter placement close to the thrombus, partial (n = 2) or complete recanalization (n = 1) was achieved. By administering urokinase into the VA, only 1 of 5 PCA occlusions was completely recanalized (TIMI 3), 1 minimally (TIMI 1), and the others remained occluded (TIMI 0). No patient suffered a symptomatic ICH leading to a clinical deterioration after IAT. Asymptomatic hemorrhagic transformation ECASS type 1 (HT1) was observed in 4 patients. One patient suffered a lacunar superior cerebellar artery infarction, detected by diffusion-weighted MRI after IAT, which was not visible on CT performed before the intervention.

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Table 2. Radiological data of 9 patients undergoing IAT for acute PCA occlusion

Patient No.	Occluded PCA segment	Time to thrombolysis, h	Placement of microcatheter	Duration min	Urokinase dose, IU	TIMI grade	Complications
1	P1 left	5	VA	45	1,000,000	3	None
2	P2 bilateral	5	P2 bilateral	70	1,250,000	2/3	None
3	P1 right	6.33	P1	25	500,000	3	HT1
4	P1 left	5.85	VA	30	500,000	1	None
5	P1 right	5.5	VA	70	1,000,000	0	None
6	P3 left	6.33	VA	50	300,000	0	HT1
7	P2 right	4.85	VA	30	500,000	0	None
8	P2 left	6.25	P2	70	1,000,000	2	HT1
9	P1 left	5.8	P1	90	700,000 (+ mechanical recanalization)	1	HT1, lacunar stroke
Median		5.8		50	700,000	1	

HT1 = Hemorrhagic transformation type 1; P1, P2, P3 = PCA segment; VA = vertebral artery; TIMI = Thrombolysis in myocardial infarction.

Table 3. Clinical outcome of 9 patients after IAT for acute PCA occlusion

Patient No.	Housing	First follow-up			Second follow-up			
		clinical findings	NIHSS	mRS	time to follow-up months	mRS	summary SSQOL	cause of death
1	Individual	Incomplete right hemianopia	1	2	84	2	3.9	
2	Individual	Incomplete right hemianopia and right hypoesthesia	2	2	52	2	3.0	
3	Individual	Incomplete left hemianopia, hypoesthesia and facial palsy	3	1	46	1	4.6	
4	Rehab	Right hemianopia, slight aphasia and right hemiparesis	5	3	40	6		Suspected stroke
5	Nursing home	N/A	N/A	4	10	6		Unknown
6	Individual	Incomplete right hemianopia	1	2	23	1	3.7	
7	Individual	Left arm weakness	1	2	22	2	4.0	
8	Individual	N/A	N/A	2	12	2	3.5	
9	Nursing home	N/A	N/A	5	11	6		Unknown
Median			1.5	2	23	2	3.8	

N/A = Not available; NIHSS = National Institute of Health Stroke Scale; mRS = modified Rankin Scale; SSQOL = Stroke Specific Quality of Life.

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Outcome of each patient is shown in table 3 and figure 1. After 3 months, 6 patients returned for follow-up examination with mRS and NIHSS, and 3 were contacted by phone for mRS assessment. The NIHSS score of the 6 patients who returned for examination had decreased to a median of 1.5 (range 1–5). In 1 patient, no visual field defect was detected anymore, whereas in the remaining 5 patients visual field defects were still present. However, in 4 of those patients, visual defects tended to be less severe than before IAT (quadrantanopia or incomplete hemianopia instead of full hemianopia as measured by confrontation visual field testing). No patient had died, and outcome was favorable (mRS score ≤ 2) in 6 patients.

At the second follow-up (time to follow-up: median of 23 months, range 10–84 months), 3 of 9 patients had died: One patient died of a probable recurrent stroke 40 months after IAT, and 2 of an unknown cause 10 and 11 months after IAT, respectively. Outcome of the 6 survivors was still favorable (mRS range 1–2): in 1 patient, mRS score had decreased from 2 to 1, the others remained stable.

SSQOL scores of the 6 surviving patients are shown in figure 1: impairment in neuropsychological domains such as energy, social role, personality and concentration was more important and therefore scored less than impairment in somatic domains such as arm function, vision, language, mobility, and self care.

