The Canadian Journal of Neurological Sciences (2025), 1–7
doi:10.1017/cjn.2025.10425

Canadian Journal of Neurological Sciences
Journal Canadien des Sciences Neurologiques

Original Article

Benefits of First Pass Recanalization by Initial Infarct Burden for Basilar Artery Strokes

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ABSTRACT: ***Background and aims:*** Achieving a first pass recanalization (FPR) improves clinical outcomes in patients with basilar artery strokes, but its association with initial infarct burden is unknown. We aimed to study the benefits of FPR for basilar artery strokes by initial infarct burden using the Posterior Circulation Alberta Stroke Program Early CT score (pc-ASPECTS). ***Methods:*** We retrospectively analyzed the prospective multicentric Endovascular Treatment of Ischemic Stroke registry and included 194 patients diagnosed with an acute basilar artery occlusion who were treated with thrombectomy. Our primary outcome was a modified Rankin Scale (mRS) of 0–3 at 90 days, and our secondary outcomes were an mRS of 4–6 and mortality. We compared the 90-day clinical outcomes of achieving an FPR versus multiple thrombectomy passes based on patients' initial infarct size on pretreatment MRI: small (pc-ASPECTS = 9–10), medium (pc-ASPECTS = 6–8) and large (pc-ASPECTS <6). ***Results:*** Patients with a medium or large infarct size had significantly better outcomes (mRS 0–3 at 3 months) if FPR was achieved than if multiple passes were required (RR = 1.61, 95% CI: 1.16, 2.24; p-value = 0.005; and RR = 3.41, 95% CI: 1.54–7.57; p-value = 0.003, respectively). No similar difference was seen among patients with small infarcts. Achieving an FPR was also associated with a significantly lower mortality risk among patients with a moderate infarct size (RR = 0.36, 95% CI: 0.17–0.79; p-value = 0.010) but not with those with small or large infarcts. ***Conclusions:*** Achieving an FPR significantly improves clinical outcomes in acute stroke patients with basilar artery occlusions undergoing thrombectomy when their infarcts are medium or large. Ongoing research to develop surgical techniques to achieve FPR is crucial to improving patients' prognoses.

RÉSUMÉ: **Avantages d'une première intervention réussie de recanalisation en fonction de l'impact initial global des AVC de l'artère basilaire.** ***Contexte et objectifs :*** Une première intervention réussie de recanalisation (first pass recanalization ou FPR) permet d'améliorer l'évolution de l'état de santé des patients victimes d'un AVC de l'artère basilaire, mais son association avec l'impact initial global (initial infarct burden) d'un tel problème demeure inconnue. À l'aide du score pc-ASPECTS, nous avons cherché à étudier les avantages de la FPR pour les AVC de l'artère basilaire, et ce, en fonction de l'impact initial global de ces problèmes. ***Méthodes :*** Nous avons analysé rétrospectivement le registre prospectif multicentrique ETIS et inclus 194 patients diagnostiqués avec une occlusion aiguë de l'artère basilaire qui ont été traités par thrombectomie. Notre critère principal d'évaluation était un score à l'échelle de Rankin modifiée (ERM) de 0 à 3 au bout de 90 jours ; nos

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Cite this article: Fahmy M, Brissette V, Roy D, Beshara J, Dargazanli C, Mourand I, Mahmoudi M, Labreuche J, Weisenburger-Lile D, Gory B, Richard S, Ducroux C, Piotin M, Blanc R, Lucas L, Marnat G, Aubertin M, Arquizan C, Bourcier R, Detraz L, Vannier S, Guillen M, Eugene F, Consoli A, Costalat V, Lapergue B, Maïer B, Guenego A, Dowlatshahi D, Shamy M, and Fahed R. Benefits of First Pass Recanalization by Initial Infarct Burden for Basilar Artery Strokes. *The Canadian Journal of Neurological Sciences*, https://doi.org/10.1017/cjn.2025.10425

