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ORIGINAL RESEARCH

Post-ASPECTS and Post-PC-ASPECTS Predict the Outcome of Anterior and Posterior Ischemic Stroke Following Thrombectomy

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Purpose: In this study, we aimed to determine whether post-Alberta Stroke Project Early CT Changes Score (post-ASPECTS) in anterior stroke and post-(posterior circulation) PC-ASPECTS in posterior stroke on CT can predict post-endovascular thrombectomy (EVT) functional outcomes among patients with acute ischemic stroke (AIS) after EVT.

Patients and Methods: A total of 247 consecutive patients aged 18 and over receiving EVT for LVO-related AIS were recruited into a prospective database. The data was retrospectively analyzed between March 2019 and February 2022 from two comprehensive tertiary care stroke centers: Foshan Sanshui District People's Hospital and First People's Hospital of Foshan in China. Patient parameters included EVT within 24 hr of symptom onset, premorbid modified Rankin scale (mRS) ≤2, presence of distal and terminal cerebral blood vessel occlusion, and subsequent 24–72-hr post-stroke onset CT scan. Univariate comparisons were performed using the Fisher's exact test or χ^2 test for categorical variables and the Mann–Whitney *U*-test for continuous variables. Logistic regression analysis was performed to further analyze for adjusting for confounding factors. A p-value of ≤0.05 was statistically significant.

Results: Overall, 236 individuals with 196 anterior circulation ischemic strokes and 40 posterior strokes of basilar artery occlusion were examined. Post-ASPECTS in anterior stroke and post-pc-ASPECTS as strong positive markers of favorable outcome at 90 days post-EVT; and lower rates of inpatient mortality/hospice discharge, 90-day mortality, and 90-day poor outcome were observed. Moreover, patients in the post-ASPECTS ≥ 7 cohort experienced shorter door-to-recanalization time (DRT), puncture-to-recanalization time (PRT), and last known normal-to-puncture time (LKNPT).

Conclusion: Post-ASPECTS ≥7 in anterior circulation AIS and post-pc-ASPECTS ≥7 in posterior circulation can serve as strong prognostic markers of functional outcome after EVT.

Keywords: endovascular therapy, thrombectomy, large vessel occlusion, cerebral ischemic stroke, ASPECTS

Introduction

Stroke is the second-leading cause of death and the third-leading cause of disability globally, despite decreases in age-standardized stroke incidence and mortality in high- versus low- and middle-income countries.[1] Ischemic strokes occurring in the anterior circulation are the most common of all acute ischemic strokes (AIS) and have epidemiological and clinical features distinct from posterior circulation infarctions, which account for 20–30% of all cases.[2,3] Endovascular Therapy (EVT)—in the form of mechanical thrombectomy—following intravenous thrombolysis, which remains the standard of care for patients with

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AIS due to large vessel occlusion (LVO) of the anterior circulation.[1,4–6] For posterior circulation LVO, successful reperfusion post-EVT has been shown to be associated with favorable outcomes in many previous studies.[7–12] However, its efficacy has not yet been established, as results from two recent randomized clinical trials failed to show improvement in functional outcomes following EVT for posterior circulation stroke (PCS).[13,14] This suggests a need to identify prognostic factors beyond recanalization that impact EVT outcomes, as poor outcomes are observed despite successful recanalization.[6] Appropriate patient selection may be the solution to the success of posterior circulation-EVT.[6]

Early ischemic changes in the middle cerebral artery (MCA) territory on pre-treatment non-contrast CT scans (NCCT) can be quantified using the Alberta Stroke Project Early CT Changes Score (ASPECTS) for hyperacute anterior circulation ischemic stroke, which divides the MCA area into 10 regions of interest.[15–17] Based on this 10-point scoring system, 10 indicates normal, and 1 point is removed for each abnormal region.[1] As such, this tool can be used to select appropriate patients for EVT based on the estimation of infarct size, as it serves as a potent predictor of post-EVT functional outcomes.[1,18,19] Specifically, patients with smaller baseline infarcts experience better long-term functional dependence, decreased reperfusion hemorrhage, and lower rates of mortality as compared to those with larger infarcts.[19] Results from a post-hoc analysis of the PROACT II trial suggested an association between baseline APSECTS (>7 vs ≤7) and intra-arterial treatment effect.[20]

Previous studies have shown that patients with an ASPECTS ≥ 7 were more likely than those with ASPECTS < 7 to receive favorable post-EVT outcomes, suggesting the benefit of fast recanalization for cases with evident damage on CT scan.[21] Patients with lower e-ASPECTS—a tool for automated use of ASPECTS—were found to be associated with a higher modified Rankin scale (mRS) after 3 months and an increased risk for symptomatic intracerebral hemorrhage.[18,22] For posterior circulation LVO, prognostic utility has been shown in combining posterior circulation ASPECTS (PC-ASPECTS) with magnetic resonance imaging (MRI) for evaluating post-EVT functional outcomes.[23] However, due to the low accessibility of MRIs, previous studies have applied PC-ASPECTS to computed tomography angiography source images (CTA-SI) for patients with suspected acute basilar artery occlusion (BAO).[24] Future studies should focus on comparing the efficacy of multimodal MRI, CTA, and CT perfusion (CTP) in predicting clinical outcomes in patients with BAO and determining the most reliable scoring system.[24] To our knowledge, there is only one study that applied PC-ASPECTS to pre-intervention non-contrast CT, a widely used and accessible tool to assess patients before EVT.[25] Thus, in this study, we aim to determine whether post-ASPECTS in anterior circulation AIS and post-PC-ASPECTS in posterior circulation can serve as prognostic markers of functional outcome after EVT.

