Stroke: Vascular and Interventional Neurology

ORIGINAL RESEARCH

First-Line Stent Retriever Versus Contact Aspiration or Combined Technique for Endovascular Therapy of Posterior Cerebral Artery Occlusion Stroke: The PLATO Study

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BACKGROUND: The optimal reperfusion technique in patients with isolated posterior cerebral artery (PCA) occlusion is uncertain. We compared clinical and technical outcomes with first-line stent retriever (SR), contact aspiration (CA), or combined techniques in patients with isolated PCA occlusion.

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METHODS: This international case–control study was conducted at 30 sites in Europe and North America and included consecutive patients with isolated PCA occlusion presenting within 24 hours of time last seen well from January 2015 to August 2022. The primary outcome was the first-pass effect (FPE), defined as expanded Treatment in Cerebral Infarction (TICI) 2c/3 on the first pass. Patients treated with SR, CA, or combined technique were compared with multivariable logistic regression.

RESULTS: There were 326 patients who met inclusion criteria, 56.1% male, median age 75 (interquartile range 65–82) years, and median National Institutes of Health Stroke Scale score 8 (5–12). Occlusion segments were PCA-P1 (53.1%), P2 (40.5%), and other (6.4%). Intravenous thrombolysis was administered in 39.6%. First-line technique was SR, CA, and combined technique in 43 (13.2%), 106 (32.5%), and 177 (54.3%) patients, respectively; FPE was achieved in 62.8%, 42.5%, and 39.6%, respectively. FPE was lower in patients treated with first-line CA or combined technique compared with SR (CA versus SR: adjusted odds ratio 0.45 [0.19–1.06]; *P*=0.07; combined versus SR: adjusted odds ratio 0.35 [0.016–0.80]; *P*=0.01). There were lower odds of functional independence (modified Rankin scale score 0–2) in the first-line CA versus SR alone group (adjusted odds ratio 0.52 [0.28–0.95]; *P*=0.04). FPE was associated with higher rates of favorable outcomes (modified Rankin scale score 0–2: 58% versus 43.4%; *P*=0.01; modified Rankin scale score 0–1: 36.6% versus 25.8%; *P*=0.05). Overall, symptomatic intracranial hemorrhage was present in 5.6% (18/326) and mortality in 10.9% (35/326) without difference between first-line technique.

CONCLUSION: In patients with isolated PCA occlusion, SR was associated with a higher rate of FPE compared with CA or combined techniques with no difference in final successful reperfusion. Functional independence at 90 days was more likely with first-line SR compared with CA. FPE was associated with better 90-day clinical outcomes.

Key Words: cerebrovascular disease/stroke ■ contact aspiration ■ ischemic stroke ■ mechanical thrombectomy ■ posterior circulation ■ medium vessel occlusion ■ stent retriever

Despite recent studies demonstrating benefit of endovascular therapy (EVT) in posterior circulation stroke,[1–8] large core infarct,[9–13] and late presentation,[14–16] the safety and efficacy of EVT for patients with isolated posterior cerebral artery occlusion (PCA) is uncertain. A study-level meta-analysis of patients with isolated PCA occlusion demonstrated no differences between EVT and medical management in the outcomes, symptomatic intracranial hemorrhage (sICH), and mortality rates in patients with PCA occlusion.[17] A patient-level analysis of 1023 patients did not show benefit with EVT in reducing overall disability by modified Rankin scale (mRS) distribution, whereas a higher proportion of patients achieved excellent 90-day outcomes (mRS score 0–1) yet with higher rates of sICH.[18] A favorable outcome with EVT can vary between 25% and 78% in patients with isolated PCA occlusion.[17,19–22] Understanding strategies to improve the clinical outcome in patients with isolated PCA occlusion who are treated with EVT is important.

The first-pass effect (FPE), defined as complete reperfusion (expanded Treatment in Cerebral Infarction [eTICI] score 2c/3) after a single thrombectomy pass, has been shown to correlate with good clinical outcomes in multiple studies of patients with large vessel occlusion.[23–25] The benefit seen in FPE likely reflects earlier reperfusion of at-risk tissue and characteristics of the occluded vessel and thrombus.[26] The degree to which FPE or final successful reperfusion confers good outcomes in patients with isolated PCA occlusion is not well characterized but is likely to persist given the benefit of FPE in large and medium vessel occlusion. Moreover, the optimal first-line technique for patients with isolated PCA occlusion remains uncertain.

In this PLATO (Posterior Cerebral Artery Occlusion) study analysis, we aimed to compare the clinical and technical outcomes of patients with PCA occlusion treated with 3 distinct first-line techniques: stent retriever (SR) only, contact aspiration (CA) only, or combined technique (CA+SR). We hypothesized that greater benefit in 3-month clinical outcomes would be seen in patients who achieved FPE. Considering data from the ASTER (Contact Aspiration Versus Stent Retriever for Recanalisation of Acute Stroke Patients With Basilar Artery Occlusion),[27] ASTER2 (Combined Use of Contact Aspiration and the Stent Retriever Technique Versus Stent Retriever Alone for Recanalisation in Acute Cerebral Infarction),[28] and COMPASS[29] randomized trials, we hypothesized that there would be no difference in the clinical and technical outcomes of patients treated with first-line SR compared with CA or combined technique.

METHODS

Ethics

Ethics committee approval was obtained from all sites. Patient written informed consent was waived due to this study's retrospective and anonymized design. The study was investigator initiated. Data were held in

Nonstandard Abbreviations and Acronyms

CA	contact aspiration
eTICI	expanded Treatment in Cerebral Infarction
EVT	endovascular therapy
FPE	first-pass effect
mRS	modified Rankin scale
NIHSS	National Institutes of Health Stroke Scale
PCA	posterior cerebral artery
sICH	symptomatic intracranial hemorrhage
SR	stent retriever

the Helsinki University research platform, a secure password-protected computing platform, with access by the lead authors (T.N.N., D.S., and S.N.) and lead statistician (M.M.Q.). Heidelberg University Hospital and Boston Medical Center served as the coordinating sites. This study was reported according to the Strengthening the Reporting of Observational Studies in Epidemiology guideline. Anonymized data are available upon reasonable request.