critères secondaires d'évaluation étaient un score de 4 à 6 à l'ERM de même que la mortalité. Au bout de 90 jours, nous avons comparé l'évolution de l'état clinique des patients ayant bénéficié d'une FPR à celle obtenue au moyen de plusieurs interventions de thrombectomie en fonction de la taille initiale de l'infarctus des patients telle que révélée lors d'un examen d'IRM pré-traitement : petit (pc-ASPECTS = 9-10), moyen (pc-ASPECTS = 6-8) et grand (pc-ASPECTS <6). ***Résultats :*** Les patients présentant un infarctus de taille moyenne ou grande ont obtenu des résultats significativement meilleurs (ERM : 0-3 au bout de 3 mois) en cas de FPR que lorsque plusieurs interventions ont été nécessaires (respectivement RR = 1,61, IC 95 % : 1,16, 2,24 ; p = 0,005 ; et RR = 3,41, IC 95 % : 1,54-7,57 ; p = 0,003). Aucune différence similaire n'a été observée chez les patients présentant de petits infarctus. Une FPR était également associée à un risque de mortalité significativement plus faible chez les patients présentant un infarctus de taille modérée (RR = 0,36, IC 95 % : 0,17-0,79 ; p = 0,010), mais pas chez ceux présentant de petits ou de grands infarctus. ***Conclusions :*** Une FPR améliore de manière notable l'évolution de l'état de santé des patients victimes d'un AVC aigu avec occlusion de l'artère basilaire subissant une thrombectomie lorsque leurs infarctus sont de taille moyenne ou grande. Les recherches en cours visant à développer des techniques chirurgicales permettant la FPR sont essentielles pour améliorer le pronostic des patients.

Keywords: Basilar artery stroke; first pass recanalization; stroke outcomes; Brain Imaging; ASPECTS

(Received 30 March 2025; final revisions submitted 13 August 2025; date of acceptance 31 August 2025)

Highlights

- First pass recanalization (FPR) for basilar artery strokes leads to better functional outcomes in patients with large (pc-ASPECTS 0–5) and moderate (pc-ASPECTS 6–8) size infarcts.
- FPR does not improve clinical outcomes for patients with small infarct size (pc-ASPECTS 9–10).
- Developing techniques directed at achieving increased FPR rates is needed.

Introduction

Stroke due to basilar artery occlusion can have a mortality exceeding 90% without early revascularization management[1] but can decrease to 31%–37% in patients treated with thrombectomy as per recent randomized controlled trials (RCTs).[2,3] The degree of established infarct on initial brain imaging can help select patients most likely to benefit from revascularization therapy, including thrombolysis or thrombectomy. The Posterior Circulation Alberta Stroke Program Early CT (pc-ASPECT) score is a 10-point categorical system that can help determine the extent of ischemic damage for posterior circulation strokes.[4]

The pc-ASPECT score (or pc-ASPECTS) was used as an inclusion criterion for two recent RCTs investigating thrombectomy for stroke due to basilar artery occlusion (ATTENTION and BAOCHE trials). While both trials showed that thrombectomy combined with best medical care led to better functional outcomes and a lower mortality rate at 90 days than best medical care alone, they had strict exclusion criteria for patients' selection. Patients were excluded from both trials if their pc-ASPECTS was less than 6 or if it was less than 8 and their age was 80 years and older.[2,3] Therefore, the benefits of thrombectomy for posterior circulation stroke in patients with a larger initial infarct burden (pc-ASPECTS<6 or <8 based on age) are uncertain. First pass recanalization (FPR) is defined as complete or near-complete recanalization of the occluded artery after a single pass without rescue therapy. Achieving a first pass effect or FPR in endovascular therapy (EVT) has previously been shown to further improve outcomes of patients with basilar artery occlusions.[5]

Using a large multicenter registry of basilar artery occlusions treated with thrombectomy, we sought to explore the benefits of FPR in various subgroups of patients with a basilar stroke based on their initial infarct size on pretreatment MRI (pc-ASPECT score).

Methods

Study design

We conducted a retrospective observational study using the Endovascular Treatment of Ischemic Stroke (ETIS) registry. We conducted our research and reported our findings according to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guideline. Institutional review board approval was not required for the secondary use of anonymized data.

Study setting[5]

The ETIS registry is a multicenter registry that includes patients with acute ischemic stroke treated with thrombectomy from six participating centers in France. Our extraction period spanned from January 2012 to May 2019. Patients extracted from the registry were solely treated with third-generation mechanical thrombectomy devices, such as stent-retrievers and contact aspiration catheters. Data included in the ETIS registry were collected by a prospective chart review. Patients with missing data were excluded from the analysis.