Materials and Methods

Study Design

This study included the retrospective analysis of prospectively collected data from 247 consecutive patients who underwent EVT for LVO-related AIS from March 2019 to February 2022 at two comprehensive tertiary care stroke centers: Foshan Sanshui District People's Hospital and First People's Hospital of Foshan, China. The data were derived from the Big Data Observatory Platform for Stroke in China (https://ss.chinasdc.cn) and individual hospital data platforms. Inclusion criteria were as follows: 1) patients aged 18 years or older; 2) underwent EVT within 24 hr of symptom onset; 3) with a premorbid Modified Rankin Score (mRS) ≤ 2; 4) have vessel occlusion including distal/terminal ICA, MCA-M1, MCA-M2, tandem (ICA+M1) and basilar artery; and 5) received a head CT scan after 24 to 72 hr post-onset, if the patients deteriorated, the CT was scanned earlier or followed up head image as medical necessity. Exclusion criteria included 1) a pre-EVT ASPECTS < 7 and 2) unavailable images to assess ASPECTS.

Data Collection

The following demographics and clinical data were collected for all patients: age, sex, vascular risk factors (including hypertension, diabetes, coronary artery disease, chronic kidney disease, frequency of prior stroke, smoking status, and dyslipidemia), lung infection, urinary tract infection, and serum laboratory examination. Time metrics of EVT consisted of the door-to-puncture time (DPT), door-to-recanalization time (DRT), puncture-to-recanalization time (PRT), and last known normal-to-puncture time (LKNPT). Measurements of the National Institute of Health Stroke Scale (NIHSS), pre-EVT ASPECTS, and post ASPECTS on CT scans to assess the infarct core volume, initial premorbid modified Rankin

Scale (mRS), modified thrombolysis in cerebral infarction (mTICI) score, and treatment with intravenous (IV) thrombolysis were also recorded.

The frequency of symptomatic intracranial hemorrhage (sICH) was assessed for individual patient cases, which is defined as any hemorrhage related to transient neurological worsening, manifested by an increase in the NIHSS score ≥ 4. Three-month mRS scores post-EVT were evaluated by routine follow-up and used to assess patient outcomes. Favorable outcome was defined as a 90-day mRS score of 0–2, as compared to a 90-day mRS score of 3–6 for poor outcome, as shown previously.[26,27] Mortality was defined as a 90-day mRS score of 6.

Ethics Approval

The study was approved by the medical ethical committee at the Foshan Sanshui District People's Hospital. All participants' legal guardians and/or next of kin consented to perform EVT. Written informed consent from the participants' legal guardians and/or next of kin was not required to participate in this study due to the nature of the retrospective study with no harm. All patient data were confidential, and all procedures performed in the studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards.

Statistical Analysis

Statistical analysis was performed using the SPSS Statistics Package (Version 26.0; IBM Corporation, Armonk, NY, USA). Continuous variables are summarized as the mean ± standard deviation for normally distributed variables or as the median with interquartile range for non-normally distributed variables as requirements. Proportions were expressed in percentages. The independent *t*-test was used to compare means between groups, the non-parametric Mann–Whitney *U*-test for medians, and the chi-square (χ^2) test and Fisher's exact test for proportions. Results were considered statistically significant for a p value < 0.05. We also calculated the area under the curve (AUC) of the receiver operating characteristic (ROC). Univariate logistic regression analyses were performed as they are shown in the Supplementary Tables 1–6. Multivariate binary logistic regression was performed to further analyze for adjusting for confounding factors. Results were considered statistically significant for a p value < 0.05.

Results

Study Population

A total of 247 patients met the inclusion criteria, with 3 excluded due to the absence of post-CT and 8 excluded for pre-EVT ASPECTS < 7. Overall, 236 patients were analyzed during the study period and incorporated into the final analysis, where 196 had anterior circulation occlusion stroke and 40 had posterior stroke of basilar occlusion. Table 1 shows the comparison of baseline demographic and clinical characteristics between individuals with post-thrombectomy ASPECTS (post-ASPECTS) ≥ 7 versus post-ASPECTS < 7. There were 110 patients with post-ASPECTS ≥ 7 (56.1%) and 86

Table 1 Characteristic and Clinical Data of Patients with Post-ASPECTS ≥ 7 versus Post-ASPECTS < 7 in Anterior Circulation Large Vessel Occlusion Following EVT

	Post-ASPECTS ≥ 7	Post-ASPECTS < 7	X^2/t/z	*p*
Number	110	86		
Age mean ± SD	64.80 ± 13.09	64.91 ± 14.42	−0.054	0.957
Male (n, %)	74 (67.27)	56 (65.12)	0.100	0.751
Hypertension (n, %)	57 (51.82)	49 (56.98)	0.517	0.472
Diabetes (n, %)	20 (18.18)	22 (25.58)	1.570	0.210
CAD (n, %)	13 (11.82)	20 (23.26)	4.509	0.034

(*Continued*)

Table 1 (Continued).