Study Population

The PLATO study (NCT05291637) was an international, multicenter, retrospective cohort study of consecutive patients aged 18 years or older with isolated PCA occlusion treated between January 1, 2015 and August 1, 2022. Since the primary report,[18] the PLATO study expanded with an additional 3 sites, culminating in 30 sites across 8 countries in this analysis. The decision to proceed to EVT and related first-line technique was determined according to local standards and technical feasibility.

Inclusion criteria for this analysis were (1) diagnosis with acute ischemic stroke attributable to an isolated PCA occlusion of the P1, P2, P3, or P4, fetal, or bilateral PCA segment; (2) patient presentation within 24 hours of symptom onset; (3) EVT performed with or without intravenous thrombolysis; and (4) prestroke mRS score 0–3. Patients were excluded if there was concomitant basilar artery occlusion or multiple vessel occlusion other than in the PCA territory.

Data Collection

Baseline demographic, clinical presentation, imaging parameters, clinical, and safety outcomes were collected. The 90-day mRS was prospectively collected by site investigators or coordinators. Imaging evaluation was based on local protocols. The site of the arterial occlusion was diagnosed by computed tomography angiography or magnetic resonance angiography. The posterior circulation Acute Stroke Prognosis Early CT Score (pc-ASPECTS) was site adjudicated based on the last image prior to decision-making with EVT. Perfusion mismatch was locally assessed by automated software or visual estimation.

In patients with visual field deficit on stroke presentation, follow-up visual outcome was by physical exam confrontation test in the clinic or standard perimetry, obtained 1 to 3 months after stroke onset. Complete visual recovery was defined as normalization of the visual field; partial recovery was defined as improvement from complete to partial homonymous hemianopia, same as unchanged visual field, and worse if a new visual field defect was not previously documented.

CLINICAL PERSPECTIVE

What Is New?

- The optimal reperfusion technique in patients with isolated posterior cerebral artery occlusion is uncertain.
- In this international case–control study of 326 patients with isolated posterior cerebral artery occlusion, stent retriever first-line was associated with a higher rate of first-pass effect (expanded Treatment in Cerebral Infarction 2c–3) compared with contact aspiration or combined techniques with no difference in final successful reperfusion.
- First-pass effect was associated with better 90-day clinical outcomes. Functional independence at 90 days was more likely with first-line stent retriever compared with contact aspiration.

What Are the Clinical Implications?

- Given the correlation between first-pass effect with excellent outcome and functional independence in this cohort, finding the best technique to achieve first-pass reperfusion is essential.
- Stent retriever alone may be the preferred first-line modality rather than combined technique or contact aspiration in patients with isolated posterior cerebral artery occlusion.
- Considering the low sample size of posterior cerebral artery technique data reported to date, we interpret our findings with caution.

Definition of Variables

Demographic, clinical, imaging, and outcome data were collected on a digital spreadsheet with a data dictionary, including standardized definitions for the PCA segments, pc-ASPECTS,[30] and Trial of Org 10172 in Acute Stroke Treatment classification. Large artery atherosclerosis refers to imaging findings of either >50% stenosis of the vertebral arteries (including extracranial segments), basilar artery, or PCA occlusion presumably due to atherosclerosis. The P1 PCA segment was the first branching point distal to the basilar artery to the branching point of the posterior communicating artery. The P2 segment was defined from the PCA branch point of the posterior communicating artery, curving around the midbrain to the quadrigeminal cistern, and P3 as from the quadrigeminal cistern to the calcarine fissure.[21] Fetal PCA was defined as the posterior communicating segment supplied by the internal carotid artery with an absent or hypoplastic ipsilateral P1 segment. Time to treatment was defined as the time from last known well to puncture time. The lead authors verified data from each site with subsequent queries (T.N.N. and S.N.).

Outcome Variables

The primary end point was FPE defined as eTICI score of 2c or 3 achieved with the first thrombectomy pass. The secondary endpoints were 90-day excellent outcome defined as mRS score 0–1, functional independence defined as mRS score 0–2, and modified FPE defined as eTICI score of 2b–3 on the first thrombectomy pass.

Other secondary outcomes were early neurological improvement (National Institutes of Health Stroke Scale [NIHSS] score improvement by 2 or more points within 24 hours), visual field recovery (none, partial, complete, worse) by 90 days, intracranial hemorrhage, sICH, and 90-day mortality. Successful reperfusion at the end of the procedure was defined as eTICI 2b or higher, equivalent to >50% estimated reperfusion of the occluded PCA. A sICH was defined as local or remote parenchymal hemorrhage type 2, subarachnoid hemorrhage, and/or intraventricular hemorrhage, combined with a neurological deterioration of 4 points or more on the NIHSS from baseline or leading to death that the physician judged was causative of the deterioration.

Statistical Analysis

Descriptive statistics were calculated for baseline demographic data, clinical characteristics, imaging findings, complications, and outcomes. We compared patients who underwent EVT with an isolated PCA occlusion treated first-line with a SR, CA, or combined technique. Results are presented as median with interquartile range (IQR) for continuous variables. Nonparametric Kruskal–Wallis test was used to assess for differences in continuous variables by treatment. For categorical variables, a chi-square test (or Fisher's exact test when appropriate) was used to examine differences in the distribution by treatment.

A mixed-effects logistic regression model accounting for clustering by sites was used for the binary endpoints. The model was fitted using PROC GENMOD in SAS 9.4 (SAS Institute, Cary, NC), with logit link function and binomial distribution specifications. An autoregressive correlation structure with the smallest quasi-likelihood independence criterion value was assumed for the within-site clustering of patients. Crude and adjusted odds ratios (aORs) with 95% CIs were obtained for each outcome of interest. The following covariates were included a priori in the multivariable model for FPE: age, sex, baseline NIHSS, year of treatment, prestroke mRS, hypertension, atrial fibrillation, treatment with intravenous thrombolysis, TOAST etiology, pc-ASPECTS score, occlusion location, and anesthesia modality. These variables were selected based on their potential role in modifying FPE from prior studies.[23-25,31] Because the covariate of time to treatment was missing in 34 patients, a sensitivity analysis with the addition of this covariate was later conducted on 288 patients to evaluate FPE in a complete case analysis.

