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Predictors of response to endovascular treatment of posterior circulation stroke

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ABSTRACT

Background: Endovascular treatment is considered a reasonable approach for patients with acute posterior circulation stroke, but it remains uncertain which patients will benefit the most from it.
Objective: To find independent clinical and angiographic predictors of outcome after endovascular treatment for posterior circulation stroke.
Methods: We evaluated consecutive patients with acute posterior circulation stroke who underwent endovascular treatment in our comprehensive stroke center from January 2015 to December 2017. Good outcome was defined as a modified Rankin score of 0–3 at 90 days. Intracranial atheromatous disease was established on focal stenosis recorded during endovascular treatment. Associations were sought between a good outcome and clinical and angiographic factors. Adjusted logistic regression models were used to define independent outcome predictors.
Results: Forty-seven consecutive patients were included: mean age 70.9 ± 12.1 years, median admission NIHSS score, 16 (IQR: 8–30). On univariate analysis, age (p = 0.01), smoking (p = 0.04), hypertension (p = 0.03), successful reperfusion (p = 0.04), presence of extracranial atherosclerosis (p = 0.02), and absence of atherosclerosis (p = 0.03) were significantly associated with a good outcome. On multivariate analysis, age < 70 years (odds ratio = 6.20, 95%CI 1.52–25.47, p = 0.01) and absence of intracranial atherosclerosis (odds ratio = 6.45, 95% CI 1.09–38.24, p = 0.04) were independently associated with a good outcome.
Conclusions: Pretreatment determination of the presence or absence of intracranial atherosclerosis can aid management of posterior circulation stroke patients. The absence of intracranial atherosclerosis may have value as a positive selection criterion for endovascular treatment in future trials. The presence of intracranial atherosclerosis could be used as a selection tool in future studies investigating new treatment protocols for this population.

1. Introduction

Posterior circulation stroke accounts for approximately 20% of all ischemic strokes [1] and is associated with a poor outcome in 68%–80% of patients. Endovascular treatment is considered a reasonable approach for these patients, but it remains uncertain whether this treatment improves the clinical outcome [2]. The largest multicenter prospective registry of posterior circulation stroke patients published to date is from the Basilar Artery International Cooperation Study (BASICS), which demonstrated no differences in the functional outcome of patients undergoing endovascular reperfusion treatment compared to intravenous fibrinolysis [3].

In light of the positive results seen in endovascular reperfusion trials in patients with anterior circulation stroke, the American Heart

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Association/American Stroke Association (AHA/ASA) guidelines have stated that endovascular treatment with mechanical thrombectomy may be a reasonable option for patients with posterior circulation strokes (Class IIb, Level of Evidence C) [4]. However, it remains unclear how these patients should be selected and what types of patients will benefit or not from thrombectomy.

Previous retrospective studies have sought clinical, procedure-related, and imaging prognostic factors associated with a favorable outcome in posterior circulation stroke. Age, stroke severity, and recanalization are reported to be associated with a good outcome in some studies, but not in others [5–7]. The findings from these studies are difficult to compare and evaluate because of differences in the patients selected, treatment modalities, and *a priori* selection of the outcome predictors.

Other efforts have been focused on designing imaging scores to systematically assess the ischemic changes and thrombus burden, and predict outcome. The Pc-ASPECTS (posterior circulation Alberta Stroke Program Early CT Score) [8] is a 10-point grading system originally proposed for evaluation of posterior circulation ischemia in the baseline CT. A cut-off < 8 has shown a proven association with unfavorable functional outcome despite basilar artery recanalization. However, the posterior fossa is prone to imaging artifacts, CT may lack sensitivity for detecting posterior fossa infarction, and the inter-rater reliability associated with these techniques is not excellent [8]. Alemseged et al. have proposed a new a 10-point imaging score, the Basilar Artery on Computed Tomography Angiography (BATMAN) score, which incorporates thrombus burden and presence of collaterals to predict clinical outcome after endovascular and intravenous treatment [9]. Lower BATMAN scores are associated with a poor outcome.