	Post-ASPECTS ≥ 7	Post-ASPECTS < 7	X^2/t/z	*p*
Prior stroke (n, %)	21 (19.09)	13 (15.12)	0.532	0.466
CKD (n, %)	9 (8.18)	8 (9.30)	0.077	0.782
Smoker (n, %)	20 (18.18)	16 (18.60)	0.006	0.940
Dyslipidemia	18 (16.36)	10 (11.63)	0.884	0.347
Atrial fibrillation	45 (40.91)	29 (33.72)	1.061	0.303
NIHSS pre-EVT (IQR)	14.00 (10.00, 17.00)	15.00 (12.75, 19.00)	−2.861	0.004
ASPECTS pre-EVT (IQR)	9.00 (8.00,9.00)	8.00 (8.00, 9.00)	−1.389	0.165
mRS pre-morbidity (IQR)	0.00 (0.00, 0.00)	0.00 (0.00, 0.00)	−1.662	0.097
IV thrombolysis (n, %)	44 (40.00)	39 (45.35)	0.566	0.452
DPT (IQR) (min)	152.50 (116.50, 199.00)	149.50 (117.00, 193.25)	−0.154	0.878
DRT (IQR) (min)	226.50 (166.75, 264.25)	248.50 (194.50, 308.25)	−2.033	0.042
PRT (IQR) (min)	54.00 (35.00, 76.00)	86.00 (50.75, 125.25)	−4.569	< 0.001
LKNPT (IQR) (min)	319.50 (240.00, 495.25)	285.50 (195.00, 399.25)	−2.190	0.029
mTICI post ≥ 2b (n, %)	103 (93.64)	63 (73.26)	15.465	< 0.001
Lung infection (n, %)	37 (33.64)	46 (53.49)	7.791	0.005
Urinary infection	13 (11.8)	7 (8.1)	0.713	0.399
sICH (n, %)	1 (0.91)	22 (25.58)	28.366	< 0.001
Serum glucose	6.83 (5.77, 8.26)	7.24 (5.93, 10.42)	−1.367	0.172
Pre-EVT creatinine	83.00 (69.75, 103.50)	82.50 (65.75, 102.25)	−0.195	0.845
TG	1.00 (81, 1.45)	1.06 (0.85, 1.86)	−1.690	0.091
CHOL	4.04 (3.43, 4.83)	4.23 (3.72, 4.95)	−0.982	0.326
HDL	0.99 (0.86, 1.17)	0.95 (0.80, 1.15)	−0.800	0.424
LDL	2.72 (2.12, 3.29)	2.74 (2.32, 3.53)	−0.806	0.421
UA	325.00 (246.50, 425.50)	307.00 (244.75, 383.25)	−0.738	0.460
Length of stay	12.00 (8.00, 16.25)	11.00 (3.00, 21.00)	−1.731	0.083
Hospitalization costs	101,957.34 (83,996.59, 128,430.92)	130,348.80 (88,059.48, 164,432.45)	−3.131	0.002
mRS discharge (IQR)	2.00 (1.00, 4.00)	5.00 (4.00, 5.00)	−9.065	< 0.001
Inpatient mortality / Hospice discharge (n, %)	4 (3.64)	36 (41.86)	43.415	< 0.001
Favorable outcome at 90 Days (n, %)	77 (70.00)	11 (12.79)	63.852	< 0.001
Mortality at 90 Days (n, %)	8 (7.27)	42 (48.84)	43.880	< 0.001
Poor outcome at 90 days (n, %)	33 (30.00)	75 (87.21)	63.852	<0.001

Notes: Data are shown as means ± standard deviations, numbers (%), or medians (IQR). Univariate comparisons were performed using the Fisher exact test or χ^2 test (categorical variables) for proportions, and the Mann–Whitney *U*-test for medians (continuous variables).

Abbreviations: ASPECTS Pre-EVT, Alberta Stroke Program Early CT Score pre-endovascular treatment; CAD, coronary artery disease; CHOL, cholesterol; CKD, chronic kidney disease; DPT, door-to-puncture time; DRT, door-to-recanalization time; HDL, high density lipoprotein; IQR, interquartile range; LKNPT, last-known normal-to-puncture time; LDL, low density lipoprotein; mRS, modified Rankin scale; mTICI, modified thrombolysis in cerebral infarction; NIHSS pre-EVT, National Institutes of Health Stroke Scale pre-endovascular treatment; PRT, puncture-to-recanalization time; SD, standard deviations; sICH, symptomatic intracranial hemorrhage; TG, triglyceride; UA, uric acid.

patients with post-ASPECTS < 7 (43.9%). There were no statistically significant differences regarding age, sex, triglyceride, cholesterol, high-density lipoprotein, low-density lipoprotein, uric acid, cerebrovascular risk factors except coronary artery disease (CAD), pre-EVT ASPECTS, mRS pre-morbidity, IV thrombolysis, DPT, and length of stay of study participants (Table 1). Admission NIHSS pre-EVT (interquartile range (IQR)) of study participants between post-ASPECTS ≥ 7 and post-ASPECTS < 7 were 14.00 (10.00, 17.00) and 15.00 (12.75, 19.00), respectively ($p = 0.004$). Time metrics of EVT included 226.50 (166.75, 264.25) vs 248.50 (194.50, 308.25) for DRT (IQR) ($p = 0.042$), 54.00 (35.00, 76.00) vs 86.00 (50.75, 125.25) for PRT (IQR) ($p < 0.001$), and 319.50 (240.00, 495.25) vs 285.50 (195.00, 399.25) for LKNPT (IQR) ($p = 0.029$), respectively. The mTICI post ≥ 2b were 93.64% (n = 103) versus 73.26% (n = 3) ($p < 0.001$). There were significant differences in sICH at 0.91% (n = 1) vs 25.58% (n = 22) (p =< 0.001), hospitalization costs at 101,957.34 (83,996.59, 128,430.92) vs 130,348.80 (88,059.48, 164,432.45) ($p = 0.002$), mRS discharge (IQR) at 2.00 (1.00, 4.00) vs 5.00 (4.00, 5.00) ($p < 0.001$), inpatient mortality/hospice discharge at 3.64% (n = 4) vs 41.86% (n = 36) ($p < 0.001$), 90-day favorable outcome at 70.00% (n = 77) vs 12.79% (n = 11) ($p < 0.001$), 90-day mortality at 7.27% (n = 8) vs 48.84% (n = 42), and 90-day poor outcome at 30.00% (n = 33) vs 87.21% (n = 75) between post-ASPECTS ≥ 7 and post-ASPECTS < 7 (Table 1).

