Endovascular Treatment for Posterior Circulation Stroke in Routine Clinical Practice

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ORIGINAL CONTRIBUTIONS

Endovascular Treatment for Posterior Circulation Stroke in Routine Clinical Practice: Results of the Multicenter Randomized Clinical Trial of Endovascular Treatment for Acute Ischemic Stroke in the Netherlands Registry

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BACKGROUND AND PURPOSE: The benefit of endovascular treatment (EVT) for posterior circulation stroke (PCS) remains uncertain, and little is known on treatment outcomes in clinical practice. This study evaluates outcomes of a large PCS cohort treated with EVT in clinical practice. Simultaneous to this observational study, several intervention centers participated in the BASICS trial (Basilar Artery International Cooperation Study), which tested the efficacy of EVT for basilar artery occlusion in a randomized setting. We additionally compared characteristics and outcomes of patients treated outside BASICS in trial centers to those from nontrial centers.

METHODS: We included patients with PCS from the Multicenter Randomized Clinical Trial of Endovascular Treatment for Acute Ischemic Stroke in the Netherlands Registry: a prospective, multicenter, observational study of patients who underwent EVT in the Netherlands between 2014 and 2018. Primary outcome was a score of 0 to 3 on the modified Rankin Scale at 90 days. Secondary outcomes included reperfusion status and symptomatic intracranial hemorrhage. For outcome comparison between patients treated in trial versus nontrial centers, we used ordinal logistic regression analysis.

RESULTS: We included 264 patients of whom 135 (51%) had received intravenous thrombolysis. The basilar artery was most often involved (77%). Favorable outcome (modified Rankin Scale score 0–3) was observed in 115/252 (46%) patients, and 109/252 (43%) patients died. Successful reperfusion was achieved in 178/238 (75%), and symptomatic intracranial hemorrhage occurred in 9/264 (3%). The 154 nontrial patients receiving EVT in BASICS trial centers had similar characteristics and outcomes as the 110 patients treated in nontrial centers (modified Rankin Scale adjusted cOR: 0.77 [95% CI, 0.5–1.2]).

CONCLUSIONS: Our study shows that high rates of favorable clinical outcome and successful reperfusion can be achieved with EVT for PCS, despite high mortality. Characteristics and outcomes of patients treated in trial versus nontrial centers were similar indicating that our cohort is representative of clinical practice in the Netherlands. Randomized studies using modern treatment approaches are needed for further insight in the benefit of EVT for PCS.

GRAPHIC ABSTRACT: A graphic abstract is available for this article.

Key Words: large vessel occlusion ■ posterior stroke ■ registries ■ reperfusion ■ treatment outcome

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ORIGINAL CONTRIBUTIONS

Nonstandard Abbreviations and Acronyms

BAO	basilar artery occlusion
BASICS	Basilar Artery International Cooperation Study
eLVO	estimated time of large vessel occlusion
eTICI	extended Thrombolysis in Cerebral Ischemia
EVT	endovascular treatment
IQR	interquartile range
LVO	large vessel occlusion
MR CLEAN	Multicenter Randomized Clinical Trial of Endovascular Treatment for Acute Ischemic Stroke in the Netherlands
mRS	modified Rankin Scale
NIHSS	National Institutes of Health Stroke Scale
PCS	posterior circulation stroke

Large vessel occlusion (LVO) of the posterior circulation comprises around 1% of all ischemic strokes and is associated with high risk of disability and mortality.[1–3] Because endovascular treatment (EVT) has been proven safe and effective for LVO stroke of the anterior circulation, its extension to the posterior circulation seemed warranted.[4] However, recent trials of patients with a basilar artery occlusion (BAO) stroke did not show superiority of EVT over best medical management.[5,6] As such, clinicians are still faced with uncertainties regarding the benefit of EVT in routine practice. Studies reporting on EVT performed for posterior circulation stroke (PCS) were often limited to single center data or the use of outdated thrombectomy devices.[7–12] Therefore, more information on the outcome after PCS and its determinants is needed to aid treatment decisions in clinical practice and perhaps the design of future RCTs. In the Netherlands, all patients treated in clinical practice with EVT for LVO stroke between 2014 and 2018 were included in the MR CLEAN Registry; a prospective multicenter database. Our primary aim is to describe patient characteristics and evaluate outcomes in this large cohort of patients with posterior LVO stroke treated with EVT in clinical practice.

During the registry study period, several Dutch stroke intervention centers participated in the BASICS trial (Basilar Artery International Cooperation Study), which tested the efficacy of EVT in patients with BAO in a randomized setting. The majority of the patients randomized in this trial were enrolled in the Netherlands and were not included in the MR CLEAN Registry. Simultaneous trial participation may have influenced the composition of our clinical practice cohort. For example, patient selection for EVT outside of BASICS could have been based on favorable characteristics (eg, young age) or trial exclusion criteria, resulting in a different patient cohort compared with other previous clinical practice registries.

