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The safety and effectiveness of endovascular treatment for patients with vertebrobasilar artery occlusions: according to the BEST and BASICS criteria

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Abstract

Background: Whether endovascular treatment (EVT) is safe and effective for vertebrobasilar artery occlusion (VBAO) is yet incompletely understood. Two RCTs, the endovascular treatment *versus* standard medical treatment for vertebrobasilar artery occlusion (BEST) trail and the Basilar Artery International Cooperation Study (BASICS), concentrating on this field were recently reported.

Objective: We use real-world registry data of VBAO to compare the outcome of EVT inside and outside the inclusion and exclusion criteria of the BEST and BASICS study to testify the feasibility of the selection paradigms of VBAO in these trials.

Methods: Consecutive patients with VBAO receiving EVT involving 21 stroke centers were retrospectively included. The safety outcomes [3-month mortality, symptomatic intracranial hemorrhage (sICH), and effectiveness outcomes (the proportion of 3-month functional independence (mRS of 0–2) and favorable outcome (mRS of 0–3)] were compared between VBAO patients who meet or failed to meet the BEST/BASICS selection criteria for EVT.

Results: Our study cohort consisted of 577 VBAO patients who underwent EVT. Of them, 446 patients had pc-ASPECTS ≧8. Successful reperfusion (mTICI 2b or 3) was achieved in 85.4% ($n = 493$). There were 418 patients fulfilling the BEST criterion for EVT and 194 fulfilling the BASICS criterion. Regression analysis indicated that adherence to BEST or BASICS criterion for EVT was not independently related to most of the safety and effectiveness outcome except that adherence to BEST was significantly associated with the 3-month favorable outcome (OR_{BEST}: 1.742, 95% CI: 1.087–2.790). However, when we put pc-ASPECTS into both criteria with a cut-off value of 8, meeting both BEST criterion plus pc-ASPECTS and BASICS criterion plus pc-ASPECTS was independently related to 3-month functional independence (OR_{BEST}: 1.687, 95% CI: 1.077–2.644; OR_{BASIC}: 1.653, 95% CI: 1.038–2.631) and favorable outcome (OR_{BEST}: 2.280, 95% CI: 1.484–3.502; OR_{BASIC}: 2.153, 95% CI: 1.372–3.378).

Conclusion: Our study indicated that, based on real-world data of EVT, adherence to BEST or BASICS criterion for EVT was not independently associated with the safety and effectiveness outcome except that adherence to BEST was significantly related to the 3-month favorable outcome. However, the BEST or BASICS selection criterion and pc-ASPECTS ≧8 might be better paradigms for EVT patient selection.

Keywords: endovascular treatment, inclusive criteria, outcomes, stroke, vertebrobasilar artery occlusions

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Introduction

Acute vertebrobasilar artery occlusion (VBAO), accounting for about 1% of all ischemic strokes, is associated with high mortality and disability of up to 70%, which represents the most devastating type of ischemic stroke.[1–4]

Previous large trials had indicated an overwhelming benefit of endovascular treatment (EVT) for treating acute anterior circulation ischemic stroke due to emergent large vessel occlusion.[5–8] However, whether EVT is safe and effective for patients with acute VBAO is yet incompletely understood.[9–11]

Recently, two multicenter, randomized controlled trials (RCTs), the endovascular treatment *versus* standard medical treatment for vertebrobasilar artery occlusion trial (BEST) and the Basilar Artery International Cooperation Study (BASICS), failed to indicate the superiority of EVT over standard medical treatment.[12,13] Despite that, it is still believed in clinical practice that EVT might be helpful for VBAO in case of proper patient selection. We hypothesized that the inclusion and exclusion protocols for EVT in BEST and BASICS are suboptimal for selecting the real patients who need EVT, which might partly explain the negative results of both studies. We therefore use a real-world multicenter database to compare the safety and effectiveness of EVT for patients with VBAO according to the current BEST/BASICS selection criteria for EVT.

Furthermore, the Acute Stroke Prognosis Early Computed Tomography Score (ASPECTS) is a standardized semi-quantitative computed tomographic (CT) grading system used to assess early ischemic changes and predict functional outcomes and ischemic core volumes in patients with acute anterior circulation ischemic stroke.[14] Low ASPECTS has been reported to be associated with poor functional outcome after reperfusion and was adopted as one of the exclusion criteria in several trails in acute anterior circulation ischemic stroke.[6,15–17] The posterior circulation ASPECTS (pc-ASPECTS), first proposed by Puetz *et al.*, was considered as one of the factors associated with functional outcome and mortality in patients with acute VBAO.[18] Several studies have shown that pc-ASPECTS <8 could also identify patients unlikely to achieve favorable outcomes despite successful reperfusion of the basilar artery.[18,19] However, neither the BEST nor the BASICS trial investigators included pc-ASPECTS evaluation in the inclusion criteria. Therefore, we further tried to consider pc-ASPECTS $\geqq 8$ as an additional selection criterion and analyzed the safety and effectiveness of EVT divided by the new selection criterion.

Methods

Study design and participants

The study was conducted based on the PostErior ciRculation iSchemIc Stroke regisTry (PERSIST), a multicenter EVT registry program of VBAO patients treated with EVT in China (registration: URL: http://www.chictr.org.cn/; unique identifier: ChiCTR2000033211). The study was approved by the ethics committee of First Affiliated Hospital of University of Science and Technology of China (2020KY-40). Due to its retrospective nature, the need for patient consent was waived. The details of the registry have been published elsewhere.[20] In brief, it is a multicenter retrospective registry program of consecutive posterior circulation ischemic stroke patients with acute, symptomatic, radiologically confirmed VBAO (basilar artery occlusion or vertebral artery occlusion resulting in no flow to the basilar artery) who were treated with EVT. The inclusion and exclusion criteria of the registry along with the BEST and BASICS selection criteria are listed in Table s1.