The results of the comparison of baseline demographic and clinical characteristics between individuals with post-PC-ASPECTS ≥ 7 and post-PC-ASPECTS < 7 in posterior circulation stroke post-EVT are presented in Table 2. There were 16

Table 2 Characteristic and Clinical Data of Patients with pc-ASPECTS ≥ 7 versus pc-ASPECTS < 7 in Posterior Circulation Stroke Following EVT

	Post-pc-ASPECTS ≥ 7	**Post-pc-ASPECTS < 7**	**X^2/t/z**	***p***
Number	16	24		
Age mean ± SD	62.19 ± 9.85	62.54 ± 9.28	0.115	0.909
Male (n, %)	14 (87.50)	19 (79.17)	0.065	0.799
Hypertension (n, %)	11 (68.75)	14 (58.33)	0.444	0.505
Diabetes (n, %)	3 (18.75)	5 (20.83)	0.000	1.000
CAD (n, %)	2 (12.50)	3 (12.50)	0.000	1.000
AF	1 (6.3)	7 (29.2)	1.882	0.0.170
Prior stroke (n, %)	2 (12.50)	9 (37.50)	1.886	0.170
Smoker (n, %)	6 (37.50)	6 (25.00)	0.243	0.622
Dyslipidemia	5 (31.25)	4 (16.67)	0.484	0.487
NIHSS pre-EVT (IQR)	22.50 (15.25, 26.75)	25.50 (23.25, 33.50)	2.469	−0.013
ASPECTS pre-EVT (IQR)	9.00 (8.25, 9.00)	8.00 (8.00, 9.00)	2.908	−0.007
mRS pre-morbidity (IQR)	0.00 (0.00, 0.00)	0.00 (0.00, 0.00)	0.536	0.754
IV thrombolysis (n, %)	4 (25.00)	9 (37.50)	0.684	0.408
DPT (IQR) (min)	127.00 (109.50, 214.75)	184.00 (121.25, 267.75)	1.242	0.222
DRT (IQR) (min)	206.00 (158.25, 304.50)	287.50 (183.00, 331.50)	1.408	0.165
PRT (IQR) (min)	60.00 (39.75, 96.25)	58.00 (32.75, 116.50)	0.166	0.881
LKNPT (IQR) (min)	402.50 (158.00, 537.50)	365.50 (264.25, 453.75)	0.014	0.989
mTICI post ≥ 2b (n, %)	16 (100.00)	22 (91.67)	n/a	0.508
Lung infection (n, %)	5 (31.25)	15 (62.50)	3.750	0.053

(*Continued*)

Table 2 (Continued).

	Post-pc-ASPECTS ≥ 7	Post-pc-ASPECTS < 7	X^2/t/z	*p*
Urinary tract infection	0 (0)	1 (4.2)	n/a	1.000
Serum glucose	7.030 (5.6, 8.2)	7.575 (6.7, 10.2)	−1.082	0.291
Pre-EVT creatinine	94.500 (74.8, 114.5)	87.500 (73.3, 99.8)	−0.912	0.374
TG	0.965 (0.8, 1.6)	1.030 (0.8, 1.3)	−0.310	0.760
CHOL	4.75±1.30	4.47 ± 1.07	0.692	0.493
HDL	1.025 (0.9, 1.1)	1.020 (0.9, 1.2)	−0.219	0.843
LDL	3.35 ±1.08	3.11 ± 0.98	0.679	0.502
UA	379.38 ± 163.16	387.43 ± 175.73	−0.123	0.903
sICH (n, %)	0 (0.00)	2 (8.33)	n/a	0.508
Length of stay (days)	14.00 (10.00, 25.00)	7.50 (2.00, 22.75)	−1.410	0.165
Hospitalization costs (RMB)	94,337.85 (85,874.56, 143,460.41)	120,816.31 (100,968.86, 147,071.16)	−1.408	0.165
mRS discharge (IQR)	2.00 (1.00, 3.00)	5.00 (5.00, 5.00)	−5.129	< 0.001
Inpatient mortality / Hospice discharge (n, %)	0 (0.00)	11 (45.83)	7.947	0.005
Favorable outcome at 90 days (n, %)	11 (68.75)	1 (4.17)	16.116	< 0.001
Mortality at 90 days (n, %)	0 (0.00)	14 (58.33)	14.359	< 0.001
Poor outcome at 90 days (n, %)	5 (31.25)	23 (95.83)	16.116	< 0.001

Notes: Data are shown as means ± standard deviations, numbers (%), or medians (IQR). Univariate comparisons were performed using the Fisher exact test or χ^2 test (categorical variables) for proportions, and the Mann–Whitney *U*-test for medians (continuous variables).
Abbreviations: ASPECTS Pre-EVT, Alberta Stroke Program Early CT Score pre-endovascular treatment; CAD, coronary artery disease; CHOL, cholesterol; DPT, door-to-puncture time; DRT, door-to-recanalization time; HDL, high density lipoprotein; IQR, interquartile range; LDL, low density lipoprotein; LKNPT, last known normal-to-puncture time; mRS, modified Rankin scale; mTICI, modified thrombolysis in cerebral infarction; NIHSS pre-EVT, National Institutes of Health Stroke Scale pre-endovascular treatment; PRT, puncture-to-recanalization time; SD, standard deviations; sICH, symptomatic intracranial hemorrhage; TG, triglyceride; UA, uric acid.