Participants

We included all patients who underwent thrombectomy within 24 h of symptom onset for a basilar artery occlusion with at least one intracranial pass. The ETIS registry included patients treated with thrombectomy at the physicians' discretion, without imposing inclusion thresholds regarding patients' age, delay since symptom onset, infarct size or baseline National Institute of Health Stroke Scale (NIHSS) score. Standardized definitions were used to collect patients' baseline radiological and clinical characteristics, procedure details and outcomes. To assess whether an FPR was achieved, original images were reviewed by three pairs of readers (always including one interventional neuroradiologist and one stroke neurologist). Discrepancies were resolved by consensus reading. Reviewers used original definitions to identify cases[6]:

1. FPR was defined by fulfillment of all three of the following criteria: (1) single pass/use of the device, (2) complete or near-complete revascularization of the large vessel occlusion and its downstream territory (modified thrombolysis in cerebral infarction [mTICI] score of 2c or 3)[7] and (3) no use of rescue

https://doi.org/10.1017/cjn.2025.10425

therapy. Specifically, we defined rescue therapy as the adjunctive use of balloon angioplasty, stenting or intra-arterial infusion of drugs in patients with an underlying intracranial atherosclerotic disease (i.e., a basilar artery stenosis in our cohort).
2. Patients for whom an FPR was not achieved (non-FPR) were patients who required >1 pass/use of the device or adjunctive rescue therapy.

To determine the mTICI score, the anatomy of the posterior cerebral arteries (to look for the presence of a P1 segment or a posterior communicating artery) was studied on the initial angiogram (when runs from the carotid arteries were performed) or on the initial noninvasive vascular imaging using CT angiography or magnetic resonance angiography.

Outcomes

Our primary outcome, a favorable clinical outcome, was defined as a modified Rankin Scale (mRS) of 0–3 at 90 days post-thrombectomy. Our secondary outcomes were non-favorable outcomes and mortality, defined as an mRS score of 4–6 and an mRS score of 6, respectively, at 90 days post-thrombectomy. Baseline characteristics such as age, sex, hypertension, hypercholesterolemia, diabetes and smoking were also compared between patients with favorable and non-favorable outcomes.

We categorized the pre-treatment MRI's pc-ASPECTS into three groups: large infarct defined as pc-ASPECTS of 0–5, medium infarct defined as pc-ASPECTS 6–8 and small infarct defined as pc-ASPECTS 9–10. We defined a large infarct as 0–5 based on recent RCTs evaluating thrombectomy's benefits for strokes with a "large core,"[8,9,10,11] defined a small infarct as minimal to no infarct seen on the MRI (9–10) and a medium infarct as strokes that do not qualify as a "large infarct/core" or as a "minimal/no infarct" on imaging (6–8). We looked at the association between FPR and clinical outcomes in basilar stroke for these pc-ASPECTS categories to help evaluate if FPR is a positive prognostic factor that varies with initial infarct burden. Pc-ASPECT scores and mRS scores were collected by six trained physicians who evaluated each case.

The pc-ASPECTS is a 10-point categorical scale to evaluate the extent of ischemic damage in posterior circulation strokes initially developed for non-contrast CT scan (NCCT). One point is subtracted for each of the following region that displays early ischemic changes or hypoattenuation on NCCT: left or right thalamus, left or right cerebellum and left or right cortex supplied by its respective posterior cerebral artery. Two points are subtracted for each of the following regions if early ischemic changes or hypoattenuation is seen on NCCT: midbrain or pons. A score of 10 can be interpreted as if no posterior circulation ischemic damage is seen on the NCCT, and a score of 0 can be interpreted as if all regions show evidence of ischemic damage.[4] The pc-ASPECTS score on MRI uses the same scoring system, but instead of hypoattenuation, diffusion restriction on Diffusion-Weighted Imaging (DWI) sequence is used to identify regions affected by early ischemic changes. While using MRI as an imaging modality has led to longer time to intervention in one small study,[12] DWI-MRI is more sensitive at detecting early ischemic changes and predicting final infarct volume than NCCT[13] and is not subject to the same artifact burden typically seen on NCCT when looking at structures of the posterior fossa.

Statistical analyses

Quantitative variables were expressed as medians with interquartile range, and qualitative variables were expressed using counts and percentages. We performed the Wilcoxon rank sum for skewed continuous variables and the Chi-square or Fisher Exact tests for categorical variables. These tests were conducted to test for potential differences in patients' characteristics between those with a favorable outcome and those with a non-favorable outcome.