To gain more insight in the composition of our patient cohort and in the interpretation and relevance of our results, we compared clinical profiles and outcomes between patients who underwent EVT for PCS in trial participating centers versus non participating centers.

METHODS

Study Design and Patients

The MR CLEAN (Multicenter Randomized Clinical Trial of EVT for Acute Ischemic Stroke in the Netherlands) Registry is a prospective, nationwide registry, in which data were collected from consecutive acute stroke patients treated with EVT in 18 intervention centers in the Netherlands after the last inclusion of patients in the MR CLEAN trial. The study protocol was evaluated by the central medical ethics committee of the Erasmus MC in Rotterdam, the need for individual patient consent was waived, and permission to carry out the study as a registry was granted. Full methods of the MR CLEAN Registry have been reported previously.[13] For the present study, we included patients treated with EVT from March 2014 up to December 2018, who met the following inclusion criteria: age ≥18 years; occlusion of the vertebral, basilar, or posterior cerebral artery confirmed by baseline computed tomography angiography; with symptoms attributable to ischemia of the posterior circulation. Patients were selected for EVT based on the judgement of the treating physician.

Source data will not be made available because of legislative issues on patient privacy. Detailed analytic methods and study materials, including log files of statistical analyses, are available to other researchers upon reasonable request to the first author. The STROBE statement of the present study can be found in the Supplemental Material.

Treatment Procedures

EVT was defined as arterial puncture in the angiography suite and could include digital subtraction angiography, catheterization with a microcatheter to the level of occlusion, either followed or not by mechanical thrombectomy. Mechanical thrombectomy included stent retriever technique, thrombus aspiration, or a combination of both, with or without delivery of a thrombolytic agent. The method of EVT was left to the discretion of the treating physicians. Preferred anesthetic approaches were center specific and could depend on individual patient characteristics.

Outcome Assessment

The primary outcome was favorable functional outcome scored on the modified Rankin Scale (mRS), which is a 7-point scale ranging from 0 (no symptoms) to 6 (death).[14] mRS score was assessed at 90 days (range of 14 days) in all intervention centers as part of usual care. Considering the high risk of disability and mortality in patients with a posterior LVO, we defined favorable functional outcome as mRS score 0 to 3.[11] Patients with mRS 3 are moderately disabled, they require some help but are able to walk without assistance. Secondary outcomes

included functional independence (indicated by mRS score 0–2), the National Institutes of Health Stroke Scale (NIHSS) score at 24 to 48 hours,[15] and reperfusion status at the end of procedure. Safety outcomes were death within 90 days, symptomatic intracranial hemorrhage, and stroke progression. The adverse events committee consisted of 2 vascular neurologists and 1 neuroradiologist who evaluated the safety variables based on discharge letters and follow-up imaging. Intracranial hemorrhage was considered symptomatic if the patient had died or had deteriorated neurologically (a decline of at least 4 points on the NIHSS), and the hemorrhage (according to the Heidelberg criteria) was related to the clinical deterioration.[16]

Imaging Assessment

An independent, experienced imaging core laboratory assessed all imaging according to predefined guidelines. The core laboratory consisted of 8 members (2 neuroradiologists, 6 interventional (neuro)radiologists), who were blinded for all clinical findings. In separate sessions, the observers evaluated the findings on baseline noncontrast computed tomography, baseline computed tomography angiography, and digital subtraction angiography. Baseline noncontrast computed tomography assessment included posterior circulation-Acute Stroke Prognosis Early Computed Tomography Score.[17] The posterior circulation-Acute Stroke Prognosis Early Computed Tomography Score is graded from 0 to 10, with 1 point subtracted from 10 for any evidence of early ischemic changes in each defined region of the posterior circulation. Baseline computed tomography angiography assessment included determination of the occluded arterial segment and posterior circulation collateral score.[18,19] The posterior circulation collateral score is a 10-point grading system, in which 1 point is scored for each patent collateral; posterior inferior cerebellar artery, anterior inferior cerebellar artery, superior cerebellar artery, and posterior communicating artery. When the diameter of the posterior communicating artery is equal or larger than the ipsilateral P1 segment, 2 points are allocated instead of 1 point. A fetal variant of the posterior cerebral artery was not included in the score. Reperfusion status was evaluated on digital subtraction angiography according to the extended Thrombolysis in Cerebral Ischemia (eTICI) score.[20] eTICI ranges from grade 0 (no reperfusion) to grade 3 (complete reperfusion). Successful reperfusion was defined as eTICI 2B-3.

Time Metrics

All-time variables were assessed by standardized approach, consistent with definitions used in previous studies concerning basilar artery strokes.[5,11] Time of first symptom onset was reported if onset was witnessed, or time last known well if onset was not witnessed. In patients with transient or mild neurological symptoms with secondary worsening consistent with the LVO, the time point of secondary worsening was considered as the estimated time of LVO (eLVO).