In this study, all cases of the real-world registry were coded as either meeting or not meeting BEST/BASICS criteria for EVT. The safety and effectiveness outcomes were compared, respectively.

Baseline characteristics

Patients' baseline and clinical characteristics [e.g. demographic data, National Institutes of Health Stroke Scale (NIHSS) score, laboratory test results, neurovascular images, operative information, and perioperative management] were retrospectively obtained by reviewing medical records. Details of the data are available in Table 2.

The pc-ASPECTS was graded according to the previous description.[18] And each region was scored 0 if abnormal or 1 if normal. A higher pc-ASPECTS represents a smaller infarct. Two neuroradiologists, who were blind to clinical outcomes and treatment assignment, retrospectively evaluated the

neuroimaging parameters to include pc-ASPECTS on non-contrast computed tomography (NCCT) and occlusion site on digital subtraction angiography (DSA). If there was a dispute, the final result was reached through consultation. The intraclass correlation coefficient for pc-ASPECTS was 0.493. However, we use the pc-ASPECTS ≧8 points as the cut-off for dichotomy; the interrater variability (κ) was 0.744 for the identification of the pc-ASPECTS ≧8. The occlusion site of 'basilar artery + vertebral artery' was defined as an occlusion of the vertebral artery resulting in no flow to the basilar artery, and the occlusion site of 'basilar artery' was limited to only basilar artery occlusion. If there is any disagreement, the final assessment was confirmed on the basis of consensus.

Outcome measurement

All patients had a CT or magnetic resonance imaging (MRI) scan within 48 h after EVT to assess hemorrhagic complications. The functional outcome of all patients was assessed by modified Rankin scale (mRS) at 3 months after stroke onset.

The primary effectiveness endpoint is 3-month functional independence, defined as an mRS score of ≦2. Favorable outcome is defined as a 3-month mRS score ≦3. Successful reperfusion is defined as a modified Thrombolysis in Cerebral Infarction (mTICI) scale score of 2b to 3.

The primary safety outcomes of this study include symptomatic intracranial hemorrhage (sICH) and mortality at 90 days after EVT. sICH was defined, based on Heidelberg Bleeding Classification, as a newly observed ICH on imaging that was related to any of the following conditions: (1) an NIHSS score that increased more than 4 points; (2) an NIHSS score that increased more than 2 points in a category; and (3) deterioration that led to hemicraniectomy, external ventricular drain placement, intubation, or other major medical interventions. There were no other explanations for symptom deteriorations.[21] After enrolling all patients, two neuroradiologists, who were unaware of the clinical data, the intervention, and outcomes, retrospectively evaluated the occlusion site and the presence of sICH and mTICI.

Statistical analyses

Differences between the two groups were tested using the Pearson's Chi-square tests for categorical values and the *t* test or Mann–Whitney *U* test for continuous variables, as appropriate.

Multivariable logistic regression models were used to evaluate the associations between EVT performed in accordance with or against BEST, BEST + pc-ASPECTS ≧8, or BASICS criterion, BASICS + pc-ASPECTS ≧8 with mRS (0–2 and 0–3) at 3 months, 3-month mortality, and sICH after adjusting for potential confounders with $p < 0.20$ on univariate analysis. Associations are presented as odds ratios (ORs) and 95% confidence intervals (CIs). All tests were two-tailed and statistical significance was determined at $p < 0.05$. All statistical analyses were performed using the SPSS software package (version 24.0).

Result

Registry characteristics

A total of 577 VBAO patients across 21 stroke centers undergoing EVT were included in the analysis; the average age was 63.51 ± 12.89 years. The median NIHSS score of included patients at admission was 23 [interquartile range (IQR), 14–29]. In our cohort, 446 patients had pc-ASPECTS ≧8. Successful reperfusion (mTICI 2b and 3) was achieved in 85.4% ($n = 493$) of patients. Three-month functional independence (mRS 0–2) was found in 176 (30.5%), favorable outcome (mRS 0–3) at 3 months in 222 (38.5%), and death within 3 months in 216 patients (37.4%). A total of 38 patients (6.6%) experienced sICH.

Outcomes of EVT according to the BEST criterion

The most common reason for non-adherence to BEST criterion was the delayed treatment time window in our registry. Of the 577 VBAO patients, 418 patients fulfilled the BEST criterion for EVT (As shown in Flow Chart). Compared with the 159 patients against BEST, significant differences were found in atrial fibrillation (AF) ($p = 0.011$), baseline NIHSS score ($p = 0.039$), intravenous tissue plasminogen activator (IV tPA) treatment ($p < 0.001$), estimated occlusion to groin puncture time ($p < 0.001$), groin puncture to reperfusion time ($p = 0.002$), and reduction in NIHSS score at discharge ($p < 0.001$). In terms of the sICH, 3-month mortality, 3-month functional independence, and favorable outcome, no significant differences were observed between groups according to the BEST criterion (Table 1).

Table 1. Baseline characteristics and outcomes (effectiveness and safety) of the study population stratified according to the BEST/BASICS criterion.

