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Original Article

Validity about Diameter of Guiding Catheter for Posterior Circulation Derived by MRA Study

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Objective: The development of large-bore aspiration catheters (ACs) has advanced the treatment of mechanical thrombectomy (MT) and their use requires larger guiding catheters (GCs). However, due to the small vessel diameter of the vertebral artery (VA), it can be difficult to cannulate large-bore GC to the VA. This study aims to determine the percentage of VAs that are amenable to GC placement based on the use of a large-bore AC and to clarify the diameters of VAs in the general population using neck MRA.

Methods: Left and right VA diameters were measured in 1394 consecutive adult patients who underwent neck MRA at our hospital between April 2020 and June 2021. Sex and left/right differences in the VA diameters, as well as the conformity ratios of GCs (6, 7, and 8 French) to right and left VAs, were examined.

Results: The patients ranged in age from 18 to 98 years (mean 70.8 ± 13.5 years), with 770 (55.2%) males. The left and right VA mean diameters were 2.82 ± 0.75 mm (range 0–5.1 mm) and 2.65 ± 0.75 mm (range 0–5.3 mm), respectively. The conformity ratios of 6, 7, and 8 French GC to left and right VAs were 85.3% and 79.9%, 74.9% and 68.4%, and 60.9% and 53.7%, respectively.

Conclusion: When performing MT for the posterior circulation system, a large-bore AC of 0.060 inches or larger is usually required, and GC placement of 7-French or larger is necessary. The results of this study showed that 7-French GC placement is achievable in approximately 70% of these cases.

Keywords ▶ mechanical thrombectomy, vertebral artery, guiding catheter

Introduction

In the case of mechanical thrombectomy (MT), a quick decision on guiding catheter (GC) size selection is required due to the urgency of the procedure. With the advent of large diameter aspiration catheters (ACs) for MT, a GC with correspondingly large diameter should be selected. When a GC is to be placed in a vertebral artery (VA), however, GC size selection can be difficult because VAs have a smaller diameter than those in the anterior circulation. Although the evidence is not as clear as in the anterior circulation, there has been an increase in the case reports of MT in the posterior circulation with good outcomes.[1,2] The selection of an appropriate GC size prior to MT may contribute to the expansion of treatment device options and future improvement of outcomes.

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Materials and Methods

This retrospective study included 1394 consecutive adult patients who underwent neck MRA at our hospital from April 2020 to June 2021. At our hospital, we routinely include the aortic arch when performing cervical MRA and the study subjects mainly consisted of patients with stroke, trauma of head and neck, and cardiovascular disease. All the images were obtained using time-of-flight methods on a 3.0 T whole-body clinical system (Ingenia CX; Philips Healthcare, Best, The Netherlands) or on a 1.5 T whole-body clinical system (Ingenia; Philips Healthcare). Imaging parameters such as repetition time, 18/17 ms; echo time, 3.45/6.9 ms (out of phase); flip angle, 18/20; matrix