Clinical and angiographic criteria able to predict a favorable or poor response to endovascular treatment in patients with posterior circulation stroke could be useful in routine practice to estimate the outcome after these procedures. Moreover, these criteria could be used as selection tools in future clinical trials investigating new treatments for posterior circulation stroke in patients predicted to be poor responders.

The aim of this study was to investigate clinical and angiographic factors predictive of outcome in patients undergoing endovascular treatment of posterior circulation stroke in a single, high-volume, comprehensive stroke center.

2. Methods

2.1. Patients

We evaluated consecutive patients with acute ischemic stroke in the posterior circulation (occlusion site in the intracranial vertebral artery, basilar artery, or posterior cerebral artery), who underwent endovascular treatment between January 2015 and December 2017. The study protocol was approved by the local ethics committee.

2.2. Parameter selection

Clinical and demographic parameters were recorded for all patients. The National Institutes of Health Stroke Scale (NIHSS) score was assessed at hospital arrival, and stroke severity was dichotomized into severe (NIHSS > 20 and/or coma-tetraparesis) and mild/moderate (NIHSS < 20, focal deficit).

A favorable outcome was defined as a modified Rankin Score (mRS) value of 0–3 at 90 days, in accordance with the definition used in the BASICS study. The distribution of the 90- day mRS, stratified by the presence or absence of intracranial atherosclerosis, was compared to the results of the BASICS study to note whether the patient outcomes achieved following endovascular treatment our stroke center were in line with those reported in this large multicenter registry of posterior circulation stroke patients (Fig. 1).

2.3. Neuroimaging evaluation: computed tomography (CT) and computed tomography angiography (CTA)

All CT and CTA images were analyzed by consensus between 2 neuroradiologists with 1 and 3 years' experience in the interpretation of acute stroke imaging to assign the pc-ASPECTS [9] and BATMAN [8] scores. In Pc-ASPECTS, one point is subtracted for hypoattenuation in the left or right thalamus, cerebellum, or posterior cerebral artery territory, respectively, and two points in any part of the midbrain or pons. Hence, lower scores indicate larger infarct volume. The BATMAN score based on CTA findings was calculated as follows: 1) presence of a filling defect in the intracranial posterior circulation (a surrogate marker of thrombus burden), scoring 1 point for each patent intracranial vertebral artery, 1 point for each patent segment of the basilar artery, and 1 point for each P1 segment of the posterior cerebral artery; and 2) patency of the posterior communicating arteries (collaterals), as previously reported [8]. A score of 10 corresponds to complete patency of the vertebrobasilar system. The thrombus burden, presence of collaterals, and BATMAN score were recorded separately.

2.4. Neuroimaging evaluation: digital subtraction angiography (DSA)

Two fellowship-trained neuroradiologists with 1 and 3 years of experience (F.M., L.L.G) reviewed the angiographic data related to the procedures, blinded to the patients' clinical information. The final interpretation was based on consensus between these readers and 2 senior interventional neurologists with more than 20 years and 10 years of experience in performing mechanical thrombectomy (A.T., D.H.).

The following regions were visually inspected: 1) the bilateral vertebral arteries from subclavian artery origin to vertebrobasilar junction (segment V1, from origin to C6 foramen; segment V2, from C6 to C1; segment V3, from C1 to foramen magnum; segment V4, from foramen magnum to vertebrobasilar junction); 2) the basilar artery; and 3) the bilateral posterior cerebral arteries (P1, precommunicanting segment; P2, ambient segment; P3, quadrigeminal segment).

Extracranial arteries were defined as those starting at the origin of the vertebral artery and running up to emergence of the posteroinferior cerebellar artery (PICA), which arises from the V4 segment and is considered the start of the intradural portion of the vertebral artery in V4. Intracranial arteries were defined as those starting at the origin of the PICA and running up to the P3 segment of the posterior cerebral artery (PCA) [10].

