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Original Article

Value of Brain Computed Tomographic Angiography to Predict Post Thrombectomy Final Infarct Size and Clinical Outcome in Acute Ischemic Stroke

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Abstract

Aims: This study aims to analyze the predictor in preoperative brain computed tomographic angiography (CTA) for final infarct and outcome in postendovascular thrombectomy patient. **Subjects and Methods:** 52 patients were retrospectively reviewed. The Alberta Stroke Program Early Computed Tomography Score (ASPECTS) comparison between preoperative noncontrast computed tomography (NCCT) and 24-h NCCT as well as preoperative CTA source image (CTA-SI) and 24-h NCCT were performed. Factors associated with increased ASPECTS and clinical outcome were evaluated. **Results:** Preoperative NCCT ASPECTS = 24-h NCCT in 23%. Whereas, 46% showed preoperative CTA-SI ASPECTS = 24-h NCCT. Moreover, 40.4% showed 24-h NCCT ASPECTS > preoperative CTA-SI (increased ASPECTS). The two significant factors associated with increased ASPECTS are thrombolysis in cerebral infarct score 2b/3 (P = 0.02) and good collateral status (P = 0.02). Finally, good clinical outcome was associated with age <60 (P = 0.04), preoperative CTA-SI ASPECTS >5 (P = 0.01), good collaterals status (P = 0.02), and increased ASPECTS (P = 0.05). **Conclusions:** Preoperative brain CTA provided the necessary factors that are associated with good clinical outcomes, which are CTA-SI ASPECTS > 5, good collateral status, and increased ASPECTS.

Keywords: *Computed tomographic angiography source image Alberta Stroke Program Early Computed Tomography Score, final infarct volume, increase Alberta Stroke Program Early Computed Tomography Score, stroke outcome*

Introduction

Stroke is a major worldwide health burden and is the leading cause of death and long-term disability. Imaging is crucial in acute stroke diagnosis and management. Noncontrast computed tomography (NCCT) is presently the imaging method of choice since it is faster and more widely available than magnetic resonance imaging (MRI).[1-3] The Alberta Stroke Program Early Computed Tomography Score (ASPECTS) from the baseline NCCT is a simple grading system developed to assess early infarct and is currently used worldwide during the decision-making process before revascularization with intravenous (IV) thrombolysis or endovascular thrombectomy.

Preoperative computed tomographic angiography (CTA) is recommended in patients who are indicated for endovascular thrombectomy.[2] CTA is able to assess the site of vessel occlusion and rapidly provide useful information that may affect management, such as collateral status and the source image of preoperative CTA (CTA-SI) to predict final infarct, which can affect patient clinical outcomes.[4]

Various studies have confirmed that good collateral status on preoperative multiphase CTA improves clinical outcomes in relation to final infarct size.[5-12] Meanwhile, CTA-SI hypoattenuated areas have been found to have correlations with final infarct size and clinical outcomes in comparison to NCCT.[11,13-17] Some studies also show that CTA-SI hypoattenuated areas represent infarct core.[11,13-15] However, we observe that a number of patients who had undergone endovascular thrombectomy in our center showed increased ASPECTS in 24-h NCCT from CTA-SI ASPECTS and these patients showed good clinical outcomes. We therefore hypothesize that

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increasing ASPECTS in postoperative NCCT may be associated with good clinical outcomes for acute ischemic stroke patients.

Subjects and Methods

Study protocol and population

In this retrospective cross-sectional study, the researchers assessed clinical and imaging information from postendovascular thrombectomy patients in the researcher's center from January 2012 to September 2017. Ninety-three postendovascular thrombectomy patients were enrolled in the study.

Patients were excluded if there was posterior circulation acute ischemic stroke (n = 15) and no CTA brain images present in our data system (n = 26). A total of 52 patients were enrolled in the final analysis. Baseline demographic data included age, sex, underlying diseases associated vascular risk factors, initial National Institutes of Health Stroke Scale (NIHSS) scores, IV recombinant tissue plasminogen activator (r-TPA) treatment, site of vessel occlusion, NCCT ASPECTS, preoperative CTA-SI ASPECTS, and follow-up NCCT ASPECTS of at least 24 h, hemorrhagic transformation, collateral status, time from symptom onset to recanalization, time from CTA to recanalization, the endovascular thrombectomy method, the thrombolysis in cerebral infarct score (TICI), and the modified Rankin Scale (mRS) for outcome analysis. The study was approved by the local ethics committee on human right related to research involving human subjects, based on the Declaration of Helsinki.