Variable	Total number (*N* = 577)	Cases meeting BEST criterion		*p* value	Cases meeting BASICS criterion		*p* value
		Yes (*n* = 418)	No (*n* = 159)		Ye (*n* = 194)	No (*n* = 383)	
Baseline characteristics							
Age, years, mean (SD)	63.51 ± 12.89	63.99 ± 12.81	62.26 ± 13.05	0.149	64.50 ± 14.02	62.51 ± 12.97	0.111
Female, *n* (%)	164 (28.4)	110 (26.3)	54 (34.0)	0.069	53 (33.3)	111 (26.6)	0.107
Hypertension, *n* (%)	390 (67.6)	286 (68.4)	104 (65.4)	0.490	132 (68.0)	258 (67.4)	0.869
Diabetes mellitus, *n* (%)	129 (22.4)	90 (21.5)	39 (24.5)	0.440	41 (21.1)	88 (23.0)	0.616
Previous TIA or stroke, *n* (%)	116 (20.1)	85 (20.3)	31 (19.5)	0.822	36 (18.6)	80 (20.9)	0.509
Smoking, *N* (%)	181 (31.4)	126 (30.1)	55 (34.8)	0.282	63 (32.5)	118 (30.9)	0.699
Drinking, *n* (%)	113 (19.6)	80 (19.1)	33 (20.9)	0.638	39 (20.1)	74 (19.4)	0.835
AF, *n* (%)	128 (22.2)	104 (24.9)	24 (15.1)	0.011	67 (34.5)	61 (15.9)	< 0.001
Initial NIHSS, median (IQR)	23 (14 to 29)	23 (15 to 29.25)	20 (12 to 28)	0.039	23 (14 to 30)	23 (14 to 28)	0.927
Pretreatment with IV thrombolysis, *n* (%)	104 (18.0)	93 (22.2)	11 (6.9)	< 0.001	38 (19.6)	66 (17.2)	0.487
Estimated occlusion to groin puncture time, h, median (IQR)	5.67 (3.83 to 8.54)	4.5 (3.46 to 6.0)	10.7 (9.25 to 14.5)	<0.001	4.3 (3.3 to 5.4)	7 (4.5 to 10.0)	<0.001
Collateral status, *n* (%)				0.329			0.968
ASITN/SIR grade 0–1	381 (66.0)	277 (66.3)	104 (65.4)		128 (66.0)	253 (66.1)	
ASITN/SIR grade 2	133 (23.1)	100 (23.9)	33 (20.8)		44 (22.7)	89 (23.2)	
ASITN/SIR grade 3–4	63 (10.9)	41 (9.8)	22 (13.8)		22 (11.3)	41 (10.7)	
BATMAN score, median (IQR)	5 (3 to 7)	5 (3 to 7)	4 (2 to 7)	0.476	5 (3 to 7)	4 (2 to 7)	0.193
Effectiveness outcomes							
Groin to reperfusion time, min, median (IQR)	110 (75 to 159)	105 (70 to 148.25)	120 (81.5 to 180)	0.002	100 (62.5 to 135)	111 (80 to 170)	0.001
mTICI ≧2b, *n* (%)	493 (85.4)	357 (85.4)	136 (85.5)	0.969	170 (87.6)	323 (84.3)	0.289
Reduction in NIHSS score at discharge, median (IQR)	−4 (−12 to 7)	−4 (−13 to 5)	0 (−7 to 10)	<0.001	−4 (−12.3 to 4.3)	−3 (−11 to 8)	0.115
mRS 0–2 at 3 months, *n* (%)	176 (30.5)	135 (32.3)	41 (25.8)	0.129	64 (33.0)	112 (29.2)	0.356
mRS 0-3 at 3 months, *N* (%)	222 (38.5)	171 (40.9)	51 (32.9)	0.051	82 (42.3)	140 (36.6)	0.183
Safety outcome							
sICH, *n* (%)	38 (6.6)	25 (6.0)	13 (8.2)	0.342	11 (5.7)	27 (7.0)	0.528
Mortality at 90 days, *n* (%)	216 (37.4)	151 (36.1)	65 (40.9)	0.292	71 (36.6)	145 (37.9)	0.767

AF, atrial fibrillation; BASICS, Basilar Artery International Cooperation Study; BEST, endovascular treatment *versus* standard medical treatment for vertebrobasilar artery occlusion; IQR, interquartile range; IV, intravenous thrombolysis; mRS, modified Rankin scale; mTICI, modified Thrombolysis in Cerebral Infarction; NIHSS, National Institutes of Health Stroke Scale; SD, standard deviation; sICH = symptomatic intracranial hemorrhage.

Table 2. Association of compliance with BEST criterion with or without pc-ASPECTS ≧8 with outcomes on multivariable logistic regression models adjusting for potential confounders.

Outcome	Compliance with BEST criterion		Compliance with BEST criterion + pc-ASPECTS ≧8	
	OR (95%CI)	P	OR (95%CI)	*p* value
sICH[a]	1.040 (0.336–3.217)	0.946	0.441 (0.198–0.984)	0.046
mRS 0–2 at 3 months[b]	1.375 (0.841–2.249)	0.204	1.687 (1.077–2.644)	0.022
mRS 0–3 at 3 months[c]	1.742 (1.087–2.790)	0.021	2.280 (1.484–3.502)	0.000
Mortality at 90 days[d]	0.733 (0.478–1.123)	0.154	0.684 (0.463–1.009)	0.055

AF, atrial fibrillation; BEST, endovascular treatment *versus* standard medical treatment for vertebrobasilar artery occlusion; BP, blood pressure; DM, diabetes mellitus; mRS, modified Rankin scale; mTICI, modified Thrombolysis in Cerebral Infarction; IV, intravenous; NIHSS, National Institutes of Health Stroke Scale; pc-ASPECTS, posterior circulation Acute Stroke Prognosis Early Computed Tomography Score; sICH, symptomatic intracranial hemorrhage.
[a]Adjustment by AF (0.065), initial NIHSS (0.131), estimated occlusion to groin puncture time (0.150).
[b]Adjustment by age (0.003), female (0.003), BP (0.124), DM (0.014), pretreatment with IV thrombolysis (0.008), mTICI ≧2b (0.000), groin to reperfusion time (0.031), initial NIHSS (0.000).
[c]Adjustment by age (0.004), female (0.055), BP (0.197), DM (0.076), pretreatment with IV thrombolysis (0.014), mTICI ≧2b (0.000), groin to reperfusion time (0.034), initial NIHSS (0.000).
[d]Adjustment by age (0.005), BP (0.098), pretreatment with IV thrombolysis (0.026), mTICI ≧2b (0.000), initial NIHSS (0.000), groin to reperfusion time (0.006).