The following covariates were included a priori in the multivariable model for clinical outcome: age, sex, baseline NIHSS score, year of treatment, prestroke mRS, hypertension, diabetes, atrial fibrillation, treatment with intravenous thrombolysis, TOAST etiology, pc-ASPECTS score, and occlusion location.

For both multivariable analyses, the stroke etiologies of small vessel disease, other determined and undetermined were grouped into 1 category. All patients included in these analyses had complete data on the a priori defined covariates. In the event of missing data for the outcome presented, we provided the number of patients with complete outcome data. The primary and secondary outcomes were evaluated using unadjusted and mixed-effects logistic regression. No adjustment for multiple testing was performed. Statistical significance for all tests was set at α=0.05.

RESULTS

Study Population

There were 1282 patients assessed for eligibility in the PLATO study, of whom 884 patients received medical management and others excluded for various reasons, leading to 398 patients treated with EVT (Figure 1). From the EVT cohort, we further excluded 32 patients

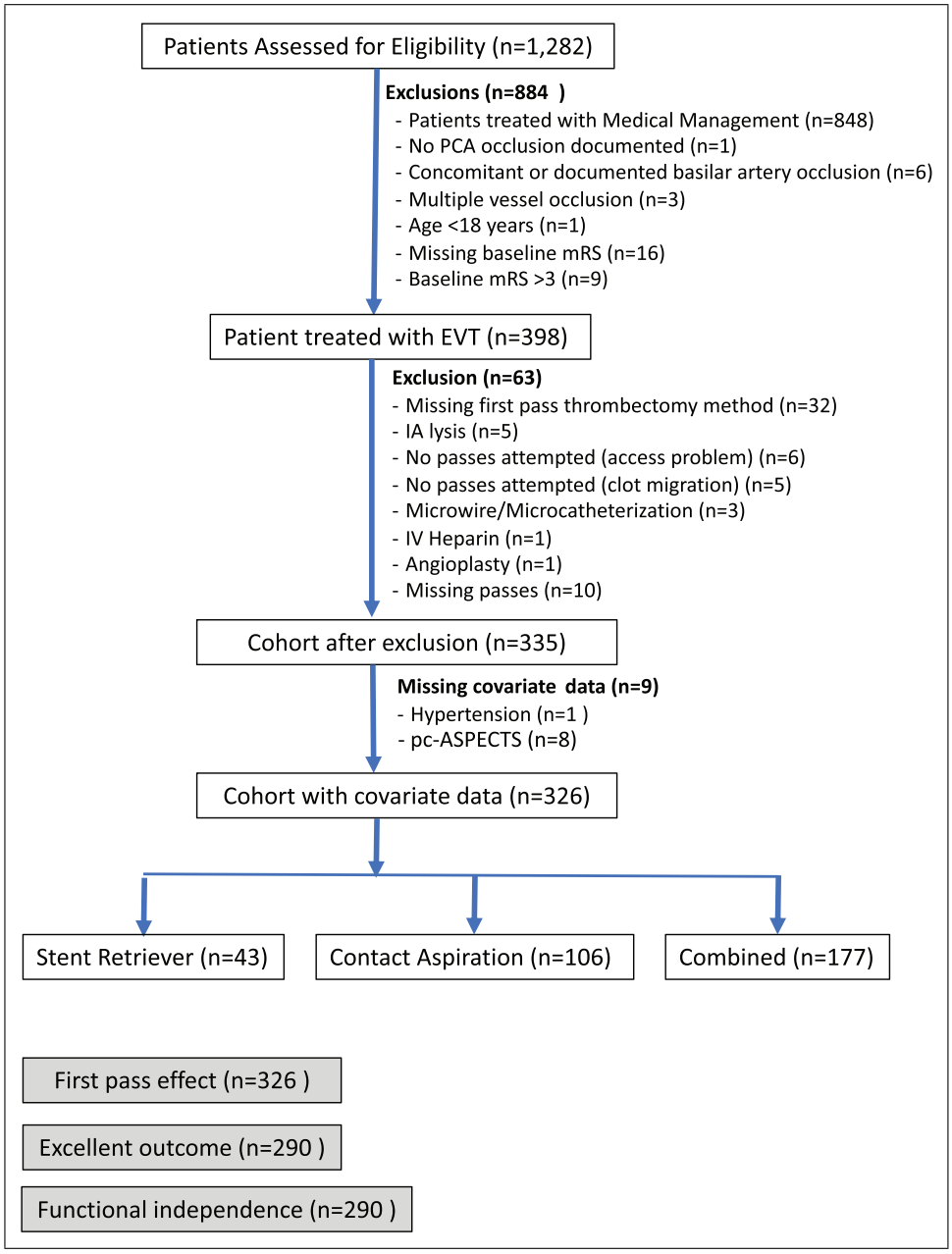

Figure 1. Study flow chart. EVT indicates endovascular therapy; IA, intra-arterial; mRS, modified Rankin scale; pc-ASPECTS, posterior circulation Acute Stroke Prognosis Early CT score; and PCA, posterior cerebral artery.

missing data on the first-line thrombectomy technique, 10 missing the number of passes, 10 patients treated with intra-arterial lysis or other techniques only, in 6 of whom access to the clot could not be gained, and 5 who had distal thrombus migration, leaving 335 patients. Finally, we excluded an additional 9 patients for lack of covariate data including hypertension and baseline pc-ASPECTS. Complete information for multivariable analysis was therefore available in 326 patients, with first-line SR, CA, and combined technique (43 [13.2%], 106 [32.5%], and 177 [54.3%] patients, respectively).

Demographic and Treatment Characteristics

The first-line technique was SR in 13.2% (N=43), CA in 32.5% (N=106), and combined in 54.3% (N=177) patients. The choice of first-line technique changed over time, with more usage of combined technique and

CA in the later compared with earlier years with SR alone (median year [IQR], first-line combined technique 2020 [2018–2020], CA 2019 [2018–2020], SR 2018 [2017–2020]; *P*=0.004).