Imaging techniques

Multislice NCCT, preoperative multiphase CTA-SI, and follow-up NCCT of at least 24 h to assess the final infarct size were performed in our center with (1) A 320-detector Toshiba (Aquillion One Toshiba Medical Systems Co., Tokyo, Japan), (2) A 64-detector Toshiba (Aquillion CX Toshiba Medical Systems Co., Tokyo, Japan), and (3) A 64-detector Philips (IQon Philips Healthcare, USA).

Continuous axial sections parallel to the orbitomeatal line of NCCT were obtained from the base of the skull to vertex. Coverage of CTA varied from skull base to vertex, C7 to vertex, and aortic arch to vertex. The contrast was injected at a flow rate of 4–5 cc/s with a total volume of 70–90 cc. The patients from other hospitals that indicated for endovascular thrombectomy performed multislice NCCT with single-phase CTA before referring to our center.

Imaging analysis

All images were independently evaluated by one interventional neuroradiologist and one radiologist. Images from preoperative NCCT, preoperative multiphase and single-phase CTA-SI, and the follow-up NCCT at least 24 h for each patient were interpreted at an interval that was at least 1 week between reading sessions. The images were randomized, and the researcher was blind to the clinical information beyond the side on which the symptoms of stroke occurred. All images were digitally reviewed at the workstation with the same large high-resolution monitor and the same optimal window setting.

Definition and imaging interpretation

Alberta Stroke Program Early Computed Tomography Score interpretation

The interpreters used the ASPECTS method to evaluate NCCT, CTA-SI, and NCCT at least 24 h. A normal CT scan should receive an ASPECTS score of 10 points. Evidence of parenchymal hypoattenuation, loss of gray-white differentiation and sulci effacement on NCCT images, and diminished contrast enhancement of the parenchyma relative to the contralateral hemisphere on CTA-SI images were not scored.

Increased Alberta Stroke Program Early Computed Tomography Score

ASPECTS increase in 24-hour NCCT ≥1 point compared with preoperative CTA-SI ASPECTS or preoperative NCCT [Figure 1].

Table 1: Collateral status in multiphase and single-phase CTA were described by Garcia-Tornel et al. as score 4-5 points in the first and second phases of multiphase CTA or score 2-3 points in single phase CTA

Score	Multiphase CTA
5	Compared to an asymptomatic contralateral hemisphere, there is no delay and normal/increased prominence of peripheral vessels/normal extent within the occluded arteries territory within the symptomatic hemisphere
4	Compared to asymptomatic contralateral hemisphere there is a delay of one phase in filling in of peripheral vessels, but prominence and extent is the same
3	Compared to asymptomatic contralateral hemisphere there is a delay of two phases in filling in of peripheral vessels but prominence and extent is the same or there is a one phase delay and decreased prominence (thinner vessels)/reduced number of vessels in some part of the territory occluded
2	Compared to asymptomatic contralateral hemisphere there is a delay of two phases in filling in of peripheral vessels and decreased prominence and extent or a one-phase delay and some regions with no vessels in some part of the territory occluded
1	Compared to asymptomatic contralateral hemisphere there are just a few vessels visible in any phase within the occluded vascular territory
	Single-phase CTA
3	Equal or >100% collateral supply of the occluded MCA territory
2	Collateral supply filling >50% but <100% of the occluded vascular territory
1	Collateral supply filling <50% but >0% of the occluded vascular territory