Table 2 summarizes compliance with BEST criterion in relationship to sICH, 3-month mortality, and 3-month functional independence and favorable outcome using multivariable logistic regression models adjusting for potential confounders. Adherence to BEST criterion for EVT was not independently related to the 3-month functional independence (OR: 1.375, 95% CI: 0.841–2.249), sICH (OR: 1.040, 95% CI: 0.336–3.217), and 3-month mortality (OR: 0.733, 95% CI: 0.478–1.123) after EVT, while adherence to BEST was significantly associated with the 3-month favorable outcome (BEST: OR: 1.742, 95% CI: 1.087–2.790).

In our registry, 446 patients had pc-ASPECTS ≧8. Univariate analysis suggested that patients fulfilling BEST inclusive criteria + pc-ASPECTS ≧8 had a higher prevalence of functional independence ($p < 0.001$) and favorable outcome ($p < 0.001$) and a lower prevalence of sICH ($p = 0.012$) and 3-month mortality ($p = 0.013$) compared with those who do not (Table s2). After adjusting for potential confounders, meeting both the BEST criterion and pc-ASPECTS ≧8 was independently related to sICH (OR: 0.441, 95% CI: 0.198–0.984) and 3-month functional independence (OR: 1.687, 95% CI: 1.077–2.644) and favorable outcome (OR: 2.280, 95% CI: 1.484–3.502), but not independently related to 3-month mortality (OR: 0.684, 95% CI: 0.463–1.009) (Table 2).

The distribution of mRS scores in VBAO patients treated with EVT at 3 months according to the BEST criterion and BEST criterion + pc-ASPECTS ≧8 is displayed in Figure 1. There was no significant difference in the distribution of mRS scores between patients with EVT meeting the BEST criterion and those outside the selection criteria ($p = 0.207$). However, the distribution of mRS scores between patients with EVT meeting the BEST criterion + pc-ASPECTS ≧8 and those outside the selection criteria was significantly different ($p < 0.001$).

Outcomes of EVT according to the BASICS criterion

A total of 194 patients underwent EVT fulfilling the BASICS criterion (only the final version of the BASICS selection criterion was applied as shown in Flow Chart). The most two common reasons for non-adherence to BASICS selection criteria were occlusion location and delayed treatment window. Patients meeting BASICS criterion for EVT tended to have a higher prevalence of AF ($p < 0.001$). The estimated occlusion to groin puncture time ($p < 0.001$) and groin puncture to reperfusion time ($p = 0.001$) were significantly shorter in patients with EVT

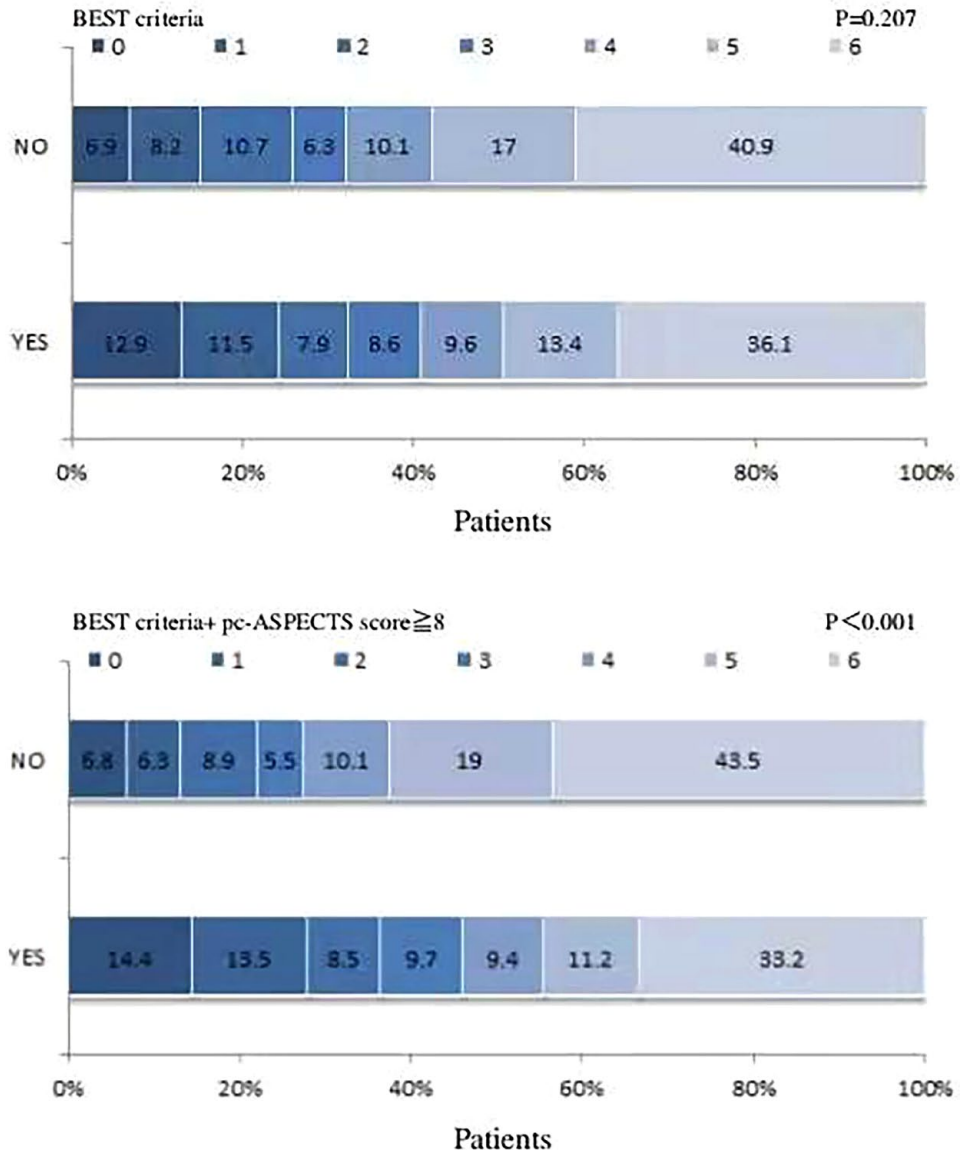

Figure 1. Distribution of 3-month modified Rankin scale (mRS) scores according to adherence to the BEST criterion.

