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Original Research Article

Impact of vertebral artery tortuosity on mechanical thrombectomy for basilar artery occlusion – A tertiary center experience

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ABSTRACT

Background: Tortuosity in anterior circulation has been associated with the outcomes of mechanical thrombectomy (MT). We classified vertebral artery (VA) tortuosity and investigated the effect of VA tortuosity on the outcomes of basilar artery occlusion (BAO) after MT.

Materials and Methods & Results: We enrolled patients who underwent MT for BAO. VA tortuosity was classified into three-types; Type-I: non-tortuous, Type-II: S-shape or VA with acute angulation (<90°), and Type-III: coiled, kinked, or VA with multiple acute angulations. The 3-month modified Rankin Scale (mRS), successful recanalization, and post-MT hemorrhagic transformation (HT) were assessed. A total of 106 patients were included. Age, baseline stroke severity, and the 3-month mRS score were significantly different according to the VA tortuosity (P=0.003, P=0.002, and P<0.001, respectively). A multivariable analysis demonstrated that VA tortuosity was a predictor for mRS score 0-3 (Type-I: reference; Type- II: 0.26 [0.07–0.95], P=0.041; Type-III: 0.12 [0.02–0.82], P=0.031). Moreover, Type-III was associated with less successful recanalization (Type-I: reference; Type-III: 0.12 [0.02–0.84], P=0.032) and was a potential factor for post-MT HT (Type-I: reference; Type-III: 3.09 [0.83– 11.56], P=0.094).

Conclusions: VA tortuosity was significantly associated with the stroke outcome after MT for BAO. Initial stroke severity and successful recanalization might affect the stroke outcome.

1. Introduction

Mechanical thrombectomy (MT) has become the main therapy for emergent large-vessel occlusion of anterior circulation and several factors are known as the predictors of the outcome.[1,2] Recently, vascular tortuosity has been gaining interest as a predictor of successful recanalization, post-procedural hemorrhagic transformation (HT), and functional outcome.[3–5] Vascular tortuosity could be a technical limitation for effective thrombectomy.[5,6] While several studies have reported the role of carotid tortuosity in predicting the outcomes of MT in anterior circulation, the role of vertebral artery (VA) tortuosity in posterior circulation stroke has rarely been focused upon.[3,5,6] Since the anatomical structure and the effectiveness of MT are different between carotid and vertebral arteries, the impact of vessel tortuosity for anterior and posterior circulation MT might be different.[7] We investigated the impact of VA tortuosity on the outcomes in patients who underwent MT due to basilar artery occlusion (BAO).

2. Materials and Methods

2.1. Participants and clinical data

We retrospectively reviewed the patients admitted to our tertiary care hospital between January 2012 and May 2022. Patients who received MT for BAO (except MT for multiple occlusions) were included. The main outcome was the

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achievement of good functional outcome (modified Rankin Scale [mRS] score 0–3) at 3 months. The procedural outcome (successful recanalization) and safety outcome (any HT) were also analysed. Modified Thrombolysis in Cerebral Infarction grade 2b/3 was defined as successful recanalization. After MT, gradient echo images were followed-up to determine HT. Informed consent was not obtained due to retrospective nature.

2.2. VA tortuosity

We classified VA tortuosity into three-types. Antero-posterior and lateral projections of digital subtraction angiography (DSA) and computed tomography angiography (CTA) were used to investigate the VA tortuosity from the ostium to V2 segment. Additional oblique projections of DSA were neuro-interventionists' discretion.

Type-I was defined as (1) straight or (2) C-shape vessel without acute angulation (<90°). Type-II was defined as (1) S-shaped or (2) vessel with one acute angulation.

Type-III was defined as (1) coiled (circular configuration), (2) kinked, or (3) vessel with multiple acute angulations (Figure 1).

All the classification processes were blind to clinical data and independently performed.