The angiographic definition of atherosclerosis was established based on findings from previous literature [11], and was classified qualitatively as presence (Fig. 2) or absence (Fig. 3). Presence was defined as significant fixed focal at the occlusion site, evidenced in the final angiography or during endovascular treatment, and showing the following criteria: 1) degree of fixed stenosis > 70%, or 2) degree of fixed stenosis > 50 in addition to flow or impairment on angiography. Milder stenosis with sufficient blood flow was considered absence.

Extracranial atherosclerosis was defined as atherosclerosis occurring from the origin of the vertebral artery to the emergence of the PICA, and intracranial atherosclerosis from the emergence of the PICA to the P3 segment of the PCA.

Successful reperfusion was defined as a modified Treatment in Cerebral Infarction (mTICI) score of 2b-3 (ie, restoration of blood flow to > 50% of the affected territory at completion of the endovascular procedure) [12].

2.5. Statistical analysis

Descriptive and frequency analyses were carried out and comparisons were made using the IBM SPSS Statistics 22.0 software. Categorical variables are reported as frequencies (percentages) and continuous variables as the mean ± standard deviation (SD) or the median and interquartile range (IQR), as appropriate. Statistical

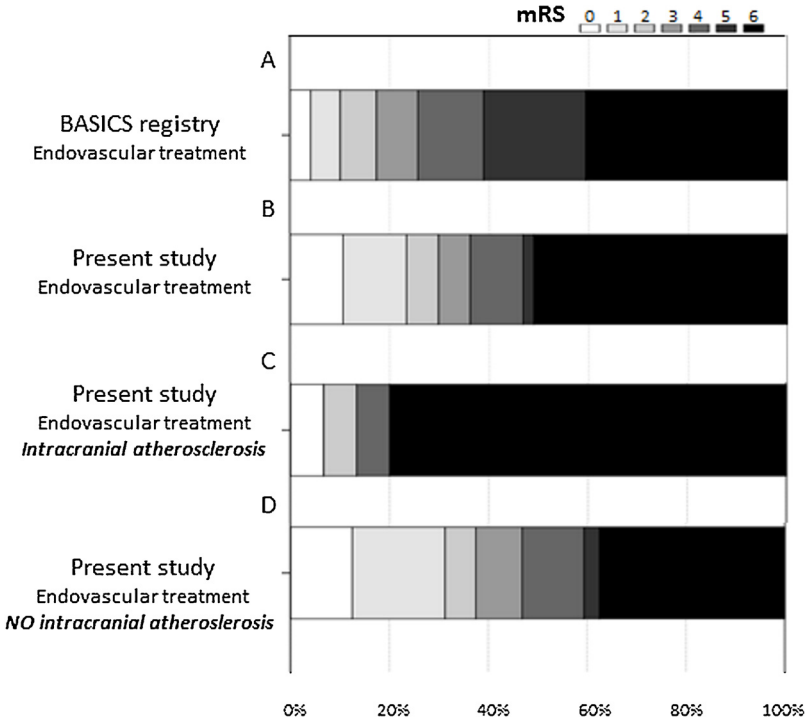

Fig. 1. Comparison of mRS distribution between the present study and the BASICS registry.
A: mRS distribution at 1 month post-treatment in all patients who underwent endovascular treatment in the BASICS registry (n = 288): B: mRS distribution at 3 months following endovascular treatment in all patients in the present study (n = 47), and in the same patients separated according to the presence (C) or absence (D) of intracranial atheromatosis. mRS, Modified Rankin Score.