The study population's median (IQR) age was 75 (65–82) years, and 56.1% were men. The median (IQR) baseline NIHSS score was 8 (5–12) and did not differ between the SR, CA, and combined treatment groups (*P*=0.875). Data on baseline visual field defect were available in 258 (79%) patients, of whom 176 (68.2%) had a visual field defect with no difference between groups (*P*=0.881). Intravenous thrombolysis was administered in 39.6% of patients, without difference between groups (*P*=0.315). There was no difference in prestroke mRS, hypertension, atrial fibrillation, diabetes, hyperlipidemia, current smoking, prior stroke, peripheral artery disease, or oral anticoagulation use between groups (Table 1). Stroke etiology of large artery atherosclerosis was more common in the combined versus CA or SR groups (26% versus 19.8% versus 18.6%, respectively), whereas cardioembolic etiology was more common in the CA and SR versus combined group (42.5% versus 41.9% versus 35.6%) (*P*=0.061).

Perfusion imaging on admission was obtained in 56%. Mismatch of more than 20% in the affected arterial territory was present in 93% of patients, with no difference between groups, *P*=0.532 (Table 2). The occlusion site was the P1 segment in 53.1% of patients, the P2 segment in 40.5%, and other in 6.4%. The other group comprised 11 patients with P3 occlusion, 6 with fetal PCA, and 4 with bilateral occlusion. The median (IQR) pc-ASPECTS was 10 (9–10). The median (IQR) time to treatment was 3.8 (2.4–7.3) hours and did not differ between treatment groups, *P*=0.437. Overall, 70% of patients were treated in the early 0 to 6 hour window; 30% were treated later (Table 2).

Procedural and Safety Metrics

General anesthesia was more frequently used in patients treated with SR first-line compared with first-line CA or combined technique (72.1% versus 54.9% versus 44.6%, respectively; *P*=0.004). The median (IQR) number of passes was 1 (1–2) with more passes (2 [1–2]) performed in patients who underwent combined technique first-line (*P*=0.01) (Table 2). FPE as defined by eTICI 2c/3 was present in 43.6% of the overall cohort and was more common in the SR compared with the CA or combined group (62.8% versus 42.5% versus 39.6%; *P*=0.02, respectively) (Table 2).

Final successful reperfusion (eTICI 2b–3) was present in 81% of cases and was no different between the 3 groups. Of 312 patients with complications reported, 7 (2.2%) patients had dissection, 12 (3.9%) had emboli to a downstream territory, and 4 (1.3%) had emboli to a new territory. Of 8 (2.6%) patients with arterial perforation, information on sICH was available for 7, of whom 3 patients had sICH (Table 2).

Clinical Outcomes

Clinical outcomes between patients treated with SR, CA, and combined did not differ between the 3 groups in unadjusted analyses (Figure 2 and Table 2). The 90-day mRS score of 0–1 was present in 30.7% of patients; mRS score 0–2 was observed in 50.0% of patients. An early improvement in NIHSS score ≥2 points was observed in 64.6% of patients. Overall, complete vision recovery was present in 70.5% of patients with reports of baseline and follow-up vision (n=44). There was no difference in sICH or mortality across the 3 groups (sICH rate: 5.6%, mortality rate: 10.9%) (Table 2).

In adjusted multivariable analyses, compared with SR patients, there were lower odds of FPE in patients who had first-line CA, but the analysis failed to attain statistical significance (aOR, 0.45 [95% CI, 0.19–1.06]; *P*=0.07). Significantly lower odds of FPE were observed for patients undergoing combined technique than SR (aOR, 0.35 [95% CI, 0.16–0.80]; *P*=0.01) (Table 3). There was no difference in 90-day excellent outcomes (mRS score 0–1) between the 3 groups. The likelihood of functional independence (mRS score 0–2) was lower in patients who received first-line CA versus SR first-line (aOR, 0.52 [95% CI, 0.28–0.95]; *P*=0.04) whereas there was a trend toward lower likelihood of functional independence in patients who underwent combined technique versus SR first-line (aOR, 0.50 [95% CI, 0.24–1.06]; *P*=0.07).

FPE was associated with higher excellent outcomes (mRS score 0–1) and functional independence (mRS score 0–2) compared with no FPE (mRS score 0–1: 36.6% versus 25.8%; *P*=0.05; mRS score 0–2: 58% versus 43.4%; *P*=0.01). These results were similar for modified FPE (mRS score 0–1: 38.2% versus 23.3%; *P*=0.006; mRS score 0–2: 59% versus 41.1%; *P*=0.002) (Table 4).

In a sensitivity analysis with the addition of time to treatment as a covariate in the multivariable model, the likelihood of FPE remained lower in patients treated with combined technique first-line compared with SR alone first-line (Table S1).

DISCUSSION

In this analysis of the PLATO study, patients with isolated PCA occlusion who underwent EVT with first-line SR technique were more likely to achieve FPE compared with patients treated with first-line combined technique. A greater number of passes was used in

Table 1. Baseline Characteristics of Patients With Posterior Cerebral Artery Occlusion Treated With Stent Retriever Versus Contact Aspiration Versus Combined Technique