2.3. Statistical analysis

We compared the factors according to the VA tortuosity using a one-way analysis of variance or Kruskal–Wallis test, as appropriate. Variables with potential association (P<0.10) in univariable logistic regression analyses were included in multivariable analyses. P-value <0.05 was considered as statistically significant. For the procedural and safety outcome, adjustments for age, sex, baseline National Institutes of Health Stroke Scale (NIHSS) score, intravenous thrombolysis, onset-to-puncture time, and MT method were made. Inter-rater reliability was calculated using the weighted kappa-coefficient. All the analyses were performed using R Software (version 4.2.0; R Foundation for Statistical Computing, Vienna, Austria).

3. Results

After excluding two patients with multiple occlusions, 106 patients were included. The mean age was 67.6±12.8 years, and 67 (63.2%) patients were men. Ninety-six (90.6%) patients were analysed by DSA with CTA, and 10 (9.4%) by CTA alone. The kappa-coefficient was 0.77 (0.68–0.87).

The mean age increased with VA tortuosity (P=0.003). The baseline NIHSS score (P=0.002) and 3-month mRS score (P<0.001) increased significantly as the VA tortuosity increased. Puncture-to-recanalization time increased in Type-III tortuosity (P=0.048). Moreover, the proportion of good functional outcomes was significantly different according to the VA tortuosity (P<0.001). The proportion of successful recanalization decreased (P=0.050) and any HT increased (P=0.048) in a more tortuous VA (Table 1).

An univariable logistic regression analysis showed that age, hyperlipidaemia, baseline NIHSS score, successful recanalization, any HT, and VA tortuosity were the potential factors for good functional outcomes. A multivariable analysis showed that the baseline NIHSS score, and VA tortuosity (Type-I: reference; Type-II: 0.26 [0.07–0.95], P=0.041; Type-III: 0.12 [0.02–0.82], P=0.031; Table 2) were associated with good functional outcomes. Successful recanalization was associated with VA tortuosity, especially in Type-III (Type-I: reference; Type-II: 0.28 [0.05 1.61], P=0.153; Type-III: 0.12 [0.02–0.84], P=0.032).

There was a potential association between any HT and Type-III (Type-I: reference; Type-II: 1.59 [0.50–5.05], P=0.435; Type-III: 3.09 [0.83–11.56], P=0.094; Supplementary Table 1).

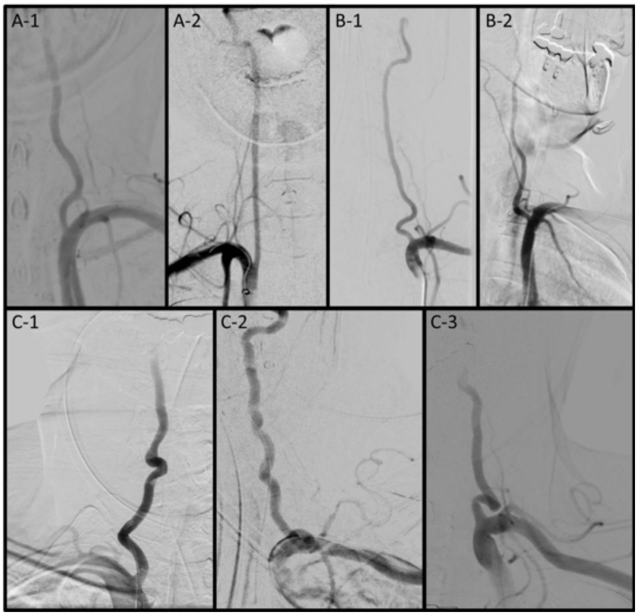

Fig. 1: Classification of vertebral artery tortuosity; **A:** Type-I: straight or C-shape without acute angulation (<90°); **B:** Type-II: S-shape or with; one acute angulation; **C:** Type-III: coiled, kinked, or with multiple acute angulations.

4. Discussion

The strength of this study lies in demonstrating that more tortuous VA is independently associated with functional outcome after MT for BAO. Due to increased friction hampering retrieval maneuvers and alteration of the vessel anatomy resulting from the traction to the pusher wire, to which the stent-retriever is connected, the devices may not be enough to recanalize occlusion in severe VA tortuosity.[4] In the same vein, more frequent manipulation in tortuous VA may lead to endothelial injury and HT. Less successful

Table 1: Baseline characteristics according to the VA tortuosity.