significance in comparisons with outcome was assessed by the Pearson's chi-square test for categorical variables (sex, risk factors, stroke severity, tPA, atheromatous disease and device), except when at least one expected frequency in the contingency table was less than 5 (occlusion site and recanalization), where Fisher's exact test was used. Mean differences in age and cost between a poor and a good outcome were compared with the Student *t* test. Median time to treatment, scores obtained in neuroimaging evaluation and number of passes needed to achieve recanalization were compared with the Mann–Whitney *U* test. The relationship between thrombus burden and stroke severity was assessed using Spearman's correlation coefficient. A receiver operator characteristic (ROC) curve was configured to calculate a cut-off point for age with the best sensitivity and specificity to predict a good outcome; the optimal cut-off point was obtained using the maximum Youden Index value (sensitivity + specificity-1). Variables associated with statistical significance < 0.1 in the bivariate analysis were entered into a forward stepwise multivariate logistic regression model to identify factors independently associated with a good clinical outcome. *P*-values < 0.05 were considered statistically significant.

3. Results

Forty-nine consecutive patients were included. Two were excluded because of missing data for the 3-month mRS score, leaving a total of 47 patients. Mean age was 70.9 ± 12.1years, median NIHSS at admission was 16 (IQR: 8–30), and 19 (40.4%) patients had a severe stroke according to the study definition (NIHSS > 20 and/or coma-tetraparesis). In all patients except one, the baseline mRS was < 2. The primary treatment was stent retriever combined with suction thrombectomy (SOLUMBRA) in 34 patients, ADAPT (A Direct Aspiration First-Pass Technique) in 10, intra-arterial fibrinolysis in 1, angioplasty/stent alone in 1, and 1 had missing data.

The baseline clinical, imaging, and angiographic characteristics, and the univariate analysis results are shown in Table 1. On univariate analysis, patients with a good outcome were younger (p = 0.01), and showed a higher prevalence of smoking (p = 0.04) and lower prevalence of hypertension (p = 0.03). According to the ROC curve, a cut-off of 70 years predicted that a patient would have a good clinical outcome with a sensitivity of 70% and specificity of 70.6%. There were no differences in outcome between patients with severe stroke or mild stroke, or patients who had received or not previous intravenous rtPA thrombolysis. In comparison with the results of the BASICS study, there was a favorable shift in the distribution of the 90-day modified Rankin scale in patients with no intracranial atherosclerosis (Fig. 1).

Reperfusion was successful (mTICI2b/3) in 85% of patients (n = 40), 36.2% patients (n = 17) had a good outcome, and the mortality rate was 43% (n = 21) (Table 1). The rate of successful reperfusions was significantly higher in patients with a good outcome (p = 0.04).

The thrombus burden, collaterals, and BATMAN score were not

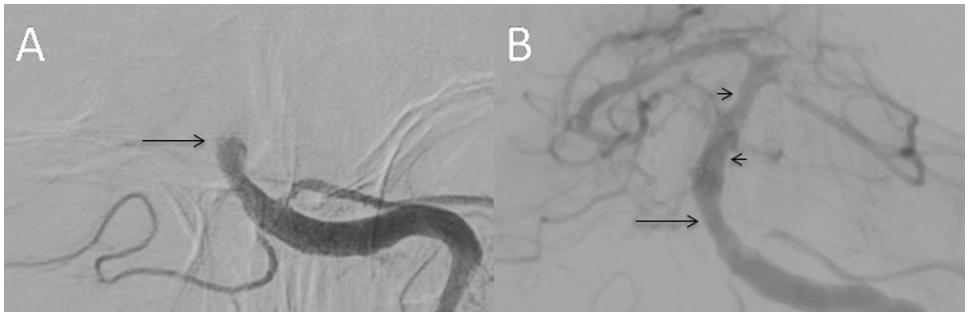

Fig. 2. Presence of angiographically defined intracranial atheromatous.
A: Preprocedure dynamic subtraction angiography. The angiogram shows basilar artery occlusion (arrow). B: Post-procedure angiography. After recanalization, a fixed focal stenosis is seen at the level of the occlusion (arrow). Moreover, multiple irregularities are evident in the basilar and cerebral posterior arteries (arrowheads).