	Overall (N=326)	SR (N=43)	CA (N=106)	Combined (N=177)	*P* value
Demographics and clinical characteristics					
Median (IQR)					
Age, y	75 (65–82)	76 (64–82)	76 (65–82)	74 (65–82)	0.857
Baseline NIHSS score	8 (5–12)	9 (5–12)	8 (5–12)	8 (5–12)	0.875
Prestroke mRS score	0 (0–1)	0 (0–1)	0 (0–1)	0 (0–1)	0.373
Year of treatment (2000s)	19 (18–20)	18 (17–20)	19 (18–20)	20 (18–20)	0.004
n (column %)					
Sex					0.056
Male	183 (56.1)	18 (41.9)	67 (63.2)	98 (55.4)	
Female	143 (43.9)	25 (58.1)	39 (36.8)	79 (44.6)	
Prestroke mRS score					0.521
0	206 (63.2)	23 (53.5)	69 (65.1)	114 (64.4)	
1	64 (19.6)	11 (25.6)	18 (17.0)	35 (19.8)	
2	32 (9.8)	4 (9.3)	9 (8.5)	19 (10.7)	
3	24 (7.4)	5 (11.6)	10 (9.4)	9 (5.1)	
Baseline NIHSS score					0.693
0–9	198 (60.7)	25 (58.1)	62 (58.5)	111 (62.7)	
10–19	98 (30.1)	12 (27.9)	33 (31.1)	53 (29.9)	
≥20	30 (9.2)	6 (14.0)	11 (10.4)	13 (7.3)	
Transfer (N=287)					0.614
Direct to EVT center	211 (73.5)	23 (71.9)	69 (70.4)	119 (75.8)	
Transferred to EVT center	76 (26.5)	9 (28.1)	29 (29.6)	38 (24.2)	
IV tPA					0.315
No	197 (60.4)	26 (60.5)	58 (54.7)	113 (63.8)	
Yes	129 (39.6)	17 (39.5)	48 (45.3)	64 (36.2)	
Baseline VFD (N=258)					0.881
No	82 (31.8)	12 (35.3)	29 (31.2)	41 (31.3)	
Yes	176 (68.2)	22 (64.7)	64 (68.8)	90 (68.7)	
Vascular risk factors					
n (column %)					
Hypertension	246 (75.5)	34 (79.1)	75 (70.8)	137 (77.4)	0.381
Atrial fibrillation	106 (32.5)	17 (39.5)	40 (37.7)	49 (27.7)	0.125
Diabetes mellitus	73 (22.4)	9 (20.9)	28 (26.4)	36 (20.3)	0.480
Coronary heart disease (N=310)	53 (17.1)	5 (14.7)	19 (17.9)	29 (17.1)	0.910
Hyperlipidemia (N=325)	141 (43.4)	22 (51.2)	48 (45.3)	71 (40.3)	0.391
Current smoker (N=273)	40 (14.7)	4 (9.5)	13 (23.5)	23 (17.0)	0.479
Prior stroke (N=315)	42 (13.3)	7 (20.6)	14 (13.2)	21 (12.0)	0.403
Peripheral artery disease (N=270)	15 (5.6)	1 (3.0)	8 (9.6)	6 (3.9)	0.150
Dialysis (N=264)	15 (5.7)	4 (12.1)	8 (8.3)	3 (2.2)	0.019
Oral anticoagulation (N=309)	55 (17.8)	8 (23.5)	22 (20.8)	25 (14.8)	0.295
Statin (N=282)	97 (34.4)	11 (32.4)	44 (44.9)	42 (28.0)	0.024
Median (IQR)					
SBP (mm Hg) (N=256)	158 (138–174)	142 (133–170)	149 (135–171)	161 (139–177)	0.033
DBP (mm Hg) (N=252)	84 (74–96)	86 (79–96)	80 (69–90)	87 (78–100)	0.004
n (column %)					
Stroke etiology					0.061
Large artery atherosclerotic	75 (23.0)	8 (18.6)	21 (19.8)	46 (26.0)	
Cardioembolic	126 (38.7)	18 (41.9)	45 (42.5)	63 (35.6)	
Small vessel atherosclerotic	5 (1.5)	3 (7.0)	1 (0.94)	1 (0.56)	
Other determined	22 (6.8)	4 (9.3)	9 (8.5)	9 (5.1)	
Undetermined	98 (30.1)	10 (23.3)	30 (28.3)	58 (32.8)	

CA indicates contact aspiration; DBP, diastolic blood pressure; EVT, endovascular therapy; IQR, interquartile range; IV tPA, intravenous tissue-type plasminogen activator; mRS, modified Rankin scale; n, number of patients; N, total number of patients; NIHSS, National Institutes of Health Stroke Scale; SBP, systolic blood pressure; SR, stent retriever; and VFD, visual field deficit.

Table 2. Procedure Metrics, Imaging, and Clinical Outcomes of Patients With Posterior Cerebral Artery Occlusion Treated With Stent Retriever Versus Contact Aspiration Versus Combined Technique