patients with pc-ASPECTS ≥ 7 (40.0%) and 24 patients with pc-ASPECTS < 7 (60.0%). There were no statistically significant differences regarding age, sex, triglyceride, cholesterol, high-density lipoprotein, low-density lipoprotein, uric acid, cerebrovascular risk factors, mRS pre-morbidity, IV thrombolysis, time metrics of EVT, mTICI post ≥ 2b, sICH, length of stay, and hospitalization costs of study participants (Table 2). Admission NIHSS pre-EVT of study participants for the post-PC-ASPECTS ≥ 7 cohort [IQR: 22.50 (15.25, 26.75)] and pc-ASPECTS < 7 cohort [IQR: 25.50 (23.25, 33.50)] was statistically significant (X2 = 2.469; p = 0.013). The pc-ASPECTS ≥ 7 pre-EVT cohort [IQR: 9.00 (8.25, 9.00)] compared to the pc-ASPECTS < 7 pre-EVT cohort [IQR: 8.00 (8.00, 9.00)] was also statistically significant (X2: 2.908; p = 0.007). Additionally, there were significant differences in mRS discharge at [IQR: 2.00 (1.00, 3.00)] vs [IQR: 5.00 (5.00, 5.00)] (X2: 5.129; p < 0.001), inpatient mortality/ hospice discharge at 0.00% (n = 0) vs 45.83% (n = 11) (X2: 7.947, p = 0.005), 90-day favorable outcome at 68.75% (n = 11) vs 4.17% (n = 1) (X2: 16.116, p < 0.001), 90-day mortality at 0.00% (n = 0) vs 58.33% (n = 14) (X2: 14.359, p < 0.001), and 90-day poor outcome at 31.25% (n = 5) vs 95.83% (n = 23) (X2: 16.116, p < 0.001) between PC-ASPECTS ≥ 7 and pc-ASPECTS < 7, respectively (Table 2). The mRS of post-ASPECTS in anterior and posterior circulation ischemic stroke following EVT is shown in Supplementary Tables 7 and 8, respectively.

Clinical Outcomes

For anterior circulation ischemic stroke post-EVT, the distribution of mRS from 0 to 6 at baseline for patients with post-ASPECTS ≥ 7 were 26.36%, 27.27%, 16.36%, 3.64%, 17.27%, 1.82%, and 7.27%, and for patients with post-ASPECTS < 7 were 1.16%, 4.65%, 6.98%, 18.60%, 12.79%, and 48.84%, respectively (Figure 1). We found that patients with lower

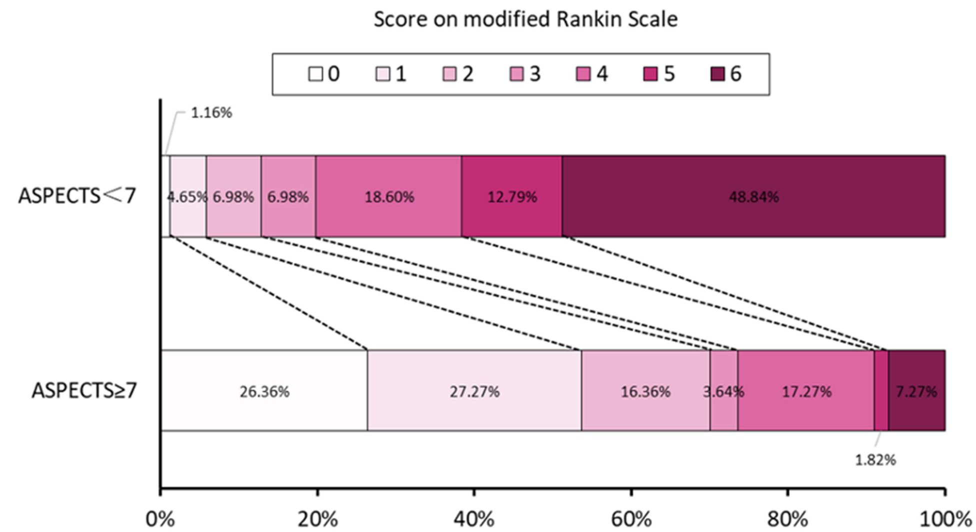

Figure 1 Distribution of mRS by baseline comparison of post-ASPECTS ≥ 7 and post-ASPECTS < 7 in anterior circulation ischemic stroke following EVT.

post-ASPECTS (<7) accounted for a greater proportion of poor outcomes (mRS of 5: 12.79%, mRS of 6: 48.84%) as compared to patients with higher post-ASPECTS (≥7) (mRS of 5: 1.82%, mRS of 6: 7.27%).

For posterior circulation ischemic stroke post-EVT, the distribution of mRS from 0 to 6 at baseline for patients with post-PC-ASPECTS ≥ 7 were 18.75%, 31.25%, 18.75%, 12.50%, 12.50%, and 6.25%, and for patients with post-pc-ASPECTS < 7 were 4.17%, 25.00%, 12.50%, and 58.33%, respectively (Figure 2). Similarly, we found that patients with lower post-pc-ASPECTS (<7) accounted for a greater proportion of poor outcomes (mRS of 5: 12.50%, mRS of 6: 58.33%) as compared to patients with higher pc-ASPECTS (≥7) (mRS of 5: 6.25%, mRS of 6: 0%).

Results on the univariate analysis of the clinical outcomes between post-ASPECTS ≥ 7 and post-ASPECTS < 7 in anterior circulation ischemic stroke, after adjusting for CAD, NIHSS, and pre-EVT ASPECTS, are presented in Table 3. Significant differences were observed for inpatient mortality/hospice discharge (OR: 0.051, 95% CI: 0.016–0.164, p < 0.001), 90-day favorable outcome (OR: 15.132, 95% CI: 6.889–33.237, p < 0.001), 90-day mortality (OR: 0.089, 95% CI: 0.037–0.216, p < 0.001), and 90-day poor outcome (OR: 0.066, 95% CI: 0.030–0.145, p < 0.001).