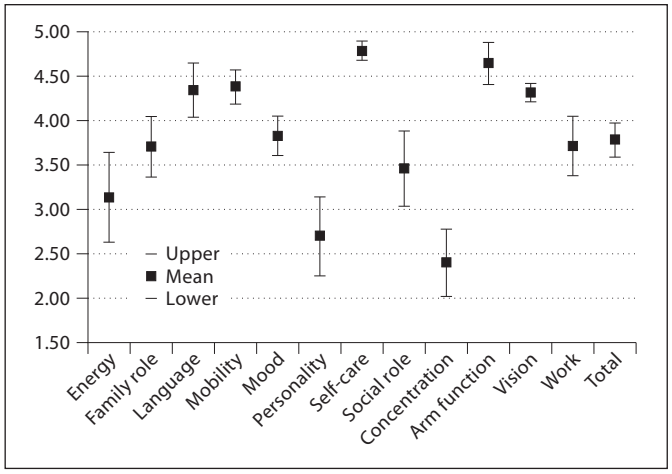

Fig. 1. Mean and 95% confidence interval of SSQOL domain scores of 6 patients with PCA stroke. Minimum value is 1, maximum value is 5. Higher numbers indicate better function.

Selected Case Presentation – Artery of Percheron Thrombolysis

IAT patient 9, an 80-year-old female suddenly developed aphasia and became comatose within a few minutes. Initial clinical evaluation revealed a Glasgow Coma Scale (GCS) score of 8/15 and a NIHSS score of 21/42. Cranial CT showed an occlusion of the P1 segment of the left PCA, presumably of cardioembolic origin due to intermittent atrial fibrillation. The patient was intubated and angiography was performed, which confirmed left PCA occlusion with the left superior cerebellar artery as the only branch originating from the P1 segment proximal to the site of the occlusion (fig. 2a–d). Basilar artery was patent, and there was no significant atherosclerosis. A microcatheter was placed into the embolus and 700,000 IU of urokinase were injected, resulting in recanalization of a thalamo-perforating artery, which could be identified as the Percheron variant 2b originating in a common trunk and branching further distally to supply paramedian parts of both thalami, which explained the patient's coma [11]. Every attempt to pass the occluded P1 segment with the microwire or microcatheter to retrieve or stent the thrombus had to be ceased because the patient reacted immediately with significant bradycardia and hypertension. Thus, after 90 min the angiography had to be finished even though the P1 segment was still occluded. Angiographically, the proximal part of the Percheron artery was reperfused, however, without parenchymal blush of the thalami, indicating no reperfusion of the microvascular network (fig. 2e, f, fig. 3). Cranial CT on the following day and MRI 3 days after thrombolysis showed a persisting occlusion of the left P1 segment with infarction of both medial thalami (on the left side with slight hemorrhagic transformation, fig. 2g, h). In addition, there was an infarction of the left medial occipital lobe and a lacunar infarction in the right superior cerebellar artery area, probably as a complication of the attempts to remove the thrombus mechanically (image not shown). There was no midbrain infarction visible. Clinical outcome was unfavorable with persistent obtundation and a right hemisyndrome. Later, the patient had to be transferred to a nursing home, where she died 11 months after the ictus.

Intravenous Thrombolysis

During the same time period, 9 patients (7 women and 2 men, median age 62 years, range 32–80 years) underwent IVT for isolated PCA occlusion. Clinical characteristics are shown in table 4. Median NIHSS score on admission was 4 (range 1–19). All patients presented with visual field defects, of whom 1 patient (IVT patient 9) suffered bilateral PCA infarction with visual field defects on both sides (preceded by a transient 'top of the basilar syndrome' which was later shown to be due to cardiac embo-