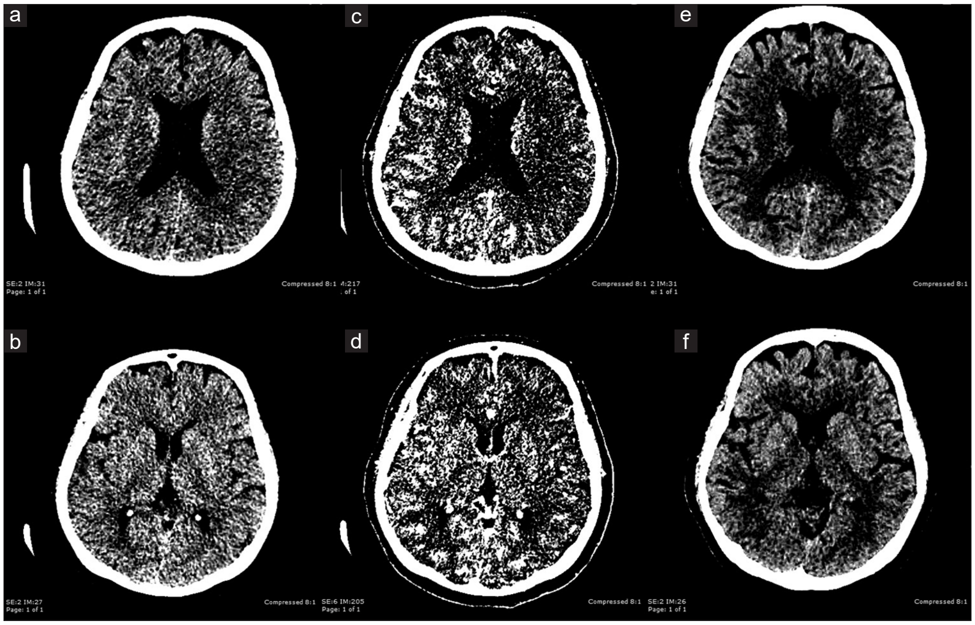

Figure 1: (a-f) Preoperative noncontrast computed tomography, preoperative computed tomographic angiography source image, and 24-h noncontrast computed tomography of the postthrombectomy patient shows increased Alberta Stroke Program Early Computed Tomography Score in 24-h noncontrast computed tomography compared with computed tomographic angiography source image (a and b) preoperative noncontrast computed tomography shows Alberta Stroke Program Early Computed Tomography Score = 10 (c and d) preoperative computed tomographic angiography source image Alberta Stroke Program Early Computed Tomography Score = 4 (e and f) 24-h noncontrast computed tomography Alberta Stroke Program Early Computed Tomography Score = 10

Good collateral status

Good collateral status in multiphase and single-phase CTA were described by García-Tornel *et al*.[12] as score 4–5 points in the first and second phases of multiphase CTA or score 2-–3 points in single phase CTA [Table 1].

Good clinical outcome

Three months mRS <2.

Statistical analysis

Demographic, clinical, and imaging results were expressed as number with percentage, mean (standard deviation [SD]), and median (range). To determine the differences between the two groups, the researchers used a *t*-test or Mann–Whitney test for continuous variables and a Chi-square or exact test for categorical data. The *t*-test was used to determine the difference between NCCT ASPECTS, CTA-SI ASPECTS, and 24-hour NCCT ASPECTS. The concordance correlation coefficiency was utilized to evaluate two interrater agreements for total ASPECTS grading and agreement of infarct size between NCCT, CTA-SI, and 24-h NCCT ASPECTS, with adjusted 95% limited of the agreement.

For preoperative CTA-SI ASPECTS, the receiver operating characteristic (ROC) curve was employed to identify the best cutoff point of the standard guideline, maximum sensitivity, and specificity for discriminating between patients with good clinical outcomes. Subgroup analysis was used as (1) ASPECTS increase or reversible ASPECTS (24-h NCCT ASPECTS higher than CTA-SI ASPECTS), (2) irreversible ASPECTS (24-h NCCT ASPECTS equal or lower than CTA-SI ASPECTS), and *t*-test was used to determine the difference between these groups.

Logistic regression and multivariate analysis were applied to determine the predictor of the increased ASPECTS score and good clinical outcomes. The results are presented as odds ratio (OR), 95% confidence interval (CI) with *P* value. Statistical analysis was performed using STRATA 15.1 (StataCorp, Texas, USA).

Results

Interrater agreement for Alberta Stroke Program Early Computed Tomography Score interpretation

In the Bland–Altman analysis, there was a small difference between the mean NCCT ASPECTS (0.11; $P < 0.05$; 95% limit of agreement −0.63–0.86), the mean CTA-SI ASPECTS (0.2; $P < 0.05$; 95% limit of agreement −0.91–1.33), and the mean follow-up NCCT ASPECTS at least 24 h (0.10; $P < 0.05$; 95% limit of agreement − 1.00–0.81). There was a substantial interrater agreement for ASPECTS grading with an excellent concordance correlation.