Patients Treated in Trial Center Versus Nontrial Center

Patients who underwent EVT outside the BASICS trial at an intervention center that was actively recruiting for the BASICS trial at the time were considered derived from a trial-center. Patients who underwent EVT at an intervention center that was not (yet) initiated as a trial site were considered derived from a nontrial center (Figure 1). For instance, one center started recruitment for the trial in November 2016. Consequently, patients included before November 2016 were considered to be derived from a nontrial center, and patients included after November 2016 were considered to be derived from a trial center.

Statistical Analysis

Baseline characteristics and outcomes were described using standard statistics and presented as median (interquartile range [IQR]) or numbers and percentages (%), unless indicated otherwise. Missing values were indicated for each variable.

For the outcome comparison between patients who underwent EVT in trial-centers versus nontrial centers, we used multivariable ordinal logistic regression analysis to estimate the common odds ratio for a 1-step shift toward a better functional outcome on the mRS. In multivariable analysis, we adjusted for potential imbalances adapted from clinical prognostic factors described in previous literature: age, sex, NIHSS at baseline, diabetes, systolic blood pressure at baseline, Glasgow coma scale, intravenous thrombolysis, time from eLVO to groin puncture, and posterior circulation collateral score. Adjusted (a) ORs and betas (β) were reported with 95% CIs.

Missing Data

Any mRS score of 0 to 5 assessed within 30 days was considered missing. These values were replaced by mRS scores derived from multiple imputation for association analyses. Descriptive analyses report observed data only, while regression models include all patients with multiple imputed data. STATA version 14.1 (StataCorp, TX) was used for all statistical analyses.

RESULTS

Patient Characteristics

Out of 5773 patients in the MR CLEAN Registry, 264 patients (4.6%) were treated with EVT for posterior LVO stroke. Of these, 154 patients were treated outside the BASICS trial in 10 trial participating centers, and 110 patients underwent EVT in 8 nontrial centers (Figure 1).

Median age at presentation was 65 years (IQR, 54–74), median NIHSS was 16 (IQR, 8–31), intravenous thrombolysis was administered in 135/264 (51%) patients, and symptoms were maximum from onset in 130/254 (51%) (Table 1). The basilar artery was most commonly involved (77%), followed by posterior cerebral artery alone (13%), and intracranial vertebral artery alone (5%). Median duration from time of eLVO to groin puncture was 240 minutes (IQR, 175–365) and 64/246 (26%) patients presented beyond 6 hours from eLVO. The duration of procedure was on average 60 minutes (IQR, 37–90), general anesthesia was used in 141/259 (54%) patients, and most often a stent retriever was used in the first thrombectomy attempt 134/219 (61%).

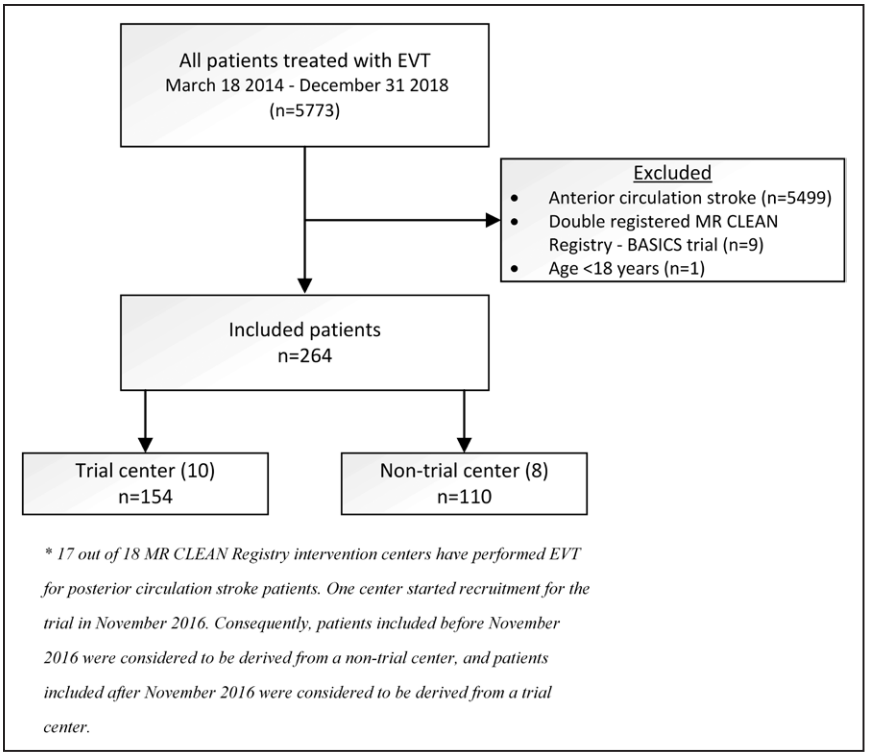

Figure 1. Flowchart patient selection. *Seventeen out of 18 MR CLEAN (Multicenter Randomized Clinical Trial of Endovascular Treatment for Acute Ischemic Stroke in the Netherlands) Registry intervention centers have performed endovascular treatment (EVT) for patients with posterior circulation stroke. One center started recruitment for the trial in November 2016. Consequently, patients included before November 2016 were considered to be derived from a nontrial center, and patients included after November 2016 were considered to be derived from a trial center. BASICS indicates Basilar Artery International Cooperation Study.