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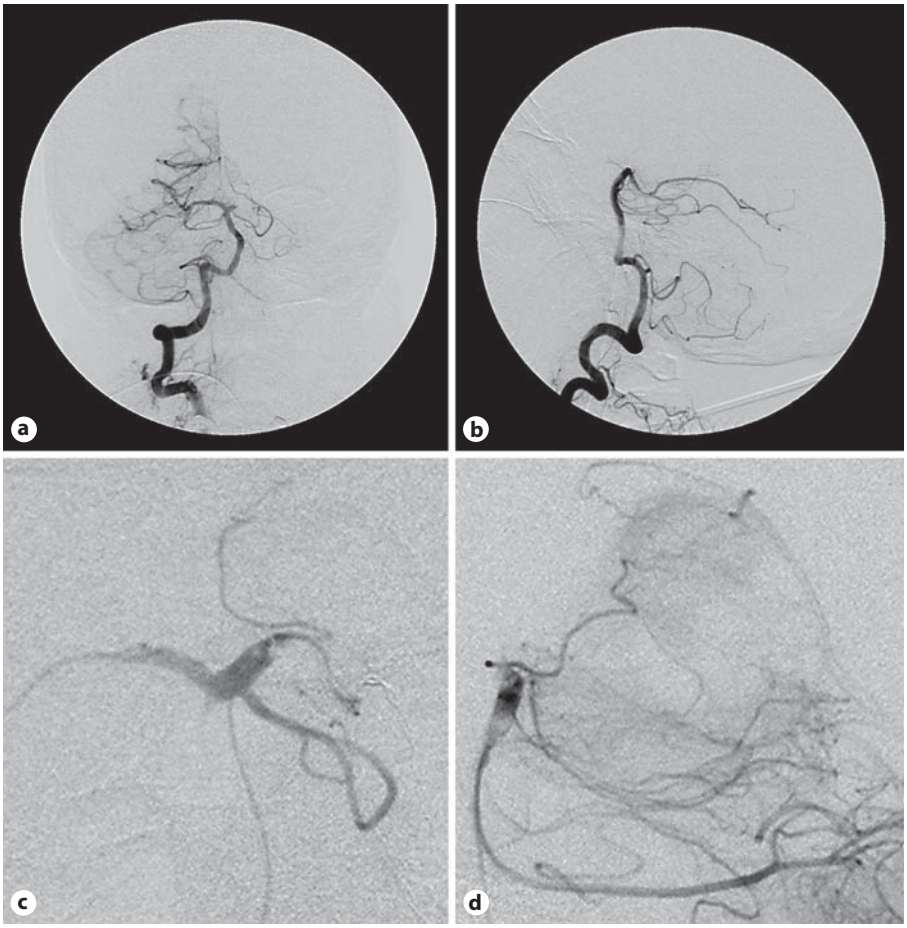

Fig. 2. a–d Acute ischemic stroke in an 80-year-old woman (NIHSS score 21) suffering from left PCA occlusion as confirmed by CTA. **a**, **b** DSA in anterior-posterior (**a**) and lateral (**b**) view shows occlusion of the P1 segment of the left PCA with variant of a left superior cerebellar artery arising from the left P1 segment. No perforating artery is visible. **c**, **d** Superselective angiography with the tip of the microcatheter at the origin of the P1 perforating vessel in anterior-posterior (**c**) and lateral (**d**) projection identifies this artery as the Percheron artery type 2b, which supplies both thalami.

lism). Radiological findings, thrombolysis data, and 3-months outcome after IVT are shown in table 5. Median time from symptom onset to initiation of tPA infusion was 3 h (range 1.5–4.5 h). Recanalization (as assessed by CTA or MRA after 12–24 h) was achieved in 5 patients. Two patients had persisting vessel occlusion, and the patient with bilateral PCA occlusion had complete recanalization on the right PCA and persisting occlusion on the left PCA; in 1 patient recanalization could not be assessed (no vessel imaging available). One patient had an asymptomatic hemorrhagic transformation, and another one had a generalized epileptic seizure the day after the stroke. After 3 months, no patient had died. Seven patients returned for follow-up examination with mRS and NIHSS, and 2 patients were contacted by phone for mRS assessment. The NIHSS score of the 7 patients who returned for examination had decreased to a median of 1 (range 0–3). In 4 patients, no visual field defect was detected anymore. In 1 patient, the visual defect tended to be less severe than before IVT, and in 2 patients, visual field defects remained unchanged. The 2 patients with NIHSS scores of 0 complained of fatigability. Outcome was favorable (mRS score ≤ 2) in 8 patients.

Discussion

PCA strokes lead to a variety of symptoms sometimes not properly described by the patient (e.g. 'blurry vision' in hemianopia) and often not easily recognized by primary care physicians, especially non-neurologists (e.g. visual field defects or aphasia). Therefore, diagnosis is often delayed and patients arrive late for thrombolytic therapy. In this study we report our experience with IAT within 6 h in patients with isolated occlusion of the PCA. Our limited experience shows that IAT for PCA occlusion is a feasible therapy with a favorable outcome (mRS 0–2) in 67% of our patients.