Demographic data

The analysis included a total of 52 patients who had received endovascular thrombectomy between January 2012 and September 2017. The mean patient age was 64.7 ± 15.9 years, and twenty-nine of the patients (55.8%)

were women. Underlying disease-associated ischemic stroke risk factors, including hypertension, diabetes mellitus, atrial fibrillation, and dyslipidemia, were present in 24 (48.8%), 8 (16.0%), 23 (46.0%), and 10 (20.4%) patients, respectively. The mean baseline NIHSS score was 17.2 ± 5.2. The researchers treated 19 patients (38%) with combined IV r-TPA and endovascular thrombectomy, while 33 patients (62%) were treated with endovascular thrombectomy alone. The mean (SD) NCCT ASPECTS and CTA-SI ASPECTS were 8.1 ± 1.6 and 5.1 ± 2.5. The median (range) follow-up NCCT ASPECTS at least 24 h was 6.5 h (0–10). In follow-up imaging, fifteen patients (29.4%) had hemorrhagic transformation of an infarct. Twenty-three patients (44.2%) had good collateral status. Internal carotid artery occlusion was identified in 31 patients (59.6%), followed by M1 middle cerebral artery (MCA) occlusion in 17 patients (32.7%) and M2 MCA occlusion in 4 patients (7.7%). The median time (range) of stroke onset to recanalization was 5.5 h (2.7–20.4) and the mean (SD) time of CTA onset to recanalization was 2.5 ± 0.9 h. Endovascular thrombectomy was performed with stent retrievers in 27 cases (55.1%), aspiration catheter in 10 cases (20.4%), and combined methods were used in 12 cases (24.5%). Successful reperfusion (TICI 2b/3) was achieved in 36 patients (61.5%), and favorable outcomes were observed in 15 patients (36.6%) [Table 2].

Table 2: Baseline characteristics

Variables	Value
Age, mean±SD	64.7±15.9
Age <60 (%)	32.7
Male sex (%)	44.2
Hypertension (%)	48.8
Diabetes (%)	16
Atrial fibrillation (%)	46
Dyslipidemia (%)	20.4
Baseline NIHSS, mean±SD	17.2±5.2
IV r-TPA (%)	38
NCCT ASPECTS, mean±SD	8.1±1.6
CTA-SI ASPECTS, mean±SD	5.1±2.5
24-h NCCT, mean±SD	5.8±2.9
Good collateral score in CTA (%)	44.2
ICAs (%)	59.6
M1 MCA (%)	32.7
M2 MCA (%)	7.7
Onset to recanalization min, mean±SD	354.9±173.9
CTA to recanalization min, mean±SD	137.3±54.8
TICI 2b/3 (%)	61.5
Stent retriever thrombectomy (%)	55.1
Aspiration thrombectomy (%)	20.4
Both techniques (%)	24.5
Good outcome at 3 months (%)	36.6
Hemorrhagic transformation (%)	29.4

SD – Standard deviation; NIHSS – National Institutes of Health Stroke Scale; IV r-TPA – Intravenous recombinant tissue plasminogen activator; NCCT – Noncontrast computed tomography; CTA-SI – Computed tomography angiography source image; ASPECTS – Alberta Stroke Program Early Computed Tomography Score; ICA – Internal carotid artery; MCA – Middle cerebral artery; TICI score – Thrombolysis in cerebral infarct score

Twenty-four hour noncontrast computed tomography Alberta Stroke Program Early Computed Tomography Score compared with computed tomographic angiography source image Alberta Stroke Program Early Computed Tomography Score and preoperative noncontrast computed tomography Alberta Stroke Program Early Computed Tomography Score

The 24-h NCCT ASPECTS was lower than preoperative NCCT ASPECTS in 40 patients (76.9%), and there was no difference in 12 patients (23.1%). The 24-h NCCT ASPECTS was higher than CTA-SI in 21 patients (40.4%), no difference in 24 patients (46.1%), and lower than CTA-SI ASPECTS in 7 patients (13.4%) [Table 3]. Using *t*-test to compare between preoperative NCCT, CTA-SI, and 24-h NCCT ASPECTS showed that the 24-hour NCCT ASPECTS (mean/SD 5.82 ± 2.90) tended to lower than preoperative NCCT ASPECTS (mean/SD 8.13 ± 1.57) with a mean difference of 2.30 ($P < 0.0001$) and also tended to be higher than the mean CTA-SI ASPECTS (mean/SD 5.10 ± 2.51) with a mean difference of 0.78 ($P = 0.01$) [Table 4].