Patients Treated in Trial Center Versus Nontrial Center

Patients treated with EVT in trial centers had on average a higher systolic blood pressure at presentation (mean 153 versus 146 mm Hg) and less often received intravenous thrombolytics (46% versus 58%) than patients treated in nontrial centers. Interventionists more often used stent retriever (68% versus 51%) and less often aspiration (27% versus 41%) as a first-pass device in a trial center compared with a nontrial center. Other baseline characteristics were not different between groups (Table 1).

We report the baseline and procedural characteristics of PCS patients dichotomized by mRS at 90 days (mRS score 0–3 [favorable functional outcome] versus mRS score 4–6 [poor outcome]) in Table 2. In our cohort, characteristics associated with poor outcome were: higher age, hypertension, diabetes, higher systolic blood pressure on admission, higher NIHSS at baseline, lower Glasgow Coma Scale score, level of occlusion (BA extending in posterior cerebral artery), longer duration of procedure, and use of general anesthesia.

Outcomes

The distribution of 90-day mRS scores is provided in Figure 2. In total, 115/252 (46%) patients achieved favorable functional outcome (mRS score 0–3), 87/252 (35%) patients achieved functional independence (mRS score 0–2), and 109/252 (43%) patients died within 90 days. Median NIHSS score at 24 hours was 8 (IQR, 3–21), successful reperfusion (eTICI 2B-3) was achieved in 178/238 (75%) patients, symptomatic intracranial hemorrhage occurred in 9/264 (3%) patients, and stroke progression occurred in 46/264 (17%) patients (Table 3).

Patients Treated in Trial Center Versus Nontrial Center

Univariable analysis shows no significant shift on the mRS scale between patients treated in trial centers versus nontrial centers (Figure 2). We noticed a lower incidence of functional independence (mRS score 0–2) in patients from trial centers (31% versus 41%, P=0.10; Table 3). Favorable functional outcome (mRS score 0–3) did not differ between groups (44% versus 48%, P=0.62) nor did reperfusion status or any of the safety outcomes.

After adjustment for prognostic factors, we found no difference in primary outcome, secondary outcome nor in all safety outcomes between patients treated with EVT in trial centers versus nontrial centers (Table 3). Results from additional multilevel analysis are not shown as they did not change the outcomes of our regression analyses.

DISCUSSION

This nationwide multicenter registry evaluates outcomes of patients with PCS treated with EVT in clinical practice. Analysis shows that 75% of patients achieved successful reperfusion, and 46% achieved favorable functional outcome at 90 days. These proportions are comparable with most registries on EVT for posterior LVO strokes

Table 1. Baseline Characteristics of Patients With Posterior Circulation Stroke and *P* Value for Difference Between Nonrandomized EVT in Trial Center Versus Nontrial Center