We used Poisson regression with robust error variance to determine the effect of infarct size (i.e., pc-ASPECTS categories) on the association between FPR and outcomes. Both crude and adjusted relative risks (RR) were computed for each pc-ASPECTS and FPR strata, using no FPR and low pc-ASPECTS (large infarct) as the reference category. Similarly, in patients with large, medium and small infarcts, we computed the crude and adjusted RRs of the outcomes in those with FPR versus those without FPR. In the adjusted analyses, we controlled for age and IV thrombolysis. We evaluated for effect modification, multiplicative and additive interaction between the pc-ASPECT score and FPR on the prevalence of a favorable outcome using different measures. These measures include using independent and combined effect measures, an interaction term in the regression model and measures of an interaction on an additive scale (i.e., relative excess risk due to interaction [RERI], attributional proportion due to interaction [AP] and synergy index), which were calculated using a previously created Excel sheet.[14] An additive interaction was considered significant when RERI or AP was significantly different than 0 or the synergy index was significantly different than 1. We used a p-value of 0.05 as the threshold for statistical significance. All statistical analyses were performed in SAS version 9.4 (SAS Institute, Inc., Cary, North Carolina).

Results

From January 2012 to May 2019, 194 patients with acute basilar artery strokes met our inclusion criteria. Of these, 93 (47.94%) patients had a favorable clinical outcome defined as an mRS 0–3 at 90 days post-thrombectomy, and 101 (52.06%) had a non-favorable outcome defined as an mRS 4–6 at 90 days post-thrombectomy. In terms of initial imaging, 47 patients had a large infarct size (pc-ASPECTS 0–5), 122 had a medium infarct size (pc-ASPECTS 6–8) and 25 had a small infarct size (pc-ASPECTS 9–10). Patients with a non-favorable outcome were more likely to have hypertension and diabetes compared to patients with a favorable clinical outcome. Patients with a favorable outcome were more likely to have received IV thrombolysis compared to patients with a non-favorable outcome. However, the proportion of IV thrombolysis use was similar between patients who achieved FPR and those who did not (39.1% vs 40.8%, respectively). More characteristics of our sample and their associations with outcomes are available in Table 1.

Among patients with pc-ASPECTS 0–5, in those that achieved FPR, a favorable clinical outcome was more likely than for those who did not achieve FPR (RR = 3.41, 95% CI: 1.54, 7.57; p-value = 0.003) (Table 2). Patients with a large infarct size who achieved FPR had a lower RR of a non-favorable outcome and mortality, although both associations were non-significant. Among patients who achieved FPR with pc-ASPECTS 6–8, they were more likely to have a favorable clinical outcome than those who did not achieve FPR (RR = 1.61, 95% CI: 1.16, 2.24; p-value = 0.005). Patients with a moderate infarct size who achieved FPR were also less likely to have a non-favorable outcome (RR = 0.45, 95% CI: 0.25, 0.82; p-value = 0.009) or to die (RR = 0.36, 95% CI: 0.17, 0.79; p-value = 0.01) (Table 2).

https://doi.org/10.1017/cjn.2025.10425

Table 1. Baseline characteristics of our patients' population

	Favorable outcome (*n* = 93)	Non-favorable outcome (*n* = 101)	*p*-value
Sex, males, *n* (%)	54 (58.1)	65 (64.4)	0.3686
Age, median (range)	64 (8–96)	65 (38–96)	0.3312
Hypertension, *n* (%)	47 (50.5)	66 (66.0)	0.0293*
High cholesterol, *n* (%)	32 (34.4)	41 (41.0)	0.3454
Diabetes, *n* (%)	15 (16.1)	28 (28.0)	0.0477*
Smoker, *n* (%)	21 (23.1)	23 (25.3)	0.7291
IV thrombolysis, *n* (%)	45 (48.4)	33 (32.7)	0.0257*
FPR, *n* (%)	44 (47.3)	20 (19.8)	<0.0001*
No FPR, *n* (%)	49 (52.7)	81 (80.2)	
Modified FPR, *n* (%)	57 (61.3)	25 (25.8)	<0.0001*
No modified FPR, *n* (%)	36 (38.7)	76 (75.3)	
pc-ASPECTS 0–5, *n* (%)	14 (15.1)	33 (32.7)	<0.0001
pc-ASPECTS 6–8, *n* (%)	57 (61.3)	65 (64.4)	
pc-ASPECTS 9–10, *n* (%)	22 (23.7)	3 (3.0)	
Pre-stroke modified Rankin Scale, median (range)	0 (0–3)	0 (0–4)	0.05
Time from symptom onset to groin puncture in hours, median (range)	5.2 (1.5–24.0)	5.7 (1.4–24.0)	0.2294

FPR = first pass recanalization; pc-ASPECTS = Posterior Circulation Alberta Stroke Program Early CT score.
*Significant association (p < 0.05). Missing values for smoker = 12, hypertension = 1, diabetes = 1, cholesterol = 1, pretreatment modified Rankin scale = 2.