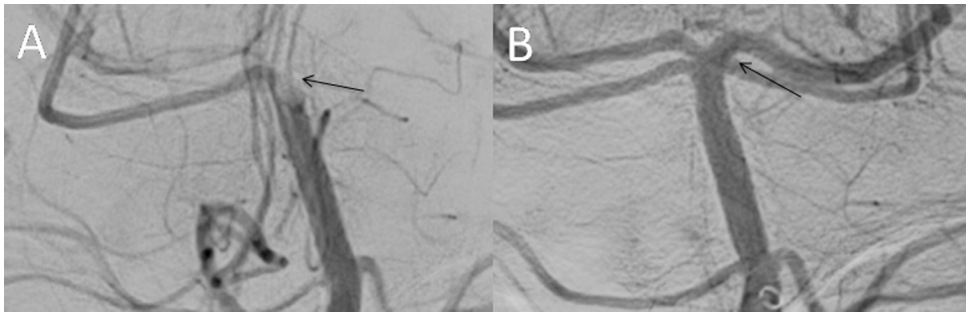

Fig. 3. Absence of angiographically defined intracranial atheromatous.
A: Preprocedure dynamic subtraction angiography. The angiogram shows occlusion at the top of the basilar artery (arrow). B: Postprocedure angiography. The angiogram shows complete recanalization.

Table 1
Baseline Clinical, Imaging, and Angiographic Parameters.

	Overall n = 47	Good outcome n = 17 (36.2%)	Poor outcome n = 30 (63.8%)	p-value
Demographics				
Age, mean ± SD	70.9 ± 12.1	63.6 ± 14.1	75.0 ± 8.7	0. 01
Sex, male	35 (74.5 %)	14 (82.4%)	21 (70.0%)	0. 49
Smoker	8 (17%)	6 (35.3%)	2 (6.7%)	0. 04
Hypertension	34 (72.3%)	9 (52.9%)	25 (83.3%)	0. 03
Diabetes	12 (25.5%)	2 (11.8%)	10 (33.3%)	0. 10
Dyslipidemia	21 (44.7%)	6 (35.3%)	15 (50%)	0. 33
Atrial fibrillation	12 (25.5%)	6 (35.3%)	6 (20%)	0. 31
Stroke severity				0. 59
Mild (focal)	28(59.6%)	11 (64.7%)	17 (56.7%)	
Severe (coma)	19 (40.4%)	6 (35.3%)	13 (43.3%)	
CT and CTA baseline				
PC ASPECTS	10 [9–10]	10 [10–10]	10 [8.5–10]	0. 08
PC BATMAN	5 [3–6]	6 [3.5–6.5]	4.5 [3–6]	0. 26
Thrombus burden	3 [1–3]	2 [0.5–3]	3 [1–3]	0. 51
Collaterals	0 [0–1]	0 [2–0]	0 [1–0]	0. 45
tPA	24 (51%)	8 (47.1%)	15 (50%)	0. 85
Angiographically defined occlusion site				0.39
PCA	9(19.1%)	5 (29.4%)	4 (13.3%)	
Basilar artery	34 (72.3%)	11 (64.7%)	23 (76.7%)	
Intracranial VA	4 (8.5%)	1 (5.9%)	3 (10%)	
Angiographically defined atheromatous disease				
Extracranial	8 (17%)	6 (35.3)	2 (6.7)	0. 02
Intracranial	15 (31.9%)	2 (11.8)	13 (43.3)	0. 03
No atherosclerosis	24 (51.1%)	9 (52.9)	15 (50%)	0. 85
Recanalization	40 (85.1%)	17 (100%)	23 (76.7%)	0. 04
Cost, euros	8149.94	6414.65	9131.97	0. 01

ASPECTS, Alberta Stroke Programme Early CT Score; BATMAN, Basilar Artery on Computed Tomography Angiography; CT, computed tomography; CTA, computed tomography angiography; NIHSS, National Institutes of Health Stroke Scale; PC, posterior circulation; PCA, posterior cerebral artery; tPA, intra-arterial tissue-type plasminogen activator; VA, Vertebral artery.
Values are expressed as the number (percentage) or the median [interquartile range], as appropriate.

significantly associated with outcome. The thrombus burden highly correlated with the NIHSS score at admission (R: 0.408, p = 0.004).