fulfilling BASICS inclusive criteria (Table 1). After adjusting for potential confounders, adherence to BASICS criterion for EVT was not independently related to 3-month mRS functional independence (OR: 1.074, 95% CI: 0.683–1.688), 3-month favorable outcome (OR: 1.205, 95%CI: 0.784–1.852), sICH (OR: 0.833, 95%CI: 0.373–1.861), and 3-month mortality (OR: 1.031, 95% CI: 0.687–1.547) (Table 3). Besides, we also get similar outcome when we compare the effectiveness and safety outcomes in subgroups stratified on the basis of the BASICS inclusive criteria for the occlusion location and time from onset to groin puncture. The results are listed in Table s3 and s4.

In our registry, 158 patients fulfilling BASICS criterion had a pc-ASPECTS ≧8. Univariate analysis showed that patients fulfilling both BASICS criterion and pc-ASPECTS ≧8 had a higher prevalence of functional independence ($p < 0.001$) and favorable outcome ($p < 0.001$) and a lower prevalence of sICH ($p = 0.032$) (Table s2). Logistic regression analysis suggested that fulfilling both BASICS criterion and pc-ASPECTS ≧8 was independently related to 3-month mRS functional

Table 3. Association of compliance with BASICS criterion with or without pc-ASPECTS ≧8 with outcomes on multivariable logistic regression models adjusting for potential confounders.

Outcome	Compliance with BASICS criterion		Compliance with BASICS criterion + pc-ASPECTS ≧8	
	OR (95%CI)	*p* value	OR (95%CI)	*p* value
sICH[a]	0.833 (0.373–1.861)	0.655	0.603 (0.247–1.474)	0.268
mRS 0–2 at 3 months[b]	1.074 (0.683–1.688)	0.758	1.653 (1.038–2.631)	0.034
mRS 0–3 at 3 months[c]	1.205 (0.784–1.852)	0.395	2.153 (1.372–3.378)	0.001
Mortality at 90 days[d]	1.031 (0.687–1.547)	0.883	0.793 (0.511–1.231)	0.301

AF, atrial fibrillation; BASICS, Basilar Artery International Cooperation Study; mRS, modified Rankin Scale; BP, blood pressure; DM, diabetes mellitus; mRS, modified Rankin scale; mTICI, modified Thrombolysis in Cerebral Infarction; IV, intravenous; NIHSS, National Institutes of Health Stroke Scale; pc-ASPECTS, posterior circulation Acute Stroke Prognosis Early Computed Tomography Score; sICH, symptomatic intracranial hemorrhage.
[a]Adjustment by AF (0.065), initial NIHSS (0.131), estimated occlusion to groin puncture time (0.150).
[b]Adjustment by age (0.003), female (0.003), BP (0.124), DM (0.014), pretreatment with IV thrombolysis (0.008), mTICI ≧2b (0.000), groin to reperfusion time (0.031), initial NIHSS (0.000).
[c]Adjustment by age (0.004), female (0.055), BP (0.197), DM (0.076), pretreatment with IV thrombolysis (0.014), mTICI ≧2b (0.000), groin to reperfusion time (0.034), initial NIHSS (0.000).
[d]Adjustment by age (0.005), BP (0.098), pretreatment with IV thrombolysis (0.026), mTICI ≧2b (0.000), initial NIHSS (0.000), groin to reperfusion time (0.006).

independence (OR: 1.653, 95% CI: 1.038–2.631) and favorable outcome (OE: 2.153, 95% CI: 1.372–3.378) (Table 3).

The distribution of mRS scores in VBAO with EVT at 3 months according to meeting the BASICS criterion and BASICS criterion + pc-ASPECTS ≧8 is displayed in Figure 2. No significant difference in the distribution of mRS scores was found between groups ($p = 0.421$). But the distribution of mRS scores between patients with EVT meeting the BEST criterion + pc-ASPECTS ≧8 and those outside the selection criteria was significantly different ($p = 0.001$).

Discussion

Our study indicated that, based on the real-world data of EVT, adherence to BEST or BASICS criterion for EVT was not independently associated with safety outcomes (sICH and 3-month mortality) and effectiveness outcome (3-month functional independence and favorable outcome) except that adherence to BEST was significantly related to 3-month favorable outcome. However, we put pc-ASPECTS ≧8 as an additional inclusion criterion for both BEST and BASICS selection criteria; most of the safety and effectiveness outcome turned to be statistically significant.

In our retrospective registry, the most common reason for not meeting BEST/BASICS inclusive criteria for EVT was the delayed treatment window. The adjusted analysis of our data demonstrated that EVT can be performed outside the recommended time window with equal effectiveness and without increased proportion of sICH and mortality when compared with the group treated within the recommended time window. It consisted of some previous published data.[12,13,22] The results suggested that the time window for patients with VBAO seemed less important than that in anterior circulation. We believed that the diversity in clinical courses and feature interferes with the time selection for EVT in patients with VBAO.[18,22,23]

The second reason for not meeting the BASICS criterion for EVT was the location of occlusion. In our registry, isolated basilar artery occlusion was found in 303 patients. Compared with the other occlusion site, the safety and effectiveness of EVT were similar. The reason may be attributed to the fact that damage caused by the harassment of perforating artery in the procedure of recanalization of isolated basilar artery might be balanced by the damage caused by the absence of compensatory capacity of collaterals such as posterior inferior cerebellar artery in vertebral artery occlusion.