Among patients with pc-ASPECTS 9–10, while the RR of a favorable clinical outcome for patients who achieved FPR was higher than those who did not achieve FPR, it was not statistically significant. The RR of a non-favorable outcome and mortality could not be calculated due to the sample size.

Compared to patients with pc-ASPECTS 0–5 who did not achieve FPR, the adjusted RR of a favorable clinical outcome was 3.86 (95% CI: 1.71, 8.71) for the independent effect of small infarct size (pc-ASPECTS 9–10) and 3.32 (95% CI: 1.43, 7.67) for the independent effect of FPR (Table 3). The chance of a favorable clinical outcome was highest among patients with both a pc-ASPECT score 9–10 and who achieved FPR compared to patients with a pc-ASPECT score 0–5 who did not achieve FPR (RR = 5.12, 95% CI: 2.46, 10.65). Finally, in both FPR and non-FPR, there was an increasing risk of a favorable clinical outcome proportional to the infarct size (Table 3).

Discussion

We performed a retrospective analysis of 194 patients with basilar artery strokes who were treated with mechanical thrombectomy. We demonstrate that patients with a medium or large infarct size for whom an FPR had been achieved are more likely to have a favorable outcome at 90 days than patients treated with multiple thrombectomy passes. Our results help fill the gap in the literature on patients with posterior circulation stroke treated with thrombectomy by infarct size. While multiple studies have shown an association between FPR and outcome in basilar artery occlusion,[5,15,517] our study is novel as it evaluated the impact of this effect stratified by infarct size.

Among patients with pc-ASPECTS 9–10, our results suggest that there is no statistically significant association between good functional outcome and achieving an FPR compared to multiple thrombectomy passes, although we can observe a positive trend (Figure 1). Interestingly, patients included in the ATTENTION trial had a median pc-ASPECTS of 9, and it resulted in a two-fold increase in the % of patients with good functional status at 90 days compared to best medical care (46% vs 23%), while patients included in the BAOCHE trial had a median pc-ASPECTS of 8 with a similar benefit (46% vs 24%).[2,3] Therefore, these trial results combined with our results showing that 88% of our patients with a pc-ASPECTS of 9–10 had a favorable clinical outcome after having been treated with thrombectomy regardless of the number of passes may suggest that patients with small posterior circulation infarct size are already destined for better prognosis when treated with thrombectomy compared to medical care alone, independent of achieving an FPR or multiple passes. Thrombectomy should then be prioritized as a treatment plan for patients with basilar artery occlusion and small infarct size due to their tendency to have good functional outcomes at 3 months compared to medical treatment alone, as shown in published RCTs, and to have good functional outcomes regardless of the number of thrombectomy passes.

Existing data on the benefits of thrombectomy for posterior circulation strokes are limited to two RCTs (BAOCHE and ATTENTION), and patients with a pc-ASPECTS <6 were excluded from BAOCHE and from ATTENTION if <80 years old, and patients 80 years and older were excluded from ATTENTION if their pc-ASPECTS was <8.[2,3] Our results suggest that achieving an FPR on patients with a pc-ASPECTS ≤8 is associated with better functional outcomes. Recently, we also demonstrated that achieving an FPR led to improved functional outcome and reduced mortality in basilar artery occlusion patients with mild (NIHSS < 10) and moderate symptoms (NIHSS 10–20), but not with more severe symptoms (NIHSS >20).[18] While the NIHSS score favors detection of anterior circulation stroke, increasing NIHSS score is inversely correlated with ASPECT score, correlating with increasing infarct volume size.[19] While we previously stated that data on the benefits of FPR for more severe stroke are lacking, our results now suggest that FPR also leads to better outcomes in patients with more severe stroke/large infarct size. This is particularly important in the setting of emerging evidence from multiple RCTs on thrombectomy's benefits for severe/large anterior circulation strokes, although high-quality evidence for severe/large posterior circulation strokes is still lacking.[8,10,11,20] Benefits seen in BAOCHE and ATTENTION could be due, in part, to their stricter inclusion criteria as described above, and more trials are needed for patients with ASPECTS <8.