Table 3: Subgroup analysis as higher, equal, or lower 24-h Alberta Stroke Program Early Computed Tomography Score than preoperative noncontrast computed tomography and computed tomography angiography source image groups

	24-h NCCT	*n* (%)
Preoperative NCCT ASPECTS	>24-h NCCT	40 (76.9)
	24-h NCCT	12 (23.1)
	<24-h NCCT	0 (0)
CTA-SI ASPECTS	>24-h NCCT	7 (13.4)
	24-h NCCT	24 (46.1)
	<24-h NCCT	21 (40.4)

NCCT – Noncontrast computed tomography; CTA-SI – Computed tomography angiography source image; ASPECTS – Alberta Stroke Program Early Computed Tomography Score

Univariate analysis

Multiple demographic, clinical, and imaging results were analyzed to determine the correlation between (1) increased ASPECTS in NCCT and (2) good clinical outcome. The CTA-SI ASPECTS score was found to be one of the most interesting associated factors. The researchers used a ROC curve to identify the best cutoff point of CTA-SI ASPECTS which included maximum sensitivity and specificity to predict patient outcomes. The best CTA-SI ASPECTS cutoff value to predict good clinical outcomes is given as >5 with 86.67% sensitivity, 61.54% specificity, and a ROC area 0.73 (95% CI 0.56–0.90).

Univariate analysis contains various predictive factors, including sex, age <60, hypertension, diabetes, atrial fibrillation, dyslipidemia, previous IV r-TPA, onset to recanalization time, CTA to recanalization time, TICI 2b/3, ASPECTS of preoperative NCCT, CTA-SI and 24-h NCCT, increased ASPECTS, CTA ASPECTS >5, good collateral CTA, and a history of asymptomatic or symptomatic hemorrhagic transformation. The statistically significant factors associated with an increased ASPECTS score in 24-hour NCCT were TICI 2b/3 (OR 5.84, *P* = 0.008) and good collateral status in CTA (OR 4.92, *P* = 0.008). Furthermore, the statistically significant factors associated with good outcome were age <60 (OR 0.94, *P* = 0.01), CTA-SI ASPECTS (OR 1.37, *P* = 0.01), CTA-SI ASPECTS >5 (OR 3.8, *P* = 0.03), increased in ASPECTS (OR 4.98, *P* = 0.01), and good collateral status in CTA (OR 38.25, *P* < 0.0001) [Table 5].

Multivariate analysis

In the multivariate analysis, TICI 2b/3 (OR 5 *P* = 0.02) and good collateral status in CTA (OR 4.2, *P* = 0.02) were found to be statistically associated

Table 4: Different Alberta stroke program early computed tomography score of preoperative noncontrast computed tomography, computed tomography angiography source image, and 24-h noncontrast computed tomography

	Mean (±SD) ASPECTS	Mean ASPECTS difference	*P*
Preoperative NCCT: 24-h NCCT	8.13±1.57:5.82±2.90	2.3	<0.0001
CTA-SI: 24-h NCCT	5.10±2.51:5.82±2.90	0.78	0.01

NCCT – Noncontrast computed tomography; CTA-SI – Computed tomography angiography source image; ASPECTS – Alberta Stroke Program Early Computed Tomography Score; SD – Standard deviation