	Overall (N=326)	SR (N=43)	CA (N=106)	Combined (N=177)	*P* value
Imaging and clot location					
Median (IQR)					
pc-ASPECTS	10 (9–10)	9 (9–10)	9 (9–10)	10 (9–10)	0.252
n (column %)					
Imaging (N=316)					
CT	279 (88.3)	32 (94.1)	92 (86.8)	155 (88.1)	0.508
Perfusion	177 (56.0)	18 (52.9)	58 (54.7)	101 (57.4)	0.845
MRI	46 (14.6)	2 (5.9)	18 (17.0))	26 (14.8)	0.277
Perfusion mismatch >20%					
(n=142)	132 (93.0)	14 (87.5)	29 (93.6)	89 (93.7)	0.532
Occlusion site*					0.846
P1	173 (53.1)	22 (51.2)	56 (52.8)	95 (53.7)	
P2	132 (40.5)	18 (41.9)	41 (38.7)	73 (41.2)	
Other	21 (6.4)	3 (7.0)	9 (8.5)	9 (5.1)	
Time metrics and procedural factors					
Median (IQR)					
Time to treatment, h (N=290)	3.8 (2.4–7.3)	3.3 (2.0–5.9)	3.9 (2.7–7.2)	3.8 (2.4–7.3)	0.437
Number of passes	1 (1–2)	1 (1–2)	1 (1–2)	2 (1–2)	0.010
n (column %)					
Time to treatment, h (N=290)					0.464
0–<6	203 (70.0)	33 (76.7)	61 (66.3)	109 (70.3)	
6–24	87 (30.0)	10 (23.3)	31 (33.7)	46 (29.7)	
Anesthesia (N=322)					0.004
General	166 (51.6)	31 (72.1)	56 (54.9)	79 (44.6)	
Local/conscious sedation	156 (48.5)	12 (27.9)	46 (45.1)	98 (55.4)	
First-pass effect (eTICI 2c/3)					0.022
No	184 (56.4)	16 (37.2)	61 (57.6)	107 (60.5)	
Yes	142 (43.6)	27 (62.8)	45 (42.5)	70 (39.6)	
Modified first-pass effect (eTICI 2b/2c/3)				0.003	
No	169 (51.8)	12 (27.9)	56 (52.8)	102 (57.1)	
Yes	157 (48.2)	31 (72.1)	50 (47.2)	76 (42.9)	
Final eTICI					0.213
eTICI 0–2a	62 (19.0)	4 (9.3)	21 (19.8)	37 (20.9)	
eTICI 2b	48 (14.7)	7 (16.3)	19 (17.9)	22 (12.4)	
eTICI 2c	27 (8.3)	1 (2.3)	8 (7.6)	18 (10.2)	
eTICI 3	189 (58.0)	31 (72.1)	58 (54.7)	100 (56.5)	
Final eTICI (2c/3)					0.359
No	110 (33.7)	11 (25.6)	40 (37.7)	59 (33.3)	
Yes	216 (66.3)	32 (74.4)	66 (62.3)	118 (66.7)	
Final eTICI (2b/2c/3)					0.214
No	62 (19.0)	4 (9.3)	21 (19.8)	37 (20.9)	
Yes	264 (81.0)	39 (90.7)	85 (80.2)	140 (79.1)	
Safety					
n (column %)					
sICH (N=322)	18 (5.6)	3 (7.0)	6 (5.8)	9 (5.1)	0.892
HBC ICH (N=258)	59 (22.9)	10 (29.4)	14 (16.5)	35 (25.2)	0.200
Fatal ICH (N=291)	6 (2.1)	1 (3.3)	1 (1.0)	4 (2.5)	0.462
Mortality (N=321)	35 (10.9)	5 (11.9)	16 (15.4)	14 (8.0)	0.156

(*Continued*)

Table 2. (Continued)

	Overall (N=326)	SR (N=43)	CA (N=106)	Combined (N=177)	*P* value
Procedural complications (N=312)					0.593
No complications	274 (87.8)	40 (93.0)	90 (88.2)	144 (86.2)	
Dissection	7 (2.2)	0 (0.0)	3 (2.9)	4 (2.4)	
Emboli same territory	12 (3.9)	1 (2.3)	3 (2.9)	8 (4.8)	
Emboli new territory	4 (1.3)	0 (0.0)	2 (2.0)	2 (1.2)	
Perforation	8 (2.6)	0 (0.0)	4 (3.9)	4 (2.4)	
Other	7 (2.2)	2 (4.7)	0 (0.0)	5 (3.0)	
Neurological outcome					
median (IQR)					
mRS score, 90 d (N=290)	2.5 (1–4)	2 (1–5)	3 (1–5)	3 (1–4)	0.683
NIHSS score change (N=291)†	3 (0–7)	2.5 (0–7)	3 (0–7)	4 (0–7)	0.671
mean (SE)					
mRS score, 90 d (N=290)	2.8 (2.0)	2.7 (2.1)	2.9 (2.1)	2.8 (1.9)	0.795
NIHSS score change (N=291)†	3.0 (9.4)	2.5 (12.3)	2.8 (9.6)	3.3 (8.6)	0.862
n (column %)					
mRS score 0–1, 90 d (n=290)	89 (30.7)	16 (40.0)	27 (29.0)	46 (29.3)	0.388
mRS score 0–2, 90 (n=290)	145 (50.0)	24 (60.0)	44 (47.3)	77 (49.0)	0.382
Decrease in NIHSS score by ≥2 points (n=291)	188 (64.6)	20 (58.8)	59 (62.8)	109 (66.9)	0.382
Vision recovery (n=44/176)‡					0.937
Complete	31 (70.5)	5 (83.3)	11 (64.7)	15 (71.4)	
Partial	3 (6.8)	0 (0.0)	1 (5.9)	2 (9.5)	
Same	7 (15.9)	1 (16.7)	4 (23.5)	2 (9.5)	
Worse	3 (6.8)	0 (0.0)	1 (5.9)	2 (9.5)	

CA indicates contact aspiration; CT, computed tomography; eTICI, expanded Treatment in Cerebral Infarction; HBC, Heidelberg Bleeding Classification; ICH, intracerebral hemorrhage; IQR, interquartile range; MRI, magnetic resonance imaging; mRS, modified Rankin scale; n, number of patients; N, total number of patients; NIHSS, National Institutes of Health Stroke Scale; PCA, posterior cerebral artery; pc-ASPECTS, Acute Stroke Prognosis Early CT Score; sICH, symptomatic intracranial hemorrhage; and SR, stent retriever.

∗Other occlusions include 11 patients with P3, 6 with fetal PCA, and 4 with bilateral occlusion.

†Change in NIHSS score is defined as NIHSS score at admission – NIHSS score at discharge. A positive score means NIHSS score at admission is >NIHSS score at discharge.

‡Of 176 with visual field defects at baseline, information on vision recovery was available for 44. Nineteen were deceased, and 113 were missing data.

the combined group but final reperfusion rate was similar across the 3 first-line techniques. Both FPE and modified FPE were associated with higher rates of 90-day excellent outcomes (mRS score 0–1) and functional independence (mRS score 0–2). In multivariable analyses, no difference in excellent outcome (mRS score 0–1) at 90 days was noted across the 3 techniques. However, functional independence (mRS score 0–2) at 90 days was more likely in patients treated with first-line SR compared with first-line CA and there was a trend in favor of first-line SR compared with combined technique. Safety outcomes including sICH and mortality were similar across the 3 groups.