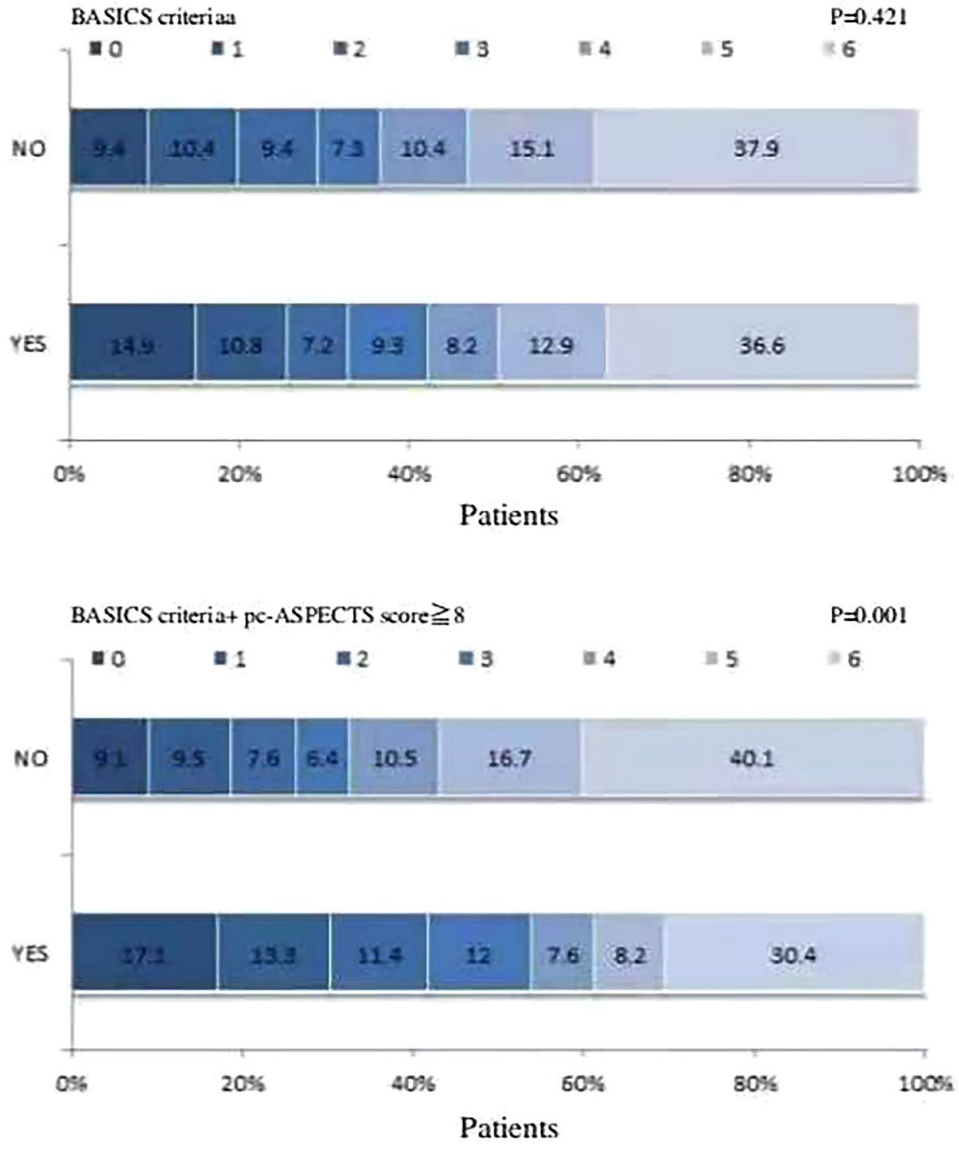

Figure 2. Distribution of 3-month modified Rankin scale (mRS) scores according to adherence to BASICS criterion.

Pc-ASPECTS is a semi-quantitative method for grading irreversible ischemia in the vertebrobasilar system. Previous studies have highlighted the importance of pc-ASPECTS on outcomes of BAO.[18,19] However, studies have yielded inconsistent results on whether patients with low pc-ASPECTS should receive EVT. Several studies have shown that pc-ASPECTS <8 could identify patients unlikely to get good outcomes despite successful reperfusion.[18,19,24,25] Another study from the Endovascular Treatment in Ischemic Stroke (ETIS) registry suggested that rapid endovascular reperfusion for patients with BAO is helpful despite pc-ASPECTS being <8.[26] In our study, we found that fulfilling the BEST or BASICS selection criteria plus pc-ASPECTS ≧8 might be better options compared with the original selection criteria. According to the recent announcement of the endovascular treatment for acute basilar artery occlusion (ATTENTION) trial and the basilar artery occlusion: Chinese endovascular (BAOCHE) trial in the European Stroke Organisation Conference 2022, both trials support our hypothesis with the inclusion criterion containing pc-ASPECTS and indicate significant advantage of EVT over standard medical treatment. We look forward for the detailed information after sufficient peer review.

In this study which contained 577 patients, the median pc-ASPECTS was 9 (IQR, 8–10). The bar diagram could be found in the supplementary materials. As we all know, patients with lower pc-ASPECTS are often in danger of life-threatening symptoms, such as irregularity of heart and respiratory rhythm. Their family members are more likely to choose standard pharmaceutical treatment in these cases, compared with the RCT studies. Moreover, unlike both RCTs, the pc-ASPECTS in our study was evaluated based on merely the NCCT. Compared with magnetic resonance angiography, the lesion of CT was hard to locate in early stage patients with acute cerebral infarction. For these reasons, the score is skewed to higher scores.