Table 5: Univariate and multivariate analyses

Univariate analysis					
Factor	**Increased ASPECTS**		**Factor**	**Good outcome**	
	OR (95% CI)	***P***		**OR (95% CI)**	***P***
Male sex	0.77 (0.25-2.31)	0.64	Male sex	0.58 (0.18-1.82)	0.35
Age	0.99 (0.96-1.03)	0.82	Age <60	0.94 (0.90-0.98)	0.01
Hypertension	1.6 (0.53-4.81)	0.40	Hypertension	0.84 (0.27-2.62)	0.77
DM	0.80 (0.19-3.28)	0.76	DM	0.69 (0.15-3.08)	0.63
AF	1.34 (0.44-4.02)	0.59	AF	0.48 (0.15-1.54)	0.22
Dyslipidemia	0.55 (0.14-2.13)	0.39	Dyslipidemia	0.83 (0.21-3.24)	0.79
IV r-TPA	1.70 (0.54-5.34)	0.35	IV r-TPA	1.02 (0.31-3.29)	0.97
NINHSS	0.99 (0.88-1.10)	0.86	NIHSS	0.99 (0.88-1.11)	0.88
Onset to recanalization time	1.0 (0.99-1.0)	0.33	Onset to recanalization time	1.00 (0.99-1.00)	0.23
CTA to recanalization time	1.0 (0.99-1.01)	0.36	CTA to recanalization time	0.99 (0.98-1.00)	0.86
TICI 2b/3	5.84 (1.58-21.5)	0.008	TICI 2b/3	2.33 (0.68-7.98)	0.17
NCCT ASPECTS	1.25 (0.87-1.81)	0.22	NCCT ASPECTS	1.30 (0.88-1.93)	0.17
CTA-SI ASPECTS	0.95 (0.76-1.18)	0.67	CTA-SI ASPECTS	1.37 (1.05-1.78)	0.01
24-h NCCT ASPECTS	1.40 (0.99-1.81)	0.07	CTA-SI ASPECTS >5	3.8 (1.10-13.0)	0.03
Hemorrhagic transformation	0.34 (0.09-1.28)	0.11	24-h NCCT ASPECTS	1.4 (0.99-1.81)	0.07
Good collateral CTA	4.92 (1.5-16.0)	0.008	Increased ASPECTS	4.98 (1.47-16.86)	0.01
			Hemorrhagic transformation	0.32 (0.07-1.36)	0.12
			Good collateral CTA	38.25 (6.9-211.79)	<0.0001
Multivariate analysis					
Factor	**Increased ASPECTS**		**Factor**	**Good outcome**	
	OR (95% CI)	***P***		**OR (95% CI)**	***P***
TICI 2b/3	5 (1.27-19.6)	0.02	Age <60	0.92 (0.85-0.99)	0.04
Good collateral CTA	4.2 (1.19-14.7)	0.02	CTA ASPECTS	1.37 (0.79-2.38)	0.25
			CTA-SI ASPECTS >5	8.71 (1.61-12.3)	0.01
			Good collateral CTA	38.25 (6.9-211.79)	0.02
			Increased ASPECTS	7.11 (0.99-8.18)	0.05

DM – Diabetes mellitus; AF – Atrial fibrillation; NIHSS – National Institutes of Health Stroke Scale; IV rtPA – Intravenous recombinant tissue plasminogen activator; NCCT – Noncontrast computed tomography; CTA-SI – Computed tomography angiography source image; ASPECTS – Alberta Stroke Program Early Computed Tomography Score; TICI score – Thrombolysis in cerebral infarct score; CI: Confidence interval; OR: Odds ratio with increased ASPECTS in 24-h NCCT. Four factors were found to be statistically associated with outcome prediction, which included age <60 (OR 0.92, *P* = 0.04), good collateral status in CTA-SI (OR 38.25, *P* = 0.02), CTA-SI ASPECTS >5 (OR 8.71, *P* = 0.01), and increased ASPECTS in 24-h NCCT (CTA-SI ASPECTS <24-h NCCT ASPECTS) (OR 7.11, *P* = 0.05) [Table 5].

Discussion

Factors predicting increased Alberta Stroke Program Early Computed Tomography Score in 24-h noncontrast computed tomography

Although the 2018 guidelines for the management of acute strokes included a selection criterion for patients to receive endovascular thrombectomy up to 24 after stroke onset using additional CT perfusion or MRI[2] with automated software, this may not be available in every hospital. Moreover, the researchers observed that a number of patients in our center who had undergone endovascular thrombectomy showed increased ASPECTS score in 24-h NCCT from CTA-SI and achieved good clinical outcomes. This subsequently inspired the researchers to study the CTA-SI-related and patient-related factors that affect decision-making before endovascular thrombectomy in our center.