In contrast to the well-described clinical presentation of PCA strokes with a broad variety of symptoms, case

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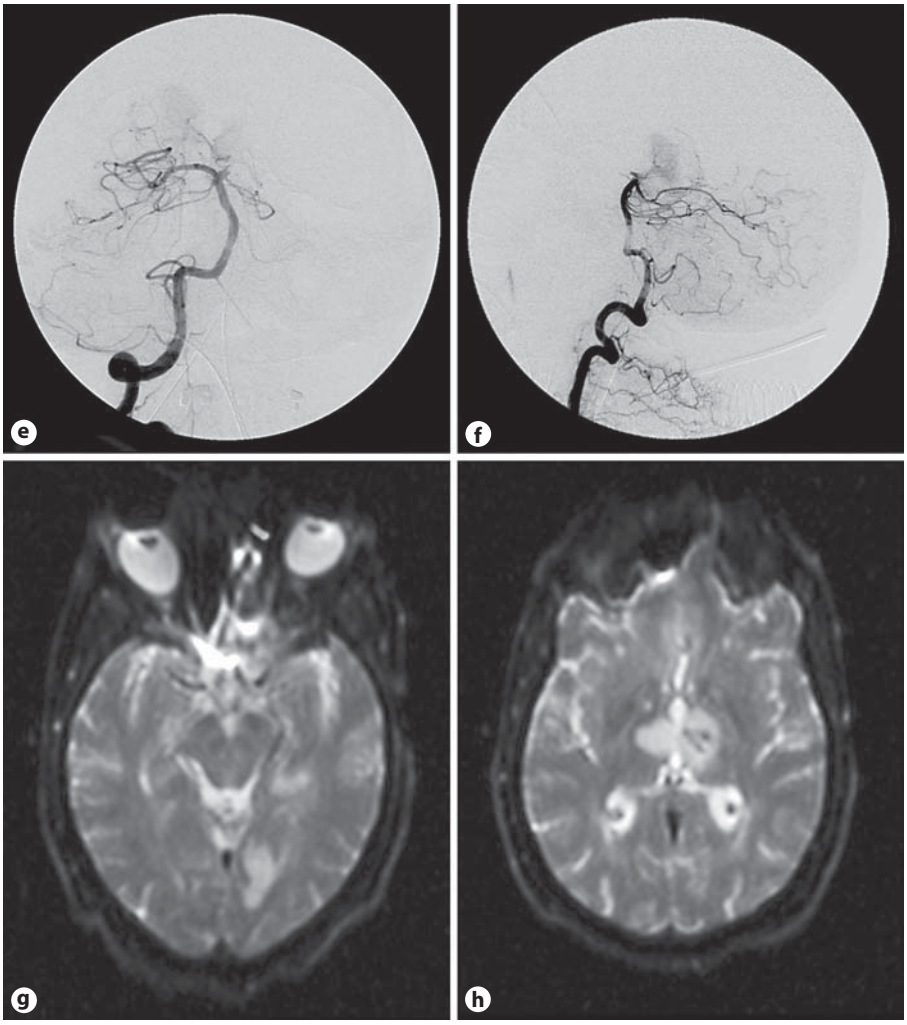

Fig. 2. e–h Acute ischemic stroke in an 80-year-old woman (NIHSS score 21) suffering from left PCA occlusion as confirmed by CTA. **e**, **f** DSA after local infusion of 700,000 IU urokinase into the site of occlusion and superselectively into the origin of the perforator shows partial recanalization of the artery of Percheron with stagnating flow, indicating infarction with no reperfusion of the thalamic capillary networks. **g**, **h** B0 diffusion-weighted MRI 3 days after thrombolysis shows infarction in the left occipital lobe and both medial thalami (with hemorrhagic transformation on the left side) without lesions of the brain stem. The bilateral thalamic infarction despite recanalization of the proximal branch of the Percheron artery and the sparing of the brain stem confirm the absence of collaterals to the thalami and the existence of an anastomotic network of the perforators to the brain stem.

series on acute management of these patients are scarce. Only case reports on IAT for PCA stroke have been published. Comparable to IAT patient 9 (see case presentation above), Kostanian and Cramer [12] recently described a case with successful IAT with tPA of an occluded artery of Percheron arising from the P1 segment of a PCA. This resulted in a favorable clinical outcome. The bad outcome of our patient might be explained by the delay of more than 7 h between onset of coma and recanalization of the Percheron artery. Horowitz et al. [13] reported a case of combined basilar artery and bilateral PCA occlusion treated with angioplasty and intra-arterial urokinase with a favorable outcome.

According to the published case reports and our present series, IAT in patients with PCA infarction appears to be safe: None of our patients suffered major complications during and after IAT; in particular, no symptomatic ICH was observed. Asymptomatic hemorrhagic transformation occurred in 4 patients but with no further impact on clinical outcome. Control MRI of patient 9 after thrombolysis showed a hemorrhagic transformation of the infarcted area and a diffusion-weighted imaging lesion in the territory of the contralateral superior cerebellar artery, which had not been visible on CT performed before the intervention, and which we therefore rated as a complication following several attempts to retrieve the thrombus mechanically.