Variable	Type-I (N=40)	Type-II (N=44)	Type-III (N=22)	P value
Age, years	62.4±14.6	70.1±9.5	72.2±12.3	0.003
Male	25 (62.5)	28 (63.6)	14 (63.6)	0.993
Hypertension	21 (52.5)	36 (81.8)	12 (54.5)	0.010
Diabetes	16 (40.0)	15 (34.1)	7 (31.8)	0.773
Hyperlipidemia	15 (37.5)	10 (22.7)	7 (31.8)	0.332
Atrial fibrillation	12 (30.0)	20 (45.5)	8 (36.4)	0.341
Previous Stroke	11 (27.5)	14 (31.8)	8 (36.4)	0.765
Intravenous thrombolysis	7 (17.5)	7 (15.9)	8 (36.4)	0.126
Baseline NIHSS score	8 (6–15)	13 (9–21)	17 (13–21)	0.002
3-month mRS score	2 (1–4)	4 (3–5)	5 (5–5)	<0.001
mRS score 0-3	29 (72.5)	24 (54.5)	5 (22.7)	<0.001
Onset-to-puncture time, min	545(263–929)	626 (391–1036)	354 (237–648)	0.034
Puncture-to-recanalization time, min	54 (36–73)	56 (24–89)	84 (60–116)	0.048
Successful recanalization	38 (95.0)	37 (84.1)	16 (72.7)	0.050
Any hemorrhagic transformation	8 (20.0)	13 (29.5)	11 (50.0)	0.048
First-pass effect	15 (37.5)	17 (38.6)	4 (18.2)	0.213
Thrombectomy method				
Contact aspiration	21 (52.5)	24 (54.5)	9 (40.9)	0.562
Stent-retriever	23 (57.5)	16 (36.4)	14 (63.6)	0.055
Angioplasty	16 (40.0)	14 (31.8)	7 (31.8)	0.693

Values are expressed as number (%), mean ± standard deviation, and median (interquartile range). NIHSS, National Institutes of Health Stroke Scale; mRS, modified Rankin Scale.

Table 2: Factors associated with good functional outcomes.

	Crude OR		**Adjusted OR**	
Variable	(95% CI)	P value	(95% CI)	P value
Age	0.97 (0.94–1.00)	0.036	0.98 (0.93–1.03)	0.441
Hyperlipidemia	2.70 (1.15–6.32)	0.022	2.45 (0.64–9.41)	0.190
Baseline NIHSS score	0.80 (0.74–0.88)	<0.001	0.82 (0.74–0.91)	<0.001
Successful recanalization	13.11 (1.65–103.86)	0.015	9.72 (0.98–96.13)	0.052
Any hemorrhagic transformation	0.33 (0.13–0.84)	0.019	0.42 (0.11–1.55)	0.193
Vertebral artery tortuosity				
Type-I				
Type-II	0.18 (0.07–0.45)	<0.001	0.26 (0.07–0.95)	0.041
Type-III	0.04 (0.01–0.19)	<0.001	0.12 (0.02–0.82)	0.031

OR, odds ratio; CI, confidence interval; NIHSS, National Institutes of Health Stroke Scale.

recanalization and more frequent post-MT HT may have comprehensively affected poor functional outcomes in those with higher VA tortuosity.

The baseline stroke severity also increased as the VA tortuosity increased. The results correspond to the results from anterior circulation MT.[3] Vascular tortuosity is associated with old age, less collaterals with hypoperfusion, and previous brain lesions, all of which affect the baseline stroke severity.[8–10] However, the effect of vessel tortuosity on successful recanalization after MT may be higher in VA than in the anterior circulation.

Our study has some limitations. First, this study was a retrospective study with small number of patients. Second, we measured VA tortuosity using 2-dimensional imaging only. 3-dimensional rotational angiography could be more accurate. Finally, other vessels, such as aorta was not considered in our study. Unrevealed tortuosity may have influenced the results. Nevertheless, we classified VA tortuosity into three-types and showed the association between VA tortuosity and stroke outcome. Particularly, highly tortuous VA was associated with less successful recanalization and poor functional outcome.

5. Source of Funding

None.

6. Conflicts of interest

There are no conflicts of interest.

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