Intracranial atherosclerosis, defined as significant fixed stenosis occurring in the segment from the PICA origin in segment V4 of the vertebral artery to segment P3 of the PCA, was recorded in 15 patients; 80% of them (n = 12) had successful reperfusion and 13.3% (n = 2) a good outcome. Extracranial atherosclerosis was recorded in 8 patients; 100% had successful reperfusion and 75% (n = 6) a good outcome. Twenty-four patients showed no evidence of intracranial or extracranial atherosclerosis; 84.6% (n = 22) had successful reperfusion and 62.5% (n = 15) a good outcome.

With regard to the procedure characteristics, the median time interval since the patient was last seen as normal to puncture was 290 min (IQR 189–464 min), with no difference between patients with a good or poor outcome (p = 0.894) (Table 2). There were no differences in outcome between patients treated with stent retrievers and those treated with ADAPT (p = 0.31).

Table 2
Procedure Characteristics and Outcome.

	Overall	Good outcome (34%)	Poor outcome (61%)	P values
Time to treatment				
OTGT, min, mean (range)	290 (189–464)	284 (196–470)	292 (169–415)	0.894
OTGT > 3 h		14 (82.4%)	22 (73.3%)	0.483
OTRT, min, mean (range)	355 (215–494)	323 (214–498)	365 (214–474)	0.879
OTRT > 3 h	43 (87.8%)	16 (94.1%)	25 (83.3%)	0.396
Number of passes	(55%, 1 pass)	1 (1–1.5)	2 (1–4)	0.009
More than 1 pass		4 (18.2%)	18 (81.8%)	0.016
More than 2 passes		1 (7.7%)	12 (92.3%)	0.012

OTGT, mean time from onset of symptoms to groin puncture; OTRT, mean time from onset of symptoms to recanalization. Values are expressed as the number (percent), unless otherwise indicated.

Significant differences in the number of passes of the device needed to achieve recanalization were found between patients with a good outcome and those with a poor outcome (median 1, IQR 1–1.5 vs 2, IQR 1–4, respectively; p = 0.009). Outcome was good in 18.2% of patients needing more than 1 device pass, and in 7.7% of patients needing more than 2 passes, (p = 0.016 and 0.012, respectively) (Table 2).

In 7 of the 15 patients with intracranial atherosclerosis, stenting and/or angioplasty were needed to achieve recanalization; in one of them, recanalization could not be achieved (TICI 0).

We found no differences in outcome according to the location of the occlusion (PCA, basilar artery, intracranial vertebral artery), and because of the small sample size, we were unable to perform subgroup analyses.

On multivariate analysis, only the absence of intracranial atherosclerosis (odds ratio 6.450, 95%CI 1.088–38.240; p = 0.040) and age < 70 years (odds ratio 6.2, 95%CI 1.516–25.465; p = 0.01) were independently associated with a good outcome at 90 days.

4. Discussion

Endovascular treatment techniques are being used in acute posterior circulation stroke, but it remains unclear which patients will benefit the most from this treatment. In our study, the absence of intracranial atheromatous disease and age < 70 years were independent predictors of a good response following endovascular treatment for acute posterior circulation stroke. Absence of intracranial atherosclerosis increased the likelihood of having a good functional outcome by 6-fold. Hence, absence of intracranial atherosclerosis may have value as a positive

selection criterion for endovascular treatment in patients with posterior circulation stroke in future trials.

Intracranial atherosclerosis was present in 30% of our patients, which is in line with epidemiologic [2] and histopathologic findings [1] in posterior circulation stroke. In particular, it is well recognized that the basilar artery is the most common intracranial site of atheromatous disease. In addition, histopathological findings in the brain suggest that intracranial atherosclerosis is rarely restricted to a single artery, but rather, is diffuse and widespread [13]. The presence of diffuse atheromatous disease may hamper the effect of successful recanalization of the occlusive lesion on the clinical outcome.