The strength of our study was the relative intact data of multiple centers and relatively large samples regarding the VBAO patients. However, several limitations should also be mentioned. First, due to the retrospective observational and non-randomized design, we urge a cautious interpretation of the results as it probably involves a high risk of selection bias. Second, it is known that the criterion applied in the BASICS trials had been modified once during the recruiting process. We only analyzed the final form of the selection criterion instead of both forms to keep the article friendly to readers. Third, our registry data were obtained during the period between December 2015 and December 2018; whether the new devices on embolectomy procedural would make difference on the selection criterion remains unknown.

In conclusion, our study found that most clinical outcomes did not reach statistical significance between patients meeting BEST/BASICS criteria for EVT and those outside the selection criteria based on the real-world data. Therefore, continued study of the efficacy and safety of EVT with more serious consideration of inclusion criteria should be performed. The ongoing multicenter controlled trails (NCT04751708) have considered the pc-ASPECTS as one of the inclusion criteria to explore the usefulness of endovascular treatment in basilar artery occlusion. We hope it will shed additional light on this crucial issue and be helpful in selecting VBAO patients suitable for EVT.

Declartions

Ethics approval and consent to participate

The study was approved by the ethics committee of First Affiliated Hospital of University of Science and Technology of China local (2020KY-40); due to the retrospective nature of the study, the need for patient consent was waived.

Consent for publication

Not applicable.

Author contributions

Wen Sun: Investigation; Methodology; Project administration; Writing – original draft; Writing – review & editing.

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Lulu Xiao: Data curation; Formal analysis.

Jinjing Wang: Data curation; Funding acquisition.

Wei Gui: Investigation; Methodology; Writing – original draft.

Genpei Luo: Conceptualization; Data curation.

Zhongyi Wu: Project administration; Supervision.

Zhongkui Han: Formal analysis; Supervision.

Wei Li: Validation; Writing – original draft.

Guoqiang Xu: Methodology; Validation; Visualization.

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Availability of data and materials

Not applicable.

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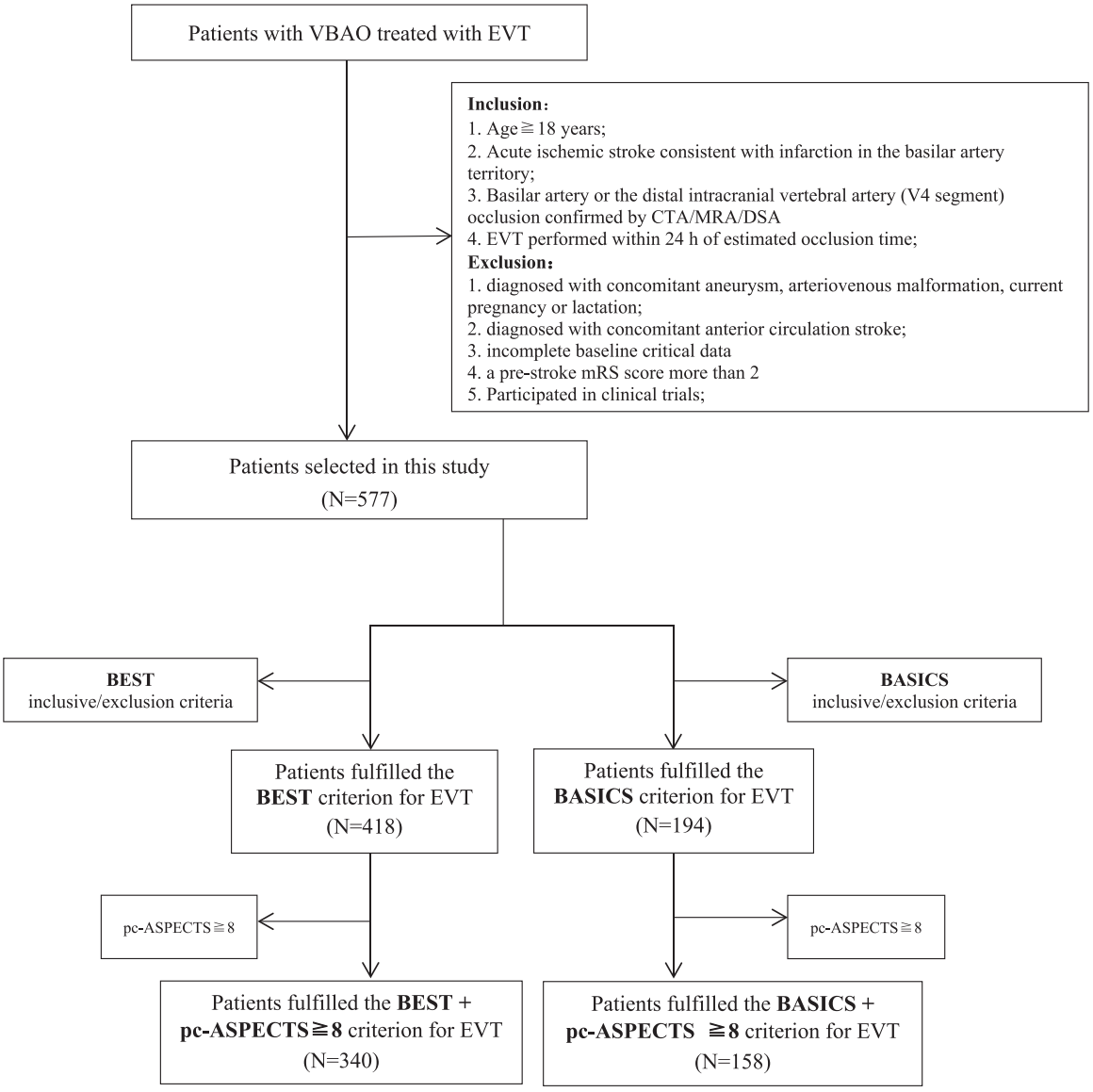
Supplemental material

Supplemental material for this article is available online.