In patients with anterior circulation large vessel occlusion, the ASTER, ASTER2, and COMPASS randomized trials demonstrated no significant difference in technical outcomes for patients treated with first-line SR versus CA or combined techniques, forming the basis of our hypothesis a priori to this study. Two meta-analyses[32,33] and an international study[34] of patients with distal or medium vessel occlusion showed no difference in final reperfusion in patients treated with either SR-based or CA techniques. Performance of a device in a distal anterior cerebral artery or large vessel occlusion territory may not be the same as its performance in a PCA occlusion territory, perhaps related to different clot composition.[26] In light of data from the ASTER2 randomized trial showing numerically higher rates of FPE with combined technique compared with SR alone, the observation of higher first-pass reperfusion rates in patients treated with first-line SR was not expected in our cohort of patients with PCA occlusion. With the evolution of endovascular techniques, we observed a departure from early SR alone use to greater usage of CA and combined technique in the later years of this study. It is possible that introducing new techniques may introduce a learning curve, or that the rates of successful reperfusion would improve with

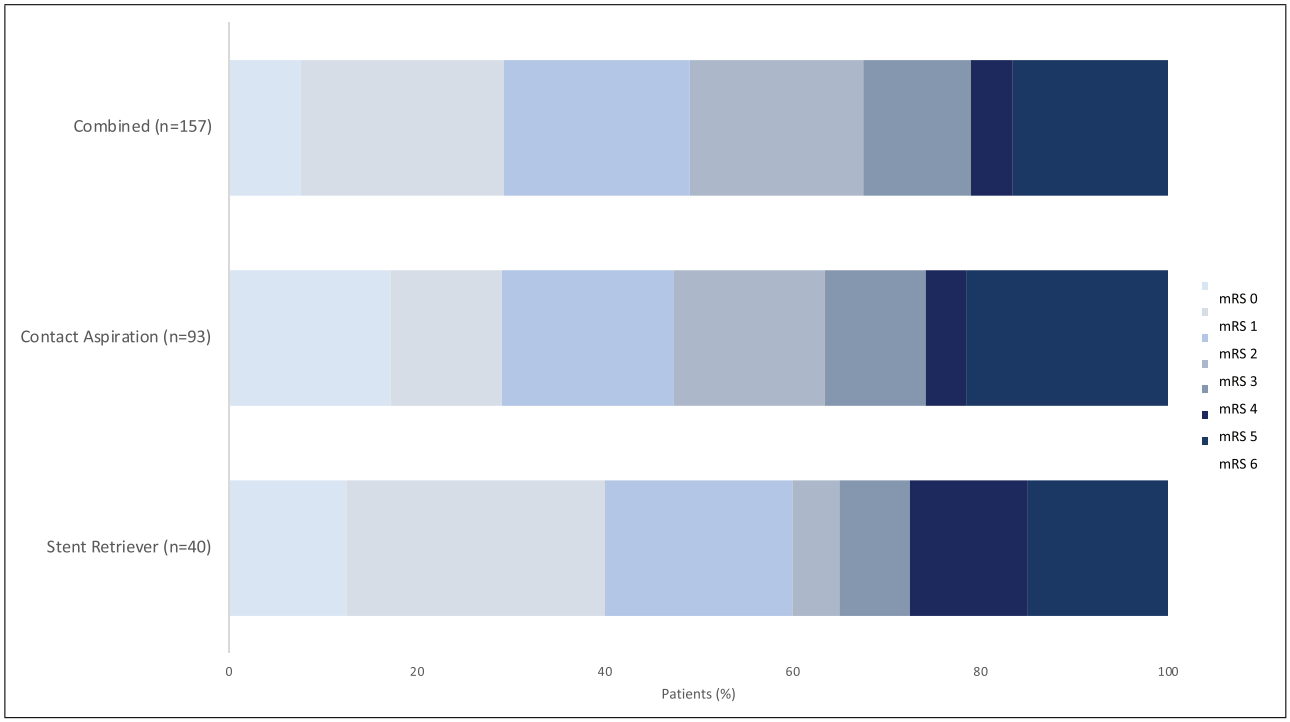

Figure 2. Distribution of 90-day mRS scores in patients with posterior cerebral artery occlusion according to first-line technique with combined, contact aspiration, or stent retriever. Clinical outcomes between patients treated with SR, CA, and combined did not differ between the 3 groups in unadjusted analyses. In adjusted analyses, the likelihood of functional independence was lower in patients who received first-line CA versus SR (aOR, 0.52 [95% CI, 0.28–0.95]; *P*=0.035) whereas there was a trend toward lower likelihood of functional independence in patients who underwent combined technique versus SR first-line (aOR, 0.50 [95% CI, 0.24–1.06]; *P*=0.072). aOR indicates adjusted odds ratio; CA, contact aspiration; ; mRS, modified Rankin scale; SR, stent retriever.

Table 3. Univariable and Multivariable Mixed-Effects Logistic Regression Evaluation of Outcomes in Patients Treated With Stent Retriever Versus Contact Aspiration Versus Combined Technique

			Univariable model		Multivariable model	
	N	Event (%)	OR (95% CI), *P*			
First-pass effect (eTICI 2c/3) (N=322)						
SR	43	27 (62.8)	Referent*			
CA	102	45 (44.1)	0.47 (0.19–1.12)	0.087	0.45 (0.19–1.06)	0.066
Combined	177	70 (39.6)	0.36 (0.16–0.80)	0.012	0.35 (0.16–0.80)	0.012
Modified first-pass effect (eTICI 2b/2c/3) (N=322)						
SR	43	31 (72.1)	Referent*			
CA	102	50 (49.0)	0.40 (0.17–0.94)	0.035	0.38 (0.16–0.87)	0.022
Combined	177	76 (42.9)	0.29 (0.13–0.61)	0.001	0.28 (0.13–0.59)	0.001
Excellent outcome (mRS score 0–1, 90 d) (N=290)						
SR	40	16 (40.0)	Referent†			
CA	93	27 (29.0)	0.56 (0.24–1.28)	0.168	0.48 (0.18–1.25)	0.132
Combined	157	46 (29.3)	0.68 (0.28–1.66)	0.402	0.49 (0.18–1.27)	0.142
Functional independence (mRS score 0–2, 90 d) (N=290)						
SR	40	24 (60.0)	Referent†			
CA	93	44 (47.3)	0.62 (0.41–0.95)	0.026	0.52 (0.28–0.95)	0.035
Combined	157	77 (49.0)	0.69 (0.43–1.10)	0.114	0.50 (0.24–1.06)	0.072

CA indicates contact aspiration; ; eTICI, expanded Treatment in Cerebral Infarction; IV tPA, intravenous tissue-type plasminogen activator; mRS, modified Rankin scale; N, the total number of patients; NIHSS, National Institutes of Health Stroke Scale; OR, odds ratio; pc-ASPECTS, posterior circulation Acute Stroke Prognosis Early CT Score; and SR, stent retriever.