According to the dataset, when comparing post-PC-ASPECTS ≥ 7 and post-PC-ASPECTS < 7 in anterior circulation ischemic stroke post-adjustment of NIHSS and pre-EVT ASPECTS, patient parameters comprising 90-day favorable

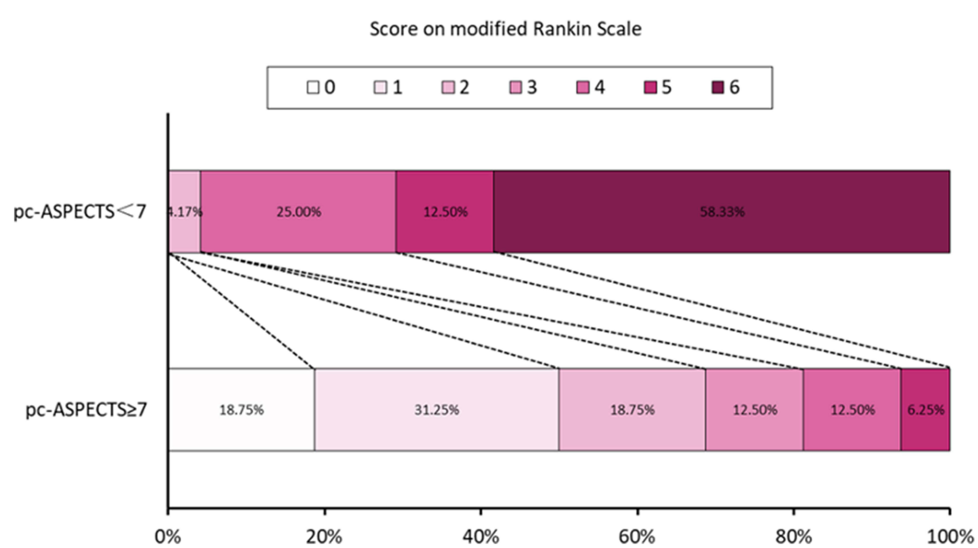

Figure 2 Distribution of mRS by baseline comparison of post-PC-ASPECTS ≥ 7 and post-PC-ASPECTS < 7 in posterior circulation ischemic stroke following EVT.

Table 3 Comparison of Outcome of Post-ASPECTS ≥ 7 versus Post-ASPECTS < 7 in Anterior Circulation Ischemic Stroke After Adjusting for CAD, NIHSS Pre-EVT, and ASPECTS Pre-EVT

	OR	95% CI	*p*
Inpatient mortality/ Hospice discharge	0.051	0.016–0.164	< 0.001
Favorable outcome at 90 days	15.132	6.889–33.237	< 0.001
Mortality at 90 days	0.089	0.037–0.216	< 0.001
Poor outcome at 90 days	0.066	0.030–0.145	< 0.001

Table 4 Comparison of Outcome of Post-PC-ASPECTS ≥ 7 versus Post-PC-ASPECTS < 7 in Posterior Circulation Ischemic Stroke After Adjusting for, NIHSS Pre-EVT, and ASPECTS Pre-EVT

	OR	95% CI	*p*
Favorable outcome at 90 days	70.799	4.550–1101.583	0.002
Poor outcome at 90 days	0.014	0.001–0.220	0.002

outcome (OR: 70.799, 95% CI: 4.550–1101.583, p = 0.002) and 90-day poor outcome (OR: 0.014, 95% CI: 0.001–0.220, p = 0.002) were both statistically significant (Table 4).

Based on the receiving operating characteristic (ROC) curve analysis, the area under curve (AUC) for post-ASPECTS was 0.860 (95% CI, 0.809–0.911, p < 0.001) (Figure 3 and Table 5).

As a result of ROC curve analysis, the AUC for PC-ASPECTS was 0.860 (95% CI, 0.809–0.911, p < 0.001) (Figure 4 and Table 6).

Discussion

Reliable early predictions of poor outcomes after successful treatment are essential for the selection of appropriate patients for EVT upon imaging criteria to help make better decisions, improve prognosis, and reduce unnecessary cost.[17,28] In this multi-center study of 247 patients, we showed that post-ASPECTS and post-PC-ASPECTS on CT can accurately predict post-EVT survival and functional outcomes of anterior and posterior AIS due to LVO, respectively. Post-ASPECTS and post-PC-ASPECTS can be dichotomized at <7 vs ≥7 to prognosticate inpatient mortality/hospice discharge, 90-day favorable outcome, 90-day poor outcome, and 90-day mortality. Consistent with previous studies, we found that both post-ASPECTS and post-PC-ASPECTS ≥ 7 serve as strong positive markers of favorable outcome at 90 days post-EVT; as well, lower rates of inpatient mortality/hospice discharge, 90-day mortality, and 90-day poor outcome were observed.[17,27–29] Differences between post-ASPECTS ≥ 7 versus post-ASPECTS < 7 were statistically significant for inpatient mortality/hospice discharge, 90-day favorable outcome, 90-day poor outcome, and 90-day mortality after adjusting for CAD, NIHSS pre-EVT, and ASPECTS pre-EVT. For pc-ASPECTS ≥ 7 versus pc-ASPECTS < 7, only 90-day favorable outcome and 90-day poor outcome were statistically significant after adjusting for CAD, NIHSS pre-EVT, and ASPECTS pre-EVT.

For acute BAO—the most devastating form of posterior circulation infarction—the following factors have been identified as independent variables impacting functional outcomes: basilar artery recanalization, location of thrombus, length of obstruction, and state of collaterals.[24] However, there are still presently no criteria developed for the appropriate identification of patients who would benefit from EVT.[24] Our current standard of care for the diagnosis of PCS is MRI using diffusion (DWI)- or perfusion-weighted (PWI) imaging sequences, but there are drawbacks such as general inaccessibility in local hospitals, limited practicability for unstable patients, comparatively higher costs, and slow scanning speed.[24,30]