Our results extend previous findings showing that intracranial atherosclerosis is a negative prognostic factor, obtained in Asian populations. Two previous studies reported that intracranial atheromatous disease is predictive of a poorer clinical outcome in patients with posterior circulation stroke [14,15]. However, these studies, performed in Chinese and Korean populations, applied very strict exclusion criteria and this may have limited the generalizability of their findings. Our results come from an unselected Caucasian population and are relevant to the current practice for posterior circulation stroke in Western countries.

Last year, two additional studies were published evaluating endovascular treatment in acute basilar occlusion in South Korea [16] and China [17] and both concluded that endovascular treatment is safe and effective in these patients. Kang et al. [16] found intracranial stenosis at the occlusion site in 55 of 212 (25.9%) patients, and Li et al. [17] reported the same finding in 40 of 68 (58.8%). The relationship between intracranial stenosis and clinical outcome was not investigated in either of these studies. Both authors concluded that an optimal treatment strategy is needed in patients with acute basilar occlusion caused by underlying stenosis.

The second finding of note in the present study is the association between younger age and a favorable clinical outcome, with age being an independent predictor of the response to endovascular treatment. Age is a classic predictor of outcome in stroke patients. However, in recent retrospective studies of patients with posterior circulation stroke, those with a good outcome were younger, but age was not an independent predictor of the response to endovascular treatment [5,6]. In these previous studies, the mean age of the case series was younger than ours (63 or 64 years vs 70 years in our study). Thus, their results may have been influenced by the younger age of the patients, whereas our results come from a consecutive, unselected population.

In the univariate analysis, extracranial atheromatous disease, defined as significant fixed stenosis from the origin of the vertebral artery to the V4 segment, was associated with a good response to endovascular treatment ($p = 0.019$). However, extracranial atherosclerosis was strongly associated with age, suggesting that the results in these patients were likely affected by bias: younger age in patients with extracranial atheromatosis could certainly have helped functional recovery after stroke and be responsible for their good outcome. An additional factor that could have contributed to this result is suggested in a recent study reporting that patients with intracranial or extracranial atherosclerosis of the anterior circulation differ with respect to the presence of a circulating metabolite associated with glucose intolerance [18]. The concept that extracranial or intracranial atherosclerosis may reflect the patient's intrinsic metabolic characteristics and additionally influence the response to endovascular therapy should be addressed in further studies.

In the present study, age, atherosclerosis, and successful recanalization were predictors of a response to treatment, whereas stroke severity at presentation was not. This last finding is interesting, but not surprising, as patients with mild stroke (low admission NIHSS score) may have a poor outcome [19], whereas others with severe stroke may experience a good outcome. Stroke severity at presentation (admission NIHSS) correlated with thrombus length (a component of the BATMAN score) in accordance with previous results [20]. The Batman score was nonsignificantly higher (median 6, IR 3–6) in patients with a good outcome than in those with a poor outcome (median 4, IR 3–6) ($p = 0.25$). This finding suggests that stroke severity at presentation and thrombus length do not have an influence on treatment response and should not be taken into consideration when deciding on treatment for posterior circulation stroke.

Furthermore, there were no significant differences in the Pc-ASPECTS score between patients with a good (median 10, IQR 10–10) or a poor outcome (median 10, IQR 8.5–10) ($p = 0.08$). This may have been related to the relatively short mean time (290 min) from the onset of symptoms to groin puncture in our center. Furthermore, Pc-ASPECTS evaluation did not enable differentiation of patients with ischemia in life-threating brain regions, such as the pons or mesencephalon, and this may also have been related to the low association with clinical outcome.

Our results complement those of previous studies [5,6] reporting that recanalization should be as complete as possible in this population, as all our patients with a good outcome had complete recanalization. However, the treating neuroradiologist should be aware that when a larger number of passes are needed to achieve recanalization, the probability of achieving a good outcome significantly decreases (18.2% when more than 1 pass was needed, 7.7% when more than 2 passes; $p = 0.016$ and $p = 0.012$).