Earlier studies suggest that CTA-SI hypoattenuated areas represent only infarct core,[11,13-15] in concordance with one group of the present study's results in 24 patients (46.1%). However, the present study also demonstrated that 24-h NCCT ASPECTS tended to be higher than CTA-SI (increased ASPECTS) in 21 patients (40.4%). Moreover, the factors that significantly associated with increased ASPECTS are TICI 2b/3 and good collateral status. This result corresponds with Sharma *et al*.[18] and findings from recent studies[16,18,19] that the CTA-SI hypoattenuated area may be similar to the infarct core with a penumbra zone and be closely correlated with cerebral blood flow on the perfusion CT, which may imply that the salvageable brain tissue may survive if good recanalization (TICI 2b/3) is achieved and the patients have a good collateral status.

Factors predicting clinical outcome of acute ischemic stroke

To the best of the researchers' knowledge, previous studies have successfully established the importance of collateral supply in predicting the final infarct volume and clinical outcomes.[5,6,9,10] Good collateral supply may help prevent or limit the extent of infarction until the reperfusion of ischemic penumbra is achieved.[5] In contrast, inadequate collateral flow may cause irreversible neuronal damage within minutes. In addition, the researchers suggest that the best cutoff value of CTA-SI ASPECTS >5 can indicate good clinical outcomes for acute ischemic stroke patients. These findings correspond with CTA-SI ASPECTS >5 by Sallustio *et al*.[15] and a recent meta-analysis study of five endovascular stroke trials.[20] These factors concur with the findings of the present study that age <60, CTA-SI ASPECTS, and good collateral status were factors that were significantly associated with good clinical outcomes and should be used as important indicators to influence decision-making for endovascular thrombectomy. Moreover, the increased ASPECTS (24-h NCCT ASPECTS > CTA-SI) is the additional factor that significantly associated with good clinical outcome.

One of the useful factors to predict the postthrombectomy outcome and complication is good collateral status in brain CTA. The published data show that chronic hypertension,[21] metabolic disease (e.g., diabetes and hyperlipidemia), and older age[22] could be a detrimental effect on leptomeningeal collateral status in large vessel occlusion acute ischemic stroke patient. In our study, hyperlipidemia was found in 20.4%, 86.3% were 60 years or more, and 48.8% of cases have had chronic hypertension. These factors may affect our patients and result in only 44.2% of cases have had good collateral status.

A lot of previously published data elucidates how good recanalization status (TICI 2b/3) positively affects positive clinical outcomes,[2,3,23] but the results of the present study are discordant with those findings. This is likely since our onset-to-recanalization time is prolonged with meantime 354.9 min (±173.9 SD). Some published results[24-27] show that good clinical outcomes may not be obtained even where TICI 2b/3 is achieved if the onset to recanalization time window is prolonged. Moreover, the present results show higher hemorrhagic transformation than previous data,[28] and there are only 44.2% of the patients in our study that have had good collateral status, which may also affect the clinical outcome.

The limitations of the present study include that it was a retrospective fashion and the small sample size which may decrease the statistical power of the study. Second, the acute ischemic stroke patient with good collateral status CTA may have NIHSS <6, which may not indicate for endovascular thrombectomy or enrolled into the present study, causing selection bias to our result. Moreover, the time interval between NCCT ASPECTS, CTA-SI ASPECTS, and follow-up NCCT ASPECTS in the evaluation of final infarct size is prolonged, and multiple confounding factors are not included in the present study such as pre-/post-operative blood pressure, which may affect the outcome. Furthermore, previous studies used additional perfusion imaging for evaluating the final infarct,[16,18,19] while the researchers' institute only performs NCCT and preoperative CTA for routinely patient selection for endovascular thrombectomy.

Conclusions

CTA-SI ASPECTS more closely approximates final infarct size than preoperative NCCT. However, if good collateral CTA present and TICI 2b/3 achieved, the final infarct was shown to be smaller than CTA-SI, which predicted a good clinical outcome as well as age <60, CTA-SI ASPECTS >5, and good collateral status. These findings may play a relevant role in predicting patient clinical outcomes and patient selection for endovascular thrombectomy. However, the use of pre- or post-operative brain CTA as the screening tool in acute ischemic stroke patients, contrast media-related complication, iodine-induced renal intoxication, and radiation protection issues, as well as the cost-effectiveness of the CTA should be considered, to prevent the sequential adverse events or further financial problem to the patient.

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Conflicts of interest

There are no conflicts of interest.

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