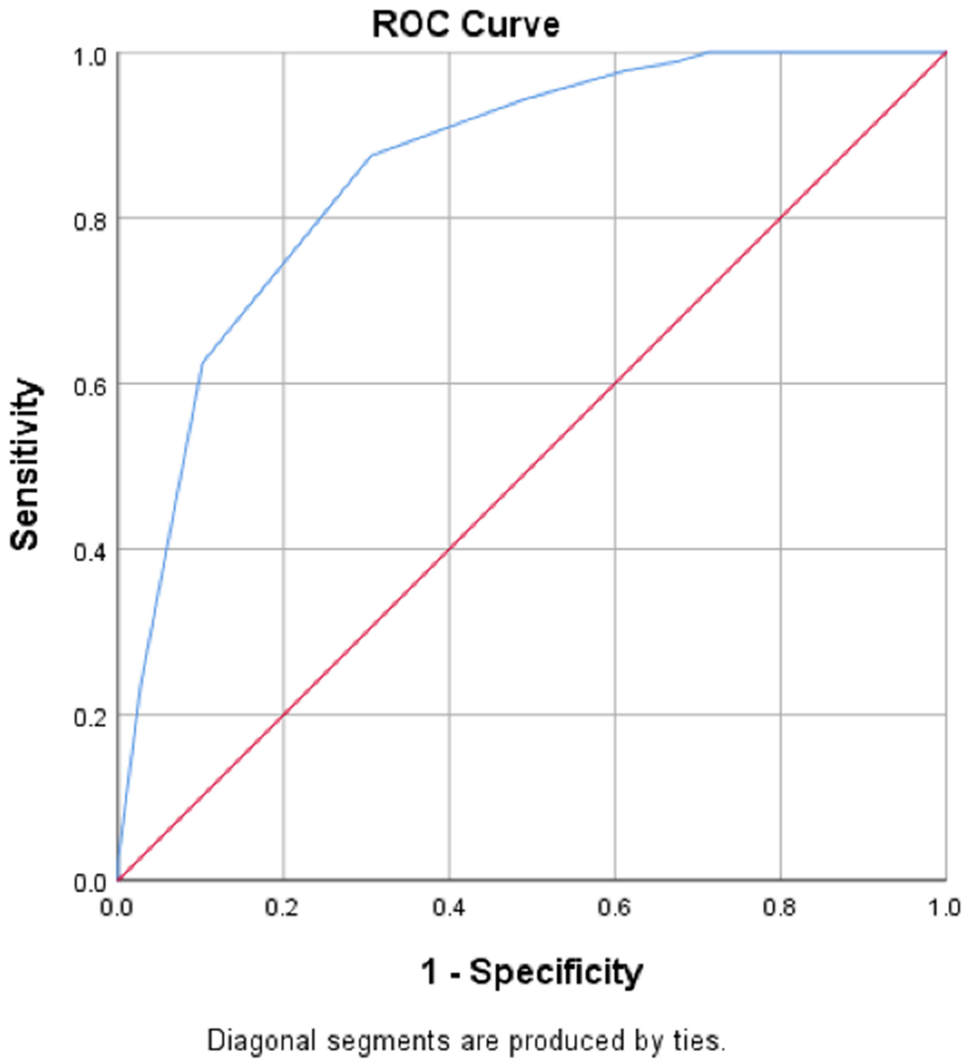

Figure 3 ROC curve of post-ASPECTS predicts 90-day favorable outcome of anterior circulation ischemic stroke following EVT. The blue line represents the boundary of the post-ASPECTS AUC.

CT remains the imaging modality of first choice for AIS patients due to its widespread availability.[31,32] Non-contrast CT (NCCT) is used to exclude intracranial hemorrhage and non-stroke pathologies, followed by CTA-SI, an advanced CT technique, to further characterize early signs of an infarct such as tissue status.[17,33] CTA also provides value in the detection of vessel occlusion. Thus, at community hospitals without readily available MRIs, an alternative diagnostic tool that can accurately and rapidly detect intracranial hemorrhage, assess vessel status and extent of ischemia, identify occlusion of major arteries at the base of the brain if present, and estimate at-risk tissue is needed. A previous study

Table 5 Area Under the Curve for Test Result Variable(s): Post-ASPECTS

Area	Std. Error[a]	Asymptotic Sig.[b]	Asymptotic 95% Confidence Interval	
			Lower Bound	Upper Bound
0.860	0.026	< 0.001	0.809	0.911

Notes: The test result variable(s): ASPECTS-post has at least one tie between the positive actual state group and the negative actual state group. Statistics may be biased. [a]Under the nonparametric assumption. [b]Null hypothesis: true area = 0.5.