We found no differences in outcome between patients treated with stent retrievers combined with suction and those undergoing the ADAPT strategy, in accordance with previous results [21]. As different mechanical thrombectomy approaches were used in our patients, this may have introduced some heterogeneity in the results. This variation in treatments highlights the need to optimize the management of these patients.

Another procedure-related factor to consider is the anesthesia used. In our clinical practice conscious sedation is used in most patients, with general anesthesia being applied according to the patient's state of agitation and consciousness level. In the study patients, those with severe stroke were more likely to be treated under general anesthesia, whereas those with focal signs received conscious sedation. An analysis according to type of anesthesia used was not performed, but there were no differences in clinical outcome between patients with severe or mild stroke. To our knowledge, only one previous retrospective study has evaluated the effect of general anesthesia on the distribution of modified Rankin scale scores in posterior circulation stroke patients undergoing mechanical thrombectomy. No association was found between the anesthesia modality and the clinical outcome [22]. However, the study excluded patients who had been intubated before arriving to the endovascular suite, whereas most of our patients were intubated prior to arrival at our center. This difference makes comparison between the two studies difficult.

Smoking was found to be related to a favorable outcome, as others have reported [5]. Even though there are data supporting a phenomenon termed *smoking-thrombolysis paradox* [5], we cannot affirm that the favorable association we found was not secondary to selection bias.

In this study, the distribution of mRS values at 90 days was comparable to that of the BASICS study. However in patients with no intracranial atherosclerosis, there was a favorable shift in the distribution of the 90-day modified Rankin score, which supports the notion that an absence of intracranial atheromatosis is an outcome predictor following endovascular treatment for posterior circulation stroke.

Clinical practice guidelines containing recommendations with strong levels of evidence for treating posterior circulation stroke are lacking [4]. The primary results of the recent BEST (Acute Basilar Artery Occlusion: Endovascular Interventions vs Standard Medical Treatment) [23] randomized clinical trial were recently presented [24]. The trial was terminated prematurely due to a high crossover rate and negative results in the intention-to-treat (ITT) analysis. Nonetheless, the per-protocol and as-treated analyses found higher rates of good clinical outcomes ($p = 0.036$ and $p = 0.008$, respectively) [24] in patients who

received endovascular treatment. These results are promising, as they provide an indication that endovascular treatment in basilar artery occlusion may result in more favorable outcomes.

New clinical trials aimed at individualizing the type of treatment in posterior circulation disease are considered to be warranted [25], and detection of intracranial atheromatosis could be used as a selection tool for randomization to new treatment protocols. We suggest that the presence or absence of intracranial atherosclerosis should be incorporated as a prognostic factor in clinical trials addressing treatment for this condition. The finding of an absence or presence of intracranial atherosclerosis could also be of value in daily clinical management of these patients, as it would enable early estimation of the prognosis after endovascular treatment.

This study has the limitation of a small sample size, which could have contributed to the lack of correlation between the BATMAN score and the prognosis, and the correlation between smoking and a favorable outcome. However, in our view, it is representative of the routine clinical practice for the management of posterior circulation stroke patients in comprehensive stroke centers with a high level of expertise in endovascular treatment of ischemic stroke.

5. Conclusions

The results of this study suggest that stroke patients aged < 70 years with an angiographically proven absence of intracranial atheromatous disease of the posterior circulation are likely to respond well to endovascular revascularization, whereas patients showing this finding are more likely to respond poorly. In our study, there were no further clinical or imaging predictors of response following endovascular treatment. Pretreatment findings of an absence or presence of intracranial atherosclerosis may be of value when deciding on the management of posterior circulation stroke patients and could be a selection criterion for use in new clinical trials aimed at defining an effective individualized type of treatment for this population.

Conflict of interests

None.

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