	Total	Trial center	Nontrial center	
	n=264	n=154	n= 110	*P* value
Age, y, median (IQR)	65 (54–74)	68 (53–75)	63 (54–72)	0.07
Male sex, n (%)	152 (58%)	85 (55%)	67 (61%)	0.35
Medical history				
Atrial fibrillation, n (%)	37/259 (14%)	23/151 (15%)	14/108 (13%)	0.61
Hypertension, n (%)	132/258 (51%)	82/151 (54%)	50/107 (47%)	0.23
Myocardial infarction, n (%)	33/259 (13%)	19/149 (13%)	14/110 (13%)	1.0
Hypercholesterolemia, n (%)	56/253 (22%)	35/149 (23%)	21/104 (20%)	0.53
Diabetes, n (%)	44/262 (17%)	26/152 (17%)	18/110 (16%)	0.87
Previous ischemic stroke, n (%)	48/261 (18%)	29/152 (19%)	19/109 (17%)	0.74
Prestroke modified Rankin Scale score, n (%)*				0.11
0–3	231 (91%)	134 (88%)	97 (94%)	
≥3	24 (9%)	18 (12%)	6 (6%)	
Intoxication and medication				
Current smoking, n (%)	54/187 (29%)	32/121 (26%)	22/66 (33%)	0.32
Statin use, n (%)	72/252 (29%)	42/148 (28%)	30/104 (29%)	0.94
Antiplatelet use, n (%)	72/257 (28%)	45/150 (30%)	27/107 (25%)	0.40
Anticoagulation use, n (%)	29/253 (11%)	20/148 (14%)	9/105 (9%)	0.22
Antihypertensive medication use, n (%)	130/251 (52%)	81/147 (55%)	49/104 (47%)	0.21
Clinical				
Mean (SD) systolic blood pressure, mm Hg†	150 (28)	153 (30)	146 (25)	0.04
Intravenous alteplase treatment, n (%)	135 (51%)	71 (46%)	64 (58%)	0.05
NIHSS, median (IQR)‡	16 (8–31)	17 (8–31)	15 (8–31)	0.37
Glasgow Coma Scale score (median)	10 (5–14)	10 (4–14)	11 (5-14)	0.36
Course of symptoms, n (%)§				0.73
Maximum from onset	130 (51%)	77 (52%)	53 (50%)	
Progressive deficit	88 (35%)	53 (36%)	35 (33%)	
Fluctuating deficit	36 (14%)	19 (13%)	17 (16%)	
Imaging				
Pc-ASPECTS on NCCT, median (IQR)‖	10 (9–10)	10 (9–10)	10 (9–10)	0.24
Level of occlusion on CTA, n (%)¶				0.16
Nonocclusive thrombosis	11 (4%)	4 (3%)	7 (7%)	
Intracranial VA	14 (5%)	9 (6%)	5 (5%)	
BA	101 (39%)	64 (42%)	37 (35%)	
BA extending into PCA	98 (38%)	52 (34%)	46 (44%)	
PCA	34 (13%)	24 (16%)	10 (10%)	
PC-collateral score, median (IQR)#	7 (5–8)	7 (5–8)	7 (5–8)	0.22
Procedure				
Duration eLVO to groin, min, median (IQR)**	240 (175–365)	255 (175–382)	225 (173–323)	0.16
Duration door to groin, min, median (intervention center) (IQR)††	84 (53–125)	82 (57–138)	85 (45–110)	0.96
Duration of procedure, min, median (IQR)‡‡	60 (37–90)	58 (38–87.5)	60 (35–92)	0.90
Use of general anesthesia, n (%)§§	141 (54%)	79 (52%)	62 (58%)	0.34
Performed procedure				
Catheterization only, n (%)	12 (5%)	8 (5%)	4 (4%)	0.19
DSA only, n (%)	28 (11%)	12 (8%)	16 (15%)	
EVT, n (%)	224 (85%)	134 (87%)	90 (82%)	

(*Continued*)

Table 1. Continued

	Total	Trial center	Nontrial center	
	n=264	n=154	n= 110	*P* value
Device used for first attempt				
Stent retriever, n (%)	134/219 (61%)	90/132 (68%)	44/87 (51%)	0.01
Aspiration device, n (%)	71/219 (32%)	35/132 (27%)	36/87 (41%)	0.02
Stent placement at occlusion location, n (%)‖‖	28 (11%)	14 (10%)	14 (14%)	0.32

Level of occlusion: VA means no further distal occlusion; BA means no PCA occlusion, but may include VA occlusion; BA extended into PCA may also include VA occlusion; PCA means no occlusion of BA. BA indicates basilar artery; CTA, computed tomographic angiography; DSA, digital subtraction angiography; eLVO, estimated time of large vessel occlusion; EVT, endovascular thrombectomy; IQR, interquartile range; NCCT, noncontrast computed tomography; NIHSS, National Institutes of Health Stroke Scale; NS, not significant; PCA, posterior cerebral artery; and PC-ASPECTS, posterior circulation Alberta Stroke Program Early CT Score.

*n=255, missing in 9 patients; †n=253, missing in 11 patients; ‡n=261, missing in 3 patients; §n=254, missing in 10 patients; ‖n=261, missing in 3 patients; ¶n=258, missing in 6 patients; #n=257, missing in 7 patients; **n=246, missing in 18 patients; ††n=251, missing in 13 patients; ‡‡n=248, missing in 16 patients; §§n=259, missing in 5 patients; |||n=245, missing in 9 patients.

and studies on EVT for basilar artery strokes.[21–24] The occurrence of symptomatic intracranial hemorrhage in our cohort is similar to other PCS/BAO cohorts, which is known to be lower than the reported average of 6% for the anterior circulation.[13,21–24] Regarding mortality within 90 days after EVT, we report a relatively high proportion (43%) compared with other PCS registries (28%–34%) but similar to several BAO registries (44%–47%).[12,25,26] We think that the high mortality might be caused by the relatively high proportion of BAOs (77%) versus vertebral or posterior cerebral artery occlusions in our cohort. Furthermore, we found similar risk factors for worse outcome as in the anterior circulation stroke population treated with EVT.