Complete or partial recanalization was achieved in 44% of our patients. Recanalization was more frequent in those patients in whom the microcatheter was placed in the PCA close to the obstructing blood clot. When urokinase had to be infused from the VA, recanalization rates tended to be worse. Nevertheless, IAT in PCA stroke seems to be efficacious: 3 months after thrombolysis, the

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Table 4. Clinical data of 9 patients undergoing IVT for acute PCA occlusion

Patient No.	Sex	Age years	Vascular risk factors	Clinical findings	NIHSS	TOAST
1	f	68	Diabetes, hypertension	Right hemianopia and severe hemisyndrome, somnolence	19	Large artery atherosclerosis
2	f	80	Hypertension, smoking, dyslipidemia, atrial fibrillation	Right hemianopia and hemiparesis, slight aphasia	4	Cardioembolic
3	f	62	Hypertension, dyslipidemia	Left hemianopia and hemiparesis	7	Cardioembolic
4	f	73	Hypertension, dyslipidemia, coronary artery disease, diabetes, smoking	Right hemiparesis and incomplete hemianopia, dysarthria	5	Large artery atherosclerosis
5	f	32	Persisting foramen ovale	Right hemianopia	3	Cardioembolic
6	f	61	Persisting foramen ovale, previous ischemic stroke	Right hemianopia	2	Cardioembolic
7	f	42	None	Right hemianopia	1	Other determined (carotid artery dissection with fetal PCA variant)
8	m	36	None	Right hemianopia and hemiparesis	5	Undetermined, negative evaluation
9	m	69	Hypertension, dyslipidemia	Right hemianopia, incomplete left hemianopia	4	Cardioembolic
Median		62			4	

NIHSS = National Institute of Health Stroke Scale; TOAST = Trial of Org 10172 in Acute Stroke Treatment.

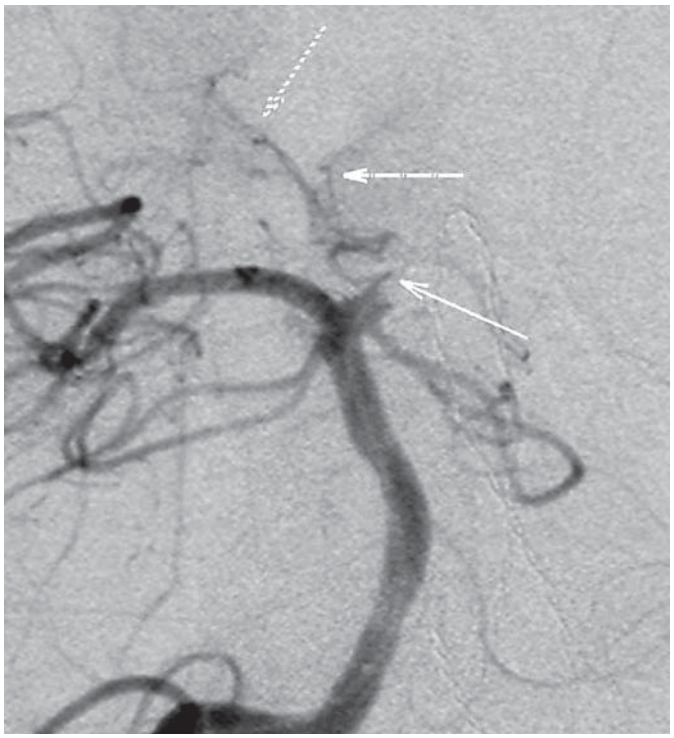

Fig. 3. Enlarged DSA in anterior-posterior view (contrast medium injection into the right VA) after urokinase infusion showing persisting occlusion of the left P1 segment of the PCA. The tip of the microcatheter is located in the common trunk of the Percheron artery (single arrow), which divides further distally into branches supplying the right (dotted arrow) and the left (interrupted arrow) thalamus.