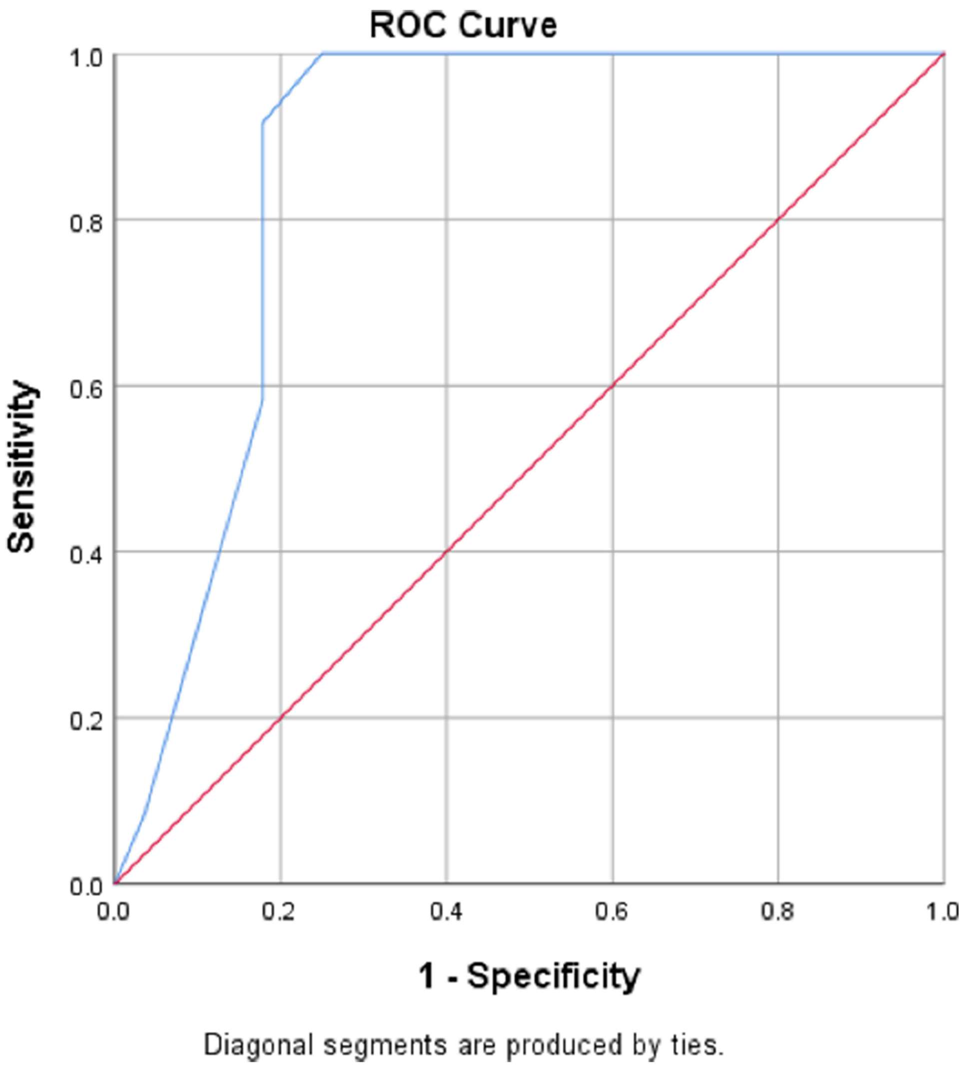

Figure 4 ROC curve of post-PC-ASPECTS predicts 90-day favorable outcome of posterior circulation stroke following EVT. The blue line represents the boundary of the post-PC-ASPECTS AUC.

found that the quality of diagnostic assessment by combining non–contrast-enhanced CT (to exclude intracranial hemorrhage), CTA (to assess vessel status), and early contrast-enhanced CTA-SI (to predict final infarct volume) together is comparable to that of multiparametric stroke MRI, including DWI, in patients with AIS within 6 hr of onset.[33] This diagnostic protocol—similar to the stroke MRI mismatch concept—can identify patients who are more likely to be at risk of infarct growth based on the assessment of their collateral status, which is strongly tied to significantly poorer clinical outcomes.[34] Consequently, combined CT/CTA/CTA-SI may be used not only to understand stroke pathology but also to predict clinical outcomes.

Table 6 Area Under the Curve Test Result Variable(S): Pc-ASPECTS

Area	Std. Error[a]	Asymptotic Sig.[b]	Asymptotic 95% Confidence Interval	
			Lower Bound	Upper Bound
0.868	0.058	< 0.001	0.755	0.980

Notes: The test result variable(s): ASPECTS-pc has at least one tie between the positive actual state group and the negative actual state group. Statistics may be biased. [a.] Under the nonparametric assumption. [b]Null hypothesis: true area = 0.5.

Although there are advanced imaging modalities, quantification of hypoattenuation on NCCT is widely used to assess patients pre-EVT based on baseline infarct size, which, as shown by the PROACT II trial, is associated with intra-arterial treatment effect.[19] Patients with smaller infarcts (APSECTS > 7) were five times more likely to have better functional outcomes with intra-arterial treatment compared to the control group, whereas patients with larger infarcts (APSECTS ≤ 7) did not benefit from treatment.[19] Our findings show post-ASPECTS and post-PC-ASPECTS ≥ 7 groups had higher rates of favorable outcome at 90 days, and lower rates of inpatient mortality/hospice discharge, 90-day mortality, and 90-day poor outcome were observed following EVT treatment. Thus, post-ASPECTS and post-pc-ASPECTS applied to NCCT have strong prognostic utility in determining clinical outcomes of anterior and posterior circulation AIS, respectively.[17,24,25,35] Moreover, we found that patients in the post-ASPECTS ≥ 7 anterior circulation group also had shorter DRT, PRT, and LKNPT. To our knowledge, there is only one other study that applied pc-ASPECTS to pre-intervention NCCT; they found that patients of BAO with a pc-ASPECTS ≥ 5 could benefit from EVT.[25] Results from the current study can be used in combination with other variables to build prognostic models to predict the outcome of EVT in stroke patients.[36–38]

Time is brain; we should spare no effort to help reduce procedural times and LKNPT through workflow optimization with multidisciplinary collaboration, reduce infarct volume and early prediction to improve endovascular time metrics and patient outcomes.[39–43] DRT and PRT can be further shortened through the standardization of acute stroke workflows to improve patient outcomes.[40]

The main limitations of this study include its retrospective study design and small sample size. Future large-scale cohort studies with larger sample sizes are required to validate and expand these findings. In addition, the current study lacks information on follow-up therapeutic drugs, such as antiplatelets and anticoagulants, due to the unavailability of patients, which may affect patient outcomes. Despite these limitations, our findings add to the overall body of knowledge on its prognostic utility in evaluating post-EVT functional outcomes among patients with anterior and posterior circulation AIS-LVO.

Conclusion

In conclusion, post-ASPECTS ≥ 7 in anterior circulation AIS and post-PC-ASPECTS ≥ 7 in posterior circulation can serve as strong prognostic markers of functional outcome after EVT.

Data Sharing Statement

Data and materials will be made available by contacting the corresponding authors, either Shuiquan Yang or Sijie Zhou.

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Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising, or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accounFigure for all aspects of the work.

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Disclosure

The authors report no conflicts of interest in this work.

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