In the MR CLEAN Registry, 264 out of 5773 patients (4.6%) had a posterior LVO. Because our registry does not include patients who were randomized in the BASICS trial that ran simultaneously, this ratio posterior/anterior EVT is fairly low. Nevertheless, even with addition of the 137 patients included in the BASICS trial in the Netherlands during our study period, the ratio of 401/5773 (7%) is lower than in other recent registries (Weber et al,[24] 12%; Huo et al,[22] 17%). Any speculation on treatment selection remains uncertain due to lack of information on patients with posterior LVO who did not receive EVT. Moreover, compared with other registries on patients with PCS treated with EVT, we report similar age, baseline NIHSS, frequencies of baseline risk factors, general anesthesia, and duration of procedure.[21–24] We note a higher frequency of treatment with intravenous thrombolytics (51%) than previously reported (17%–34%).[21,23,25] Time from eLVO to artery puncture was relatively short: median 240 minutes versus 225 to 562 in other studies.[22–25] We note that the time of eLVO was used as a proxy of time of stroke onset, while this timing method was not described in the other PCS registries, except for studies on BAO.[5,11,25,27]

Patients treated in trial centers had similar baseline characteristics as patients in nontrial centers, except for systolic blood pressure, which could also explain the (nonsignificant) imbalance in intravenous thrombolysis administration. Trial-participating centers more often used a stent retriever and less often aspiration as first-line therapy compared with nontrial centers. We note that the BASICS trial did not mandate certain thrombectomy techniques. The difference in first-line therapy might be due to possible imbalance in patient sample size between centers that prefer stent retriever or aspiration.

We found no significant differences in outcomes between patients treated with EVT in trial centers versus nontrial centers. More importantly, patients from trial centers who were treated outside of BASICS did not have more favorable characteristics or better outcomes, contrary to what might have been suspected. This suggests that there is no consensus on what factors are associated with favorable treatment effect. We think that this underlines the representativeness of our cohort and value of our results for assessment of EVT performed in clinical practice.

Compared with the intervention group of the BASICS trial, we report similar favorable functional outcome (46% versus 43%), but higher mortality (43% versus 38%). We note that for this study, we did not aim to report on potential selection bias in the trial. However, since the outcomes of our clinical cohort are similar to slightly worse than the BASICS trial (including outcomes of our vertebral/posterior cerebral artery infarcts), we might expect little influence of any possible selection on the results of BASICS. To test this hypothesis, both databases will be pooled for further analysis.

Different from anterior circulation stroke, we found no association between shorter duration of eLVO to groin and better functional outcome. Difference in underlying etiology or course of symptoms might play a role in the duration times and will be further analyzed in future subgroup studies.

Occlusions of the basilar artery extending in the posterior cerebral artery were associated with poor

Table 2. Baseline- and Procedural Characteristics in Patients With Posterior Circulation Stroke Dichotomized by mRS Score at 90 Days

	mRS score 0–3	mRS score 4–6	
	n=115	n=137	*P* value
Age, y, median (IQR)	62 (50–71)	69 (57–77)	0.02
Male sex, n (%)	62 (54%)	84 (61%)	0.24
Medical history			
Atrial fibrillation, n (%)	18/114 (16%)	17/133 (13%)	0.50
Hypertension, n (%)	49/114 (43%)	76/132 (58%)	0.02
Myocardial infarction, n (%)	15/113 (13%)	17/134 (13%)	0.90
Hypercholesterolemia, n (%)	25/111 (23%)	28/120 (22%)	0.85
Diabetes, n (%)	12/115 (10%)	30/135 (22%)	0.01
Previous ischemic stroke, n (%)	16/115 (14%)	30/134 (22%)	0.09
Prestroke modified Rankin Scale score, n (%)*			0.21
0–3	103 (93%)	117 (88%)	
≥3	8 (7%)	16 (12%)	
Intoxication and medication			
Current smoking, n (%)	31/93 (33%)	19/85 (22%)	0.10
Statin use, n (%)	30/112 (27%)	38/128 (30%)	0.62
Antiplatelet use, n (%)	29/112 (26%)	41/133 (31%)	0.40
Anticoagulation use, n (%)	14/111 (13%)	12/130 (9%)	0.40
Antihypertensive medication use, n (%)	52/112 (46%)	71/127 (56%)	0.14
Clinical			
Mean (SD) systolic blood pressure, mm Hg†	144 (25)	155 (31)	0.003
Intravenous alteplase treatment, n (%)	55 (48%)	73 (53%)	0.39
NIHSS, median (IQR)‡	13 (7–21)	21 (10–35)	0.003
Glasgow Coma Scale score (median)	11 (7–15)	7 (4–12)	0.01
Course of symptoms, n (%)§			0.85
Maximum from onset	59 (52%)	64 (50%)	
Progressive deficit	40 (35%)	46 (36%)	
Fluctuating deficit	14 (12%)	19 (15%)	
Imaging			
Pc-ASPECTS on NCCT, median (IQR)‖	10 (9–10)	10 (9–10)	0.10
Level of occlusion on CTA, n (%)¶			0.008
Nonocclusive thrombosis	8 (7%)	2 (1%)	
Intracranial vertebral artery (VA)	5 (4%)	8 (6%)	
BA	52 (46%)	45 (34%)	
BA extending into PCA	31 (28%)	63 (47%)	
Posterior cerebral artery	16 (14%)	16 (12%)	
PC-collateral score, median (IQR)#	7 (6–8)	6 (5–8)	0.07
Procedure			
Duration eLVO to groin, min, median (IQR)**	245 (174–420)	235 (175–335)	0.85
Duration door to groin, min, median (intervention center) (IQR)††	80 (52.5–132)	85.5 (57–121)	0.70
Duration of procedure, min, median (IQR)‡‡	45 (35–73)	70 (42.5–95)	<0.001
Reperfusion on DSA, n (%)§§	90 (84%)	81 (67%)	0.003
Use of general anesthesia, n (%)‖‖	56 (49%)	82 (62%)	0.048
Device used for first attempt			
Stent retriever, n (%)	57/97 (59%)	74/115 (64%)	0.40
Aspiration device, n (%)	34/97 (35%)	33/115 (29%)	0.32
Stent placement at occlusion location, n (%)¶¶	11 (10%)	16 (13%)	0.52