Our study suggests a lower mortality risk and poor functional outcome risk for patients with moderate infarct size, but not for large infarct size, and no patients with a small infarct burden died. Our results are in keeping with our past study that also showed no association between FPR and a lower mortality risk in patients with severe stroke symptoms (NIHSS >20).[18] However, our results now suggest that there is an association with better functional outcomes in patients with large infarct size for whom an FPR had been achieved. Our results suggest that the NIHSS score may be less reliable to predict outcomes than pc-ASPECTS. In fact, a patient with an NIHSS score >20 due to an early basilar artery occlusion may still fall in the category of pc-ASPECTS 9–

https://doi.org/10.1017/cjn.2025.10425

Table 2. Relative risks for FPR versus non-FPR by pc-ASPECTS strata

	RR (95% CI)	*p*-value	Adjusted RR (95% CI)[&]	*p*-value
Favorable outcome				
pc-ASPECTS 0–5	3.14 (1.34, 7.38)	0.0086*	3.41 (1.54, 7.57)	0.0025*
pc-ASPECTS 6–8	1.50 (1.04, 2.16)	0.0289*	1.61 (1.16, 2.24)	0.0047*
pc-ASPECTS 9–10	1.38 (0.96, 1.98)	0.0846	1.14 (0.88, 1.48)	0.3353
Non-favorable outcome				
pc-ASPECTS 0–5	0.57 (0.30, 1.07)	0.0787*	0.54 (0.29, 1.02)	0.0571
pc-ASPECTS 6–8	0.47 (0.26, 0.85)	0.0128*	0.45 (0.25, 0.82)	0.0085*
pc-ASPECTS 9–10	N/A		N/A	
Mortality				
pc-ASPECTS 0–5	0.62 (0.32, 1.17)	0.1397	0.61 (0.32, 1.18)	0.1413
pc-ASPECTS 6–8	0.39 (0.18, 0.84)	0.0158*	0.36 (0.17, 0.79)	0.0103*
pc-ASPECTS 9–10	N/A		N/A	

CI = confidence interval; FPR = first pass recanalization; N/A = not applicable; pc-ASPECTS = Posterior Circulation Alberta Stroke Program Early CT score; RR = relative risk. *Significant association ($p < 0.05$). [&]Adjusted for age over 80 and IV thrombolysis.

Table 3. Relative risks of a favorable outcome (mRS of 0–3) – independent and joint effects of FPR and pc-ASPECTS

	Crude RR (95% CI)	*p*-value	Adjusted RR (95% CI)[&]	*p*-value
Favorable outcome				
Non-FPR				
pc-ASPECTS 0–5	Reference	–	Reference	–
pc-ASPECTS 6–8	2.24 (1.04, 4.82)	0.0396*	2.15 (1.01, 4.62)	0.0485*
pc-ASPECTS 9–10	4.00 (1.78, 8.98)	0.0008*	3.86 (1.71, 8.71)	0.0012*
FPR				
pc-ASPECTS 0–5	3.14 (1.34, 7.38)	0.0986*	3.32 (1.43, 7.67)	0.0050*
pc-ASPECTS 6–8	3.36 (1.55, 7.25)	0.0020*	3.34 (1.56, 7.12)	0.0018*
pc-ASPECTS 9–10	5.50 (2.67, 11.34)	<0.0001*	5.12 (2.46, 10.65)	<0.0001*
Non-favorable outcome				
Non-FPR				
pc-ASPECTS 0–5	Reference	–	Reference	–
pc-ASPECTS 6–8	0.71 (0.54, 0.93)	0.0134*	0.73 (0.55, 0.96)	0.0265*
pc-ASPECTS 9–10	0.36 (0.13, 0.96)	0.0419*	0.37 (0.13, 1.01)	0.0511
FPR				
pc-ASPECTS 0–5	0.57 (0.30, 1.07)	0.0787*	0.54 (0.28, 1.02)	0.0560
pc-ASPECTS 6–8	0.33 (0.18, 0.60)	0.0003*	0.33 (0.18, 0.60)	0.0003*
pc-ASPECTS 9–10	N/A		N/A	
Mortality				
Non-FPR				
pc-ASPECTS 0–5	Reference	–	Reference	–
pc-ASPECTS 6–8	0.62 (0.44, 0.86)	0.0043*	0.64 (0.45, 0.89)	0.0089*
pc-ASPECTS 9–10	0.39 (0.15, 1.05)	0.0635	0.40 (0.14, 1.11)	0.0769*
FPR				
pc-ASPECTS 0–5	0.61 (0.32, 1.17)	0.1397	0.58 (0.30, 1.12)	0.1057*
pc-ASPECTS 6–8	0.24 (0.11, 0.51)	0.0002*	0.24 (0.11, 0.51)	0.0002*
pc-ASPECTS 9–10	N/A		N/A	