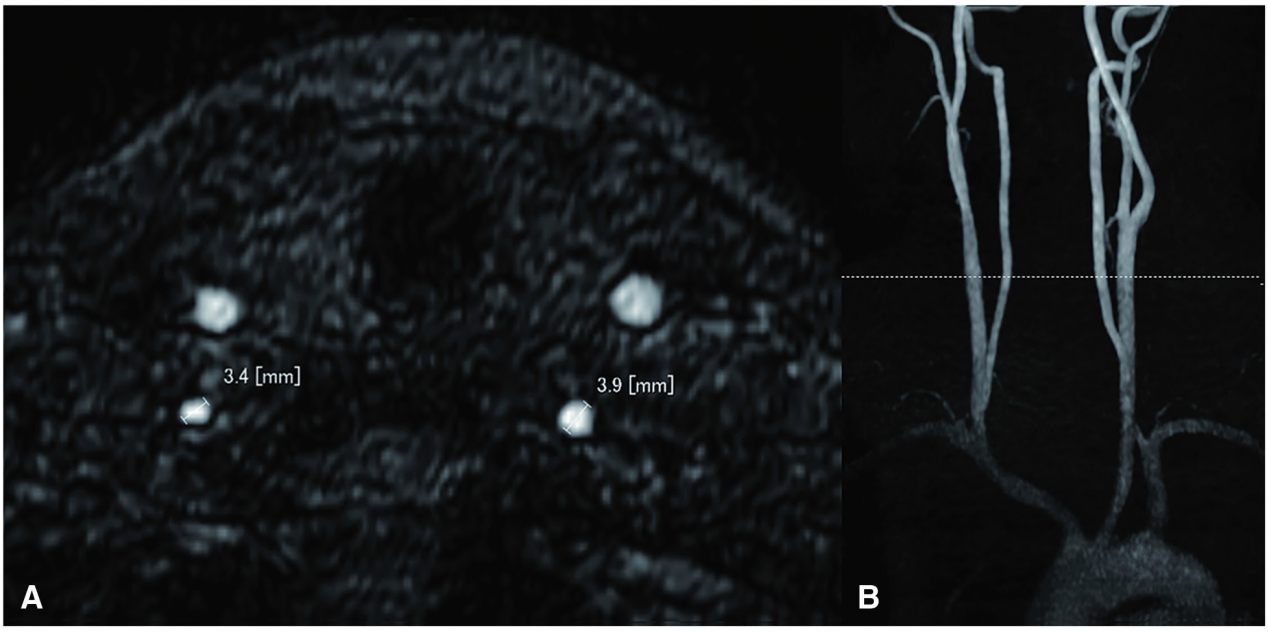

Fig. 1 An example of VA measurement by MRA. The right and left VA diameters are measured in TOF axial slice (**A**). The measurement sites are indicated by white dotted lines in the 3D-MRA (**B**). TOF: time of flight; VA: vertebral artery

size, 336 × 192/256 × 100; field of view, 200 × 200 mm; slices, 340/270; slice thickness, 1.2/1.5 mm; and sensitivity encoding acceleration factor, 3.5/2.3 were kept constant between the two sequences. The total data acquisition time for 3.0 T was 4 min 51s and for 1.5 T was 5 min 19s in all cases. One neuroradiologist certified by the Japanese Society of Neuroendovascular Therapy used axial slices to measure bilateral VA diameters (**Fig. 1**). The measurement site was chosen to be the VA, which runs through the transverse foramen of the fifth cervical vertebrae. Patients were considered to be on the dominant side if the difference between the right and left diameters was greater than twice the difference between the two sides. The research within our submission has been approved by the ethics institutional review board of Eastern Chiba Medical Center.

Statistics

The single-sample Kolmogorov–Smirnov test was used to determine the data's suitability for normal distribution. The homogeneity analysis of group variances was performed using Levene's statistics. The independent-samples t-test was used to determine the differences between males and females, as well as the left and right biometric measurements. For nominal variables, the Fisher's exact test was used. The significance level was set at $p < 0.05$. All the statistical analysis was performed using R version 4.0.0 (The R Foundation for Statistical Computing, Vienna, Austria).

Results

The patient's mean age was 70.8 ± 13.5 years (range 18–98 years). In all, 770 (55.1%) cases were male. The mean diameters of left and right VAs were 2.82 ± 0.75 mm (range 0–5.1 mm) and 2.65 ± 0.75 mm (range 0–5.3 mm), respectively. The left VA diameter was significantly larger ($p < 0.001$) than the right. As for the dominant side, the left side was predominant in 148 cases (10.6%) and the right side in 91 cases (6.5%), while VA aplasia was found in 11 cases (0.8%) on the left and 12 cases (0.9%) on the right. For females, mean VA diameters on the left and right sides were 2.76 ± 0.72 mm (range 0–4.6 mm) and 2.60 ± 0.70 mm (range 0–4.6 mm), respectively. For males, those were 2.88 ± 0.78 mm (range 0–5.1 mm) and 2.69 ± 0.79 mm (range 0–5.3 mm), respectively. Males had significantly larger VA diameters than females on both the left and right sides ($p = 0.003$ and $p = 0.042$, respectively) (**Table 1**).

Outer diameters of 6, 7, and 8 French GCs used for endovascular treatment correspond to 2.00 mm, 2.33 mm, and 2.66 mm, respectively, and thus, we investigated to what extent VA diameters are compatible with these GC sizes. Diameters less than 6-French (<2.00 mm) were found in 205 (14.7%) left VAs and 280 (20.1%) right VAs. Diameters less than 7-French (<2.33 mm) were found in 350 (25.1%) left VAs and 450 (31.5%) right VAs. Diameters less than 8-French (<2.66 mm) were 545 (39.1%) for the left VA and 645 (46.3%) for the right VA (**Fig. 2**). Thus,

Table 1 Result of our study about VA diameter

	All	Female	Male	p-value
Number	1394	624	770	
Age	70.77 ± 13.54 (range 18–98)	71.46 ± 14.18 (range 18–98)	70.21 ± 12.98 (range 18–97)	0.084
L_VA (mm)	2.82 ± 0.75 (range 0–5.1)	2.76 ± 0.72 (range 0–4.6)	2.88 ± 0.78 (range 0–5.1)	0.003
R_VA (mm)	2.65 ± 0.75 (range 0–5.3)	2.60 ± 0.70 (range 0–4.6)	2.69 ± 0.79 (range 0–5.3)	0.042
Dominant	Left 148, right 91	Left 54, right 40	Left 94, right 51	0.277
Aplasia	Left 11, right 12	Left 2, right 4	Left 9, right 8	0.64

L: left; R: right; VA: vertebral artery