Level of occlusion: VA means no further distal occlusion; BA means no PCA occlusion, but may include VA occlusion; BA extended into PCA may also include VA occlusion; PCA means no occlusion of BA. BA indicates basilar artery; CTA, computed tomographic angiography; eLVO, estimated time of large vessel occlusion; IQR, interquartile range; NCCT, noncontrast computed tomography; NIHSS, National Institutes of Health Stroke Scale; NS, not significant; and PCA, PC-ASPECTS, posterior circulation Alberta Stroke Program Early CT Score.

*n=255, missing in 9 patients; †n=253, missing in 11 patients; ‡n=261, missing in 3 patients; §n=154, missing in 10 patients; ‖n=261, missing in 3 patients; ¶n=258, missing in 6 patients; #n=257, missing in 7 patients; **n=246, missing in 18 patients; ††n=251, missing in 13 patients; ‡‡n=248, missing in 16 patients; §§n=236, missing in 28 patients; ‖‖n=259, missing in 5 patients; ¶¶n=245, missing in 9 patients.

(*Continued*)

functional outcome. Stroke severity often differs between vertebral, posterior cerebral, and basilar artery strokes and therefore might impede comparison of outcomes between studies on overall posterior LVO stroke with BAO stroke alone. However, because the proportion of both vertebral and posterior cerebral artery occlusions was similar between good and poor outcome in our cohort, we think stratification by occlusion location was not necessary for our primary outcome analysis. Future randomized trials should nevertheless consider stratifying for vertebral or posterior cerebral artery occlusion, as prognosis often differs from BAO.

The strength of our study is the use of a large database with consecutive PCS patients that were selected in clinical practice for EVT without the use of prespecified selection criteria. As such, it reflects on clinical judgement and subsequent treatment outcomes in clinical practice. Also, all outcome measures have been collected prospectively according to protocol. Finally, our study covers the period between 2014 and 2018 in which we may expect limited use of outdated thrombectomy approaches.

Our study had several limitations. First of all, because of the lack of information on the nontreated PCS patients, we were unable to determine any possible variables that were used for treatment selection in clinical practice. Second, consistent with other EVT studies, we used eTICI score to determine the reperfusion status. However, the interobserver agreement for eTICI as a recanalization scale for the posterior circulation seems lower compared with the anterior circulation.[28]