CI = confidence interval; FPE = first pass effect; mRS = modified Rankin Scale; N/A = not applicable; pc-ASPECTS = Posterior Circulation Alberta Stroke Program Early CT score; RR = relative risk. *Significant association ($p < 0.05$). [&]Adjusted for age over 80 and IV thrombolysis.

https://doi.org/10.1017/cjn.2025.10425

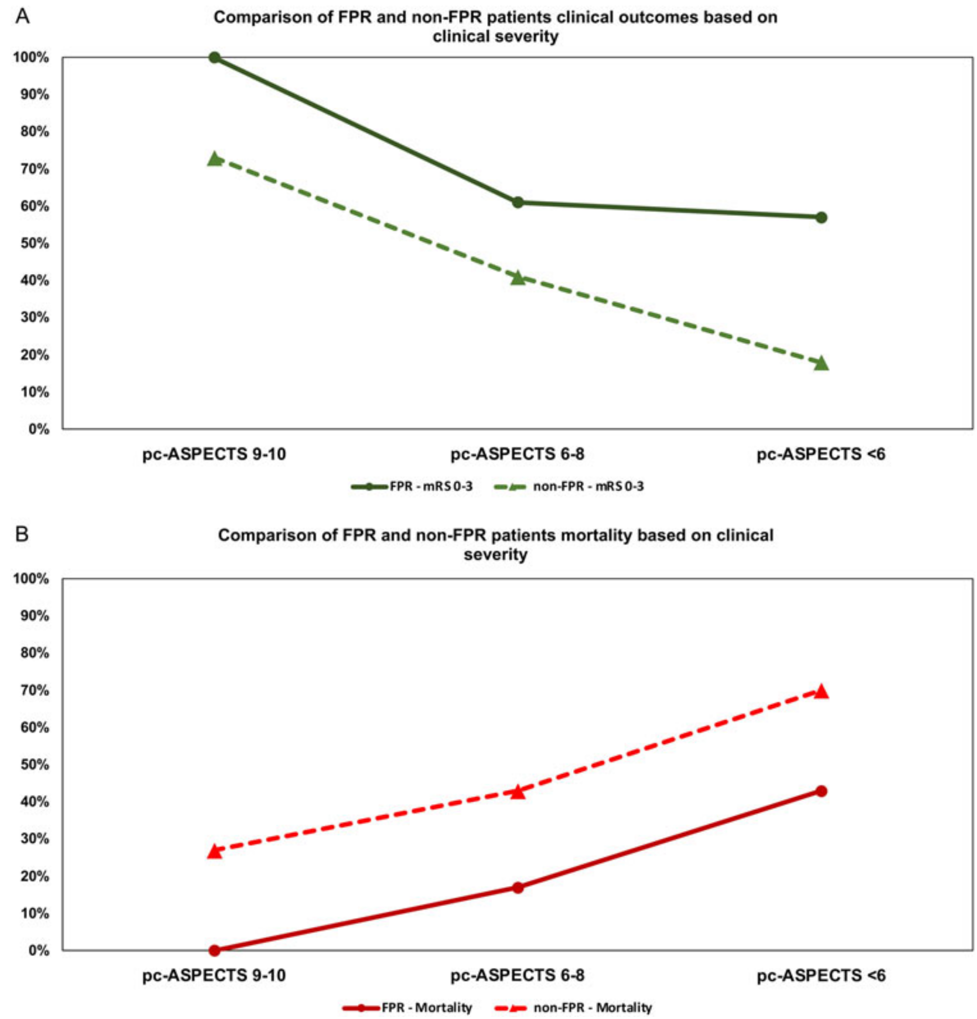

Figure 1. Comparison of first pass recanalization (FPR) and non-FPR clinical outcomes (A) and mortality (B) based on initial infarct size. pc-ASPECTS = Posterior Circulation Alberta Stroke Program Early CT score.