References

1. Mattle HP, Arnold M, Lindsberg PJ, *et al.* Basilar artery occlusion. *Lancet Neurol* 2011; 10: 1002–1014.
2. Boeckh-Behrens T, Pree D, Lummel N, *et al.* Vertebral artery patency and thrombectomy in basilar artery occlusions. *Stroke* 2019; 50: 389–395.
3. Yoon W, Kim SK, Heo TW, *et al.* Predictors of good outcome after stent-retriever thrombectomy in acute basilar artery occlusion. *Stroke* 2015; 46: 2972–2975.
4. Lee YY, Yoon W, Kim SK, *et al.* Acute basilar artery occlusion: differences in characteristics and outcomes after endovascular therapy between patients with and without underlying severe atherosclerotic stenosis. *Am J Neuroradiol* 2017; 38: 1600–1604.
5. Campbell BCV, Donnan GA, Lees KR, *et al.* Endovascular stent thrombectomy: the new standard of care for large vessel ischaemic stroke. *Lancet Neurol* 2015; 14: 846–854.

6. Berkhemer OA, Fransen PS, Beumer D, *et al.* A randomized trial of intraarterial treatment for acute ischemic stroke. *N Engl J Med* 2015; 372: 11–20.
7. Goyal M, Demchuk AM, Menon BK, *et al.* Randomized assessment of rapid endovascular treatment of ischemic stroke. *N Engl J Med* 2015; 372: 1019–1030.
8. Campbell BC, Mitchell PJ, Kleinig TJ, *et al.* Endovascular therapy for ischemic stroke with perfusion-imaging selection. *N Engl J Med* 2015; 372: 1009–1018.
9. Tsivgoulis G, Safouris A, Krogias C, *et al.* Endovascular reperfusion therapies for acute ischemic stroke: dissecting the evidence. *Expert Rev Neurother* 2016; 16: 527–534.
10. Gory B, Eldesouky I, Sivan-Hoffmann R, *et al.* Outcomes of stent retriever thrombectomy in basilar artery occlusion: an observational study and systematic review. *J Neurol Neurosurg Psychiatry* 2016; 87: 520–525.
11. Schonewille WJ, Wijman CA, Michel P, *et al.* Treatment and outcomes of acute basilar artery occlusion in the Basilar Artery International Cooperation Study (BASICS): a prospective registry study. *Lancet Neurol* 2009; 8: 724–730.
12. Langezaal LCM, van der Hoeven EJRJ, Mont' Alverneet FJA, *et al.* Endovascular therapy for stroke due to basilar-artery occlusion. *N Engl J Med* 2021; 384: 1910–1920.
13. Liu X, Dai Q, Ye R, *et al.* Endovascular treatment versus standard medical treatment for vertebrobasilar artery occlusion (BEST): an open-label, randomised controlled trial. *Lancet Neurol* 2020; 19: 115–122.
14. Barber PA, Demchuk AM, Zhang J, *et al.* Validity and reliability of a quantitative computed tomography score in predicting outcome of hyperacute stroke before thrombolytic therapy. *Lancet* 2000; 355: 1670–1674.
15. Saver JL, Goyal M, Bonafe A, *et al.* Stent-retriever thrombectomy after intravenous t-PA vs. t-PA alone in stroke. *N Engl J Med* 2015; 372: 2285–2295.
16. Jovin TG, Chamorro A, Cobo E, *et al.* Thrombectomy within 8 hours after symptom onset in ischemic stroke. *N Engl J Med* 2015; 372: 2296–2306.
17. Goyal M, Menon BK, Coutts SB, *et al.* Effect of baseline CT scan appearance and time to recanalization on clinical outcomes in endovascular thrombectomy of acute ischemic strokes. *Stroke* 2011; 42: 93–97.
18. Puetz V, Sylaja PN, Coutts SB, *et al.* Extent of hypoattenuation on CT angiography source images predicts functional outcome in patients with basilar artery occlusion. *Stroke* 2008; 39: 2485–2490.
19. Nagel S, Herweh C, Köhrmann M, *et al.* MRI in patients with acute basilar artery occlusion – DWI lesion scoring is an independent predictor of outcome. *Int J Stroke* 2012; 7: 282–288.
20. Xiao L, Sun W, Wang J, *et al.* Influence of renal impairment on clinical outcomes after endovascular recanalization in vertebrobasilar artery occlusions. *J Neurointervent Surg*. Epub ahead of print 1 December 2021. DOI: 10.1136/neurintsurg-2021-018003.
21. von Kummer R, Broderick JP, Campbell BC, *et al.* The Heidelberg bleeding classification: classification of bleeding events after ischemic stroke and reperfusion therapy. *Stroke* 2015; 46: 2981–2986.
22. Writing Group for the BG, Zi W, Qiu Z, *et al.* Assessment of endovascular treatment for acute basilar artery occlusion via a nationwide prospective registry. *JAMA Neurol* 2020; 77: 561–573.
23. Phan K, Phan S, Huo YR, *et al.* Outcomes of endovascular treatment of basilar artery occlusion in the stent retriever era: a systematic review and meta-analysis. *J Neurointerv Surg* 2016; 8: 1107–1115.
24. Tei H, Uchiyama S, Usui T, *et al.* Posterior circulation ASPECTS on diffusion-weighted MRI can be a powerful marker for predicting functional outcome. *J Neurol* 2010; 257: 767–773.
25. Strbian D, Sairanen T, Silvennoinen H, *et al.* Thrombolysis of basilar artery occlusion: impact of baseline ischemia and time. *Ann Neurol* 2013; 73: 688–694.
26. Guillaume M, Lapergue B, Gory B, *et al.* Rapid successful reperfusion of basilar artery occlusion strokes with pretreatment diffusion-weighted imaging posterior-circulation ASPECTS <8 is associated with good outcome. *J Am Heart Asso* 2019; 8: e010962.



Flow chart.

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