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Table 5. Radiological data and outcome of 9 patients undergoing IVT for acute PCA occlusion

Patient No.	Occluded PCA segment	Time to thrombolysis, h	Recanalization	Complication	3-months follow-up			
					housing	clinical findings	NIHSS	mRS
1	P1 left	4	No	None	Individual	N/A	N/A	3
2	P1 left	3.5	N/A	HT1	Individual	Slight aphasia	1	1
3	P2 right	2.5	Yes	None	Individual	Left hypoesthesia	1	1
4	P2 left	3	No	None	Individual	Incomplete right hemianopia and hypoesthesia, slight ataxia	3	2
5	P2 left	2	Yes	None	Individual	None	0	1
6	P2 left	4	Yes	None	Individual	None	0	2
7	P2 left	4.5	Yes	None	Individual	Incomplete right hemianopia	1	2
8	P2 left	1.5	Yes	Early epileptic seizure	Individual	Right hemianopia, alexia	2	2
9	P2 right P3 left	3	Right yes, left no	None	Individual	N/A	N/A	1
Median		3					1	2

P1, P2, P3 = PCA segment; N/A = Not available; HT1 = Hemorrhagic transformation type 1; NIHSS = National Institute of Health Stroke Scale; mRS = modified Rankin Scale.

NIHSS score had decreased substantially in those 6 patients who returned for a follow-up examination. Unfortunately, NIHSS scores could not be determined in 3 patients: 2 patients were severely disabled and were living in a nursing home, so it must be assumed that their NIHSS scores were still high (NIHSS scores before IAT were 15/42 and 21/42, respectively, no substantial recanalization was achieved). They died, respectively, 10 and 11 months after the stroke from an unknown cause. One patient refused to return for follow-up, but his NIHSS score before IAT was relatively low (2/42, good recanalization was achieved). He was living in his own house and was independent in daily life activities (mRS score of 2).

Before IAT, 8 out of 9 patients suffered from visual field defects with variable additional sensorimotor symptoms, aphasia or obtundation. After 3 months, hemianopia had completely resolved only in 1 patient, whereas visual field defects were still present in all other patients. Motor symptoms had resolved in most patients.

During the same time period, 9 patients were treated with IVT for acute isolated PCA occlusion, and two of them had P1 PCA occlusion. Before IVT, visual field defects were present in all patients, and in 3 cases, it was the only neurological deficit. IVT led to vessel recanalization (assessed by MRA or CTA after 12–24 h) in 56%. One patient suffered an asymptomatic hemorrhagic transformation and 1 patient had a generalized epileptic seizure, which was probably not related to IVT itself but rather to cortical ischemia. Three months after thrombolysis, outcome was favorable (mRS 0–2) in 89% of the patients. Median NIHSS score had decreased to 1, and no patient had died. All patients were living at home. A statistical comparison of the two different treatment modalities (IVT vs. IAT) was not performed because of the small sample size.

In addition to traditional functional outcome scales, such as mRS and NIHSS, we assessed QOL in our IAT patients a median of 23 months after the stroke. QOL scales measure patient-centered outcome, are sensitive for minimal changes, and do not only focus on gross physical aspects of disability, but include psychological and cognitive functions like memory, emotion, thinking, communication, and social role. The QOL of our patients was most likely impaired in the domains energy, personality and concentration, whereas more physical function related items such as self-care, mobility, upper extremity function, vision, and language were barely affected.

Our case presentation illustrates the importance of the perforating vessels for the brain stem and thalamus, orig-

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inating from the P1 and P2 segments of the PCA [14]. Unfortunately, occlusion and recanalization of these perforators can only partially be visualized even when using high-resolution angiography. In IAT patient 9, we could clearly identify a Percheron artery type 2b, which is present in about 7% [11, 15, 16]. In addition to the degree of recanalization, angiographically invisible anastomoses between perforators, which are present in about 75%, may be of paramount importance for patient outcome [17].

Our study has several limitations: the main limitation is the small sample size and the lack of a control group of untreated patients. Furthermore, patients with acute PCA occlusions qualifying for IAT or IVT represent a highly selected patient group. Another limitation is the wide range of long-term follow-up. However, all patients had at least 10 months of follow-up. Because most of the changes after stroke occur within a few months and substantial changes after more than 1 year are rare, it is unlikely that this has biased our results.

In our series, IAT was feasible and recanalization was better when the microcatheter could be placed in or close to the obstructing blood clot compared to urokinase infusion from a distant vessel. Functional clinical outcome was favorable in the majority of our patients. QOL was more likely to be impaired in psychological domains than in physical function. No major complications were observed. Therefore, we think that IAT may be a therapeutic option in patients with acute occlusions of the PCA. Further studies are needed to prove the efficacy of IAT in PCA stroke and to compare IVT and IAT in patients with isolated PCA occlusion.

Disclosure Statement

The authors report no conflicts of interest.

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