*The multivariable covariates include age, sex, baseline NIHSS score, year of treatment, prestroke mRS score, hypertension, atrial fibrillation, IV tPA, stroke etiology, pc-ASPECTS score, occlusion site, and anesthesia modality.

†The multivariable covariates include age, sex, baseline NIHSS score, year of treatment, prestroke mRS score, hypertension, atrial fibrillation, IV tPA, stroke etiology, pc-ASPECTS score, and occlusion site.

Table 4. First-Pass Effect and 90-Day Outcomes

	FPE (N=131)	No FPE (N=159)		Modified FPE (N=144)	No modified FPE (N=146)	
	n (column %), *P*					
mRS score 0–1	48 (36.6)	41 (25.8)	0.046	55 (38.2)	34 (23.3)	0.006
mRS score 0–2	76 (58.0)	69 (43.4)	0.013	85 (59.0)	60 (41.1)	0.002

FPE = eTICI 2c/3; no FPE = eTICI 0/1/2a/2b; modified FPE = eTICI 2b/c/3; no modified FPE = eTICI 0/1/2a. eTICI indicates expanded Treatment in Cerebral Infarction; FPE, first-pass effect; and mRS, modified Rankin scale.

more experience gained in later years. However, even after adjusting for years of treatment, the association of higher FPE rates with SR alone remained.

Although some studies have suggested potential benefits of the combined technique, the evidence supporting its superiority over SR alone is not definitive. The combined technique introduces increased procedural complexity, resulting in longer procedure times and potential complications associated with using multiple devices. The reported advantages (better navigation and clot engagement in tortuous/distal anatomy) of the combined technique in the anterior circulation may not be easily transferred to the posterior circulation. This may be because the angioarchitecture between the vertebral artery, basilar artery, and PCA tends to be less tortuous than the anterior circulation in cases of medium vessel occlusion. Additionally, the larger diameter of the basilar artery compared with the middle cerebral artery may reduce the risk of clot loss and friction during SR retrieval.[35] As a result, adding an aspiration catheter may not confer additional advantage compared with using a SR alone in the posterior circulation.

Several studies have examined the SR technique versus CA across distal or medium vessel occlusion territories. The TOPMOST (Treatment for Primary Medium Vessel Occlusion Stroke) study evaluated the SR technique (with or without CA) versus CA across 141 patients with PCA occlusion and found no difference between the 2 groups with regard to final reperfusion or clinical outcome.[36] Of note, rates of final TICI 3 reperfusion with SR alone were numerically higher in TOPMOST compared with the combined technique (84% versus 64%; *P*=0.08).[36] The higher final complete reperfusion rate with SR alone across both TOPMOST and PLATO cohorts suggests that SR alone may be the preferred first-line modality rather than combined technique in patients with isolated PCA occlusion. There may be no advantage of an aspiration catheter in addition to an SR in patients undergoing SR-based thrombectomy. Considering the relatively small sample size across both cohorts, we interpret these findings with caution.

As the endovascular field evolves to treat patients with more distal vessel occlusion and milder severity of stroke, optimizing the efficacy and safety of the procedure becomes more important.[37] Given the correlation between FPE and modified FPE with both excellent outcome and functional independence in this cohort, finding the best technique to achieve the first-pass reperfusion is essential. Vessel recanalization after a single pass reduces potential risks of subsequent instrumentation, endothelial injury, and hemorrhagic risk with subsequent passes. The rates of sICH and mortality did not differ significantly across the 3 first-line techniques in our study and were similar to rates reported from the literature in distal vessel occlusion.[36,38]

Despite the strength of the PLATO study in demonstrating difference between first-line techniques, there are important limitations to consider. The primary end point was a technical outcome and may not directly correlate with patient-centered clinical outcomes. The first-line technical strategy was according to the physician's discretion and nonrandomized. A type 2 error is possible as the sample size of patients treated with SR alone was small. Given that the technical success and outcomes of EVT are dependent on operator experience, randomization of first-line technique may be difficult in future studies. We did not collect data on whether the thrombectomy technique was switched after the first pass; thus, the technique that ultimately led to final reperfusion is uncertain in patients who underwent 2 or more passes. However, as our primary outcome was FPE, we believe the data regarding the device used first-line to achieve this end point were robust. In patients who were recorded as having a combined technique, we did not record whether the aspiration catheter was in contact or distant from the face of the clot. As a result, the combined technique group may represent heterogeneous techniques. There was no imaging core laboratory and we did not measure clot length, which can affect reperfusion success. We did not study the usage of balloon guide catheter.[39,40] Although the use of a balloon guide catheter has been associated with increased likelihood of technical success, inflation of a balloon guide catheter in the posterior circulation does not arrest antegrade flow as contralateral antegrade flow is maintained via the contralateral vertebral artery. Thus, the use of a balloon guide catheter is mechanistically unlikely to affect the success of PCA EVT and any differences are more likely due to operator-level or site-level factors. We did not measure cognitive outcomes in this study, which may play an important role in patient

recovery. There were 5 patients whose stroke pathophysiology was recorded as small vessel disease. As concomitant stroke mechanisms can exist in the same patient, we acknowledge this classification may be a limitation in the interpretation of our results.

CONCLUSIONS

In patients with isolated PCA occlusion undergoing EVT, first-line SR was associated with higher likelihood of first-pass reperfusion compared with first-line CA or combined technique, and with better 90-day clinical outcomes after adjusted analyses. An FPE was associated with higher rates of 90-day excellent outcomes and functional independence. No difference in sICH or mortality was noted across the 3 techniques.

ARTICLE INFORMATION

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Supplemental Materials

Table S1

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