10, where recanalization leads to improved functional outcome, regardless of the number of passes. In contrast, a patient with a pc-ASPECT score 0–5 has imaging evidence of large infarct and seems to benefit from FPR compared to multiple passes, which was not seen when looking only at the severity of symptoms without accounting for the amount of damaged brain tissue. More research should be performed on comparing the NIHSS score and the pc-ASPECTS in predicting outcome, but in the meantime, achieving an FPR should remain a priority for patients who qualify for thrombectomy as per national clinical guidelines.

Modifiable and non-modifiable factors help predict achieving an FPR. For patients with vertebrobasilar occlusion specifically, non-modifiable factors found to be significant positive predictors of FPR are the presence of atrial fibrillation, female sex, stroke of cardioembolic etiology or unknown stroke etiology and the presence of a mid- or distal basilar artery occlusion.[21] Modifiable factors for vertebrobasilar occlusion are the use of contact aspiration techniques, the use of large catheters[21] and the use of balloon guided catheters.[6] Identifying non-modifiable positive factors that can predict FPR could help with thrombectomy decision-making in difficult cases, and choosing devices associated with a higher probability of achieving an FPR in basilar artery occlusions is encouraged as to optimize clinical outcomes.

Strengths and limitations

Our study's main strength resides in the stratification by infarct size for patients undergoing thrombectomy for basilar artery occlusion, a component not included in prior studies looking at the benefits of FPR for posterior circulation strokes. Our study's limitations are inherent to a non-randomized design. We did not collect information on factors known to influence recanalization success such as the site of occlusion of the basilar artery and stroke etiology, which could help refine further studies. Finally, we used the mTICI scale to define FPR in our posterior circulation stroke patients, which has not been well-validated for posterior circulation stroke.[22] Using another scale such as the Arterial Occlusive Lesion scale would be more appropriate,[23] but we did not have this information in our population database, and there are still limitations attached to such a scale.[24] Additionally, our study does not account for limitations directly around the categorical nature of the pc-ASPECT/ASPECT score that evaluates a continuous measure of volume loss. For instance, not only ASPECTS regions are unequal in their contribution to functional outcome (i.e., in low DWI-ASPECTS [0–5] receiving thrombectomy, the involvement of M6 region in right-sided strokes and the internal capsule in left-sided strokes is associated with increased disability),[25] but more data are required to identify how much volume needs to be lost in a specific region to register a point on the pc-ASPECTS. Finally, our study assessed data collected between 2012 and 2019, and revascularization techniques have improved since. We did not collect data on the different techniques of thrombectomy. More recent data will be needed, with stratification by thrombectomy techniques.

Conclusion

In conclusion, FPR is significantly associated with better functional outcomes in patients with large (pc-ASPECTS 0–5) and moderate (pc-ASPECTS 6–8) size infarcts, but not in patients with small infarct size (pc-ASPECTS 9–10). The lack of an observed association for patients with small infarct size may be secondary to their already good prognosis when treated with thrombectomy compared to medical care alone, regardless of the number of passes. Our results add important information to the lack of data from RCTs on patients with posterior circulation strokes with pc-ASPECTS $\leq$ 8. The achievement of FPR in clinical practice enhances quality of life and lowers mortality rates, and more research should be directed at developing surgical techniques directed at achieving first past recanalization to optimize clinical outcomes.

Data availability statement. Data requests should be sent directly to the corresponding author. Data will be shared upon reasonable requests.

Acknowledgments. None.

Author contributions. VB and MF share the first author role, have written the first draft of the manuscript, participated in review/editing and participated in data analysis and interpretation. All other authors have participated in the review/editing of the manuscript. RF is the senior author of the manuscript and has participated in the review/editing of the manuscript, data analysis and interpretation.

Funding statement. No funding was associated with this study.

Competing interests. Sébastien Richard receives unrelated payments through ACTICOR; Gaultier Marnat receives unrelated consulting fees from Balt SAS, Stryker Neurovascular, Terumo Neuro and Sim&Cure and receives unrelated payments through Medtronic, Penumbra, Wallaby Phenox and Bracco. Michel Shamy has been awarded the following grants that are unrelated to this work: HSFC Project Grant 2025–2027, Brain Heart Interconnectome Exploration Grant 2025–2027 and Department of Medicine Project Grant 2025–2026. The other authors declare no conflicts of interest.

Informed consent. Informed consent was not required/not applicable for the secondary use of anonymized data.

Guarantor statement. The guarantor of this manuscript is Dr Robert Fahed.

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