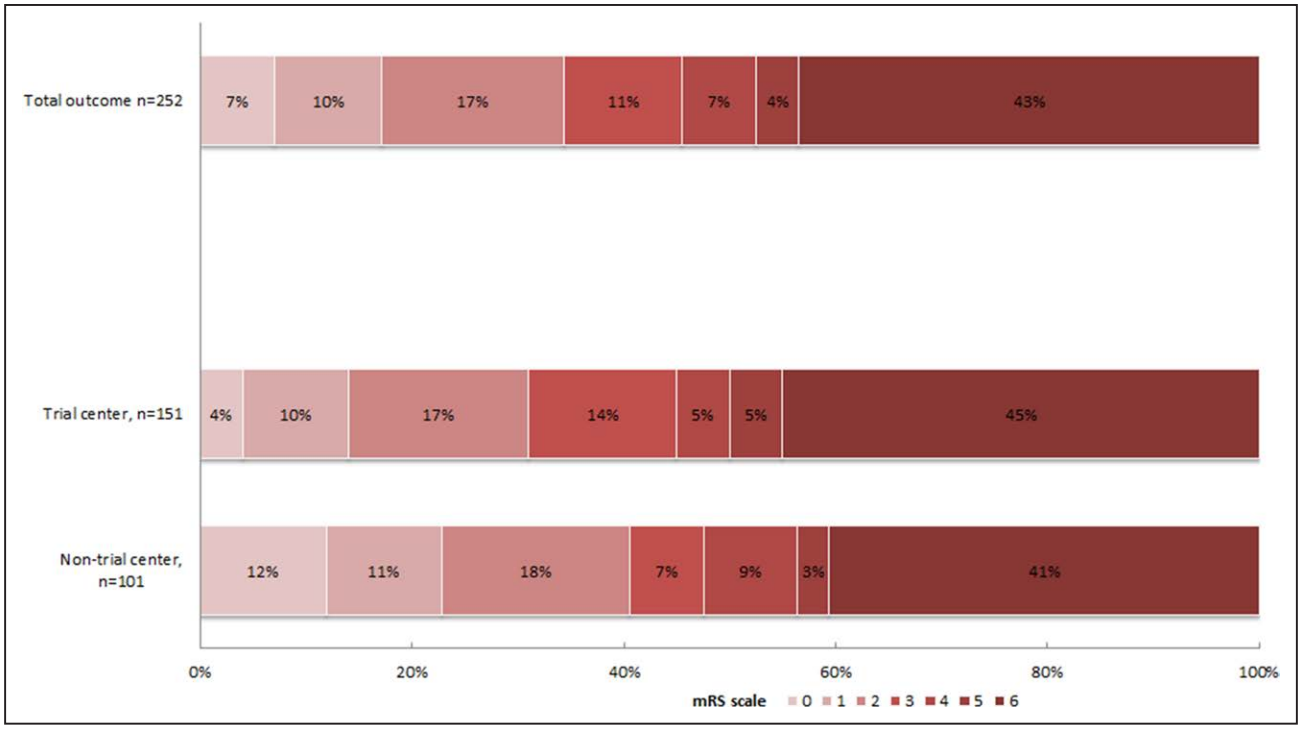

Figure 2. Modified Rankin Scale (mRS) distribution at 90 d.

CONCLUSIONS

In summary, our study shows that high rates of successful reperfusion and favorable clinical outcome can be achieved with EVT for posterior LVO stroke, despite high mortality. Because overall outcomes of our patient cohort were similar to the BASICS trial, we expect little influence of any potential selection on the final reported result. Characteristics and outcomes of patients treated in trial centers versus nontrial centers were similar, indicating that our cohort is representative of clinical practice, although a moderate effect of the simultaneously running trial cannot be excluded. Randomized studies using modern treatment approaches are needed for further insight in the benefit of EVT for PCS.

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Table 3. Outcome of Patients With PCS Stroke Treated With EVT in Trial Center Versus Nontrial Center

Outcome	Total n=264	Trial center n=154	Nontrial center n=110	Unadjusted OR (95% CI)	Adjusted (c)OR (95% CI)
Primary outcome					
mRS score of 0–3 at 90 d, n (%)	115 (46%)	67 (44%)	48 (48%)	0.85 (0.5–1.4)	1.05 (0.6–1.9)
Secondary outcomes					
mRS at 90 d, median*	4 (2 to 6)	5 (2 to 6)	4 (2 to 6)	0.69 (0.4 to 1.1)	0.77 (0.5 to 1.2)
mRS score of 0–2 at 90 d, n (%)	87 (35%)	46 (30%)	41 (41%)	0.64 (0.4 to 1.1)	0.74 (0.4 to 1.3)
NIHSS 24 h, median†	8 (3 to 21)	8 (2 to 28)	6 (3 to 15)	β 3.05 (−0.5 to 6.6)	β 1.51 (−1.7 to 4.7)
Successful reperfusion on DSA, n (%)‡	178 (75%)	103 (74%)	75 (76%)	0.91 (0.5 to 1.6)	0.85 (0.5 to 1.6)
Safety outcomes					
Mortality at 90 d, n (%)	109 (43%)	68 (45%)	41 (41%)	1.20 (0.7 to 2.0)	0.89 (0.5 to 1.6)
sICH	9 (3%)	7 (5%)	2 (2%)	2.57 (0.5 to 12.6)	2.47 (0.5 to 13.1)
Progression of stroke	46 (17%)	30 (19%)	16 (15%)	1.42 (0.7 to 2.8)	1.31 (0.6 to 2.6)

β, regression coefficient, estimated with linear regression analyses. Adjusted (c)OR indicates adjusted (common) odds ratio; DSA, digital subtraction angiography; EVT, endovascular treatment; mRS, modified Rankin Scale; NIHSS, National Institutes of Health Stroke Scale; PCS, posterior circulation stroke; and sICH, symptomatic intracranial hemorrhage.

*n=252, missing in 12 patients; †n=236, missing in 28 patients, ‡n=238, missing in 26 patients.

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Supplemental Materials

STROBE checklist

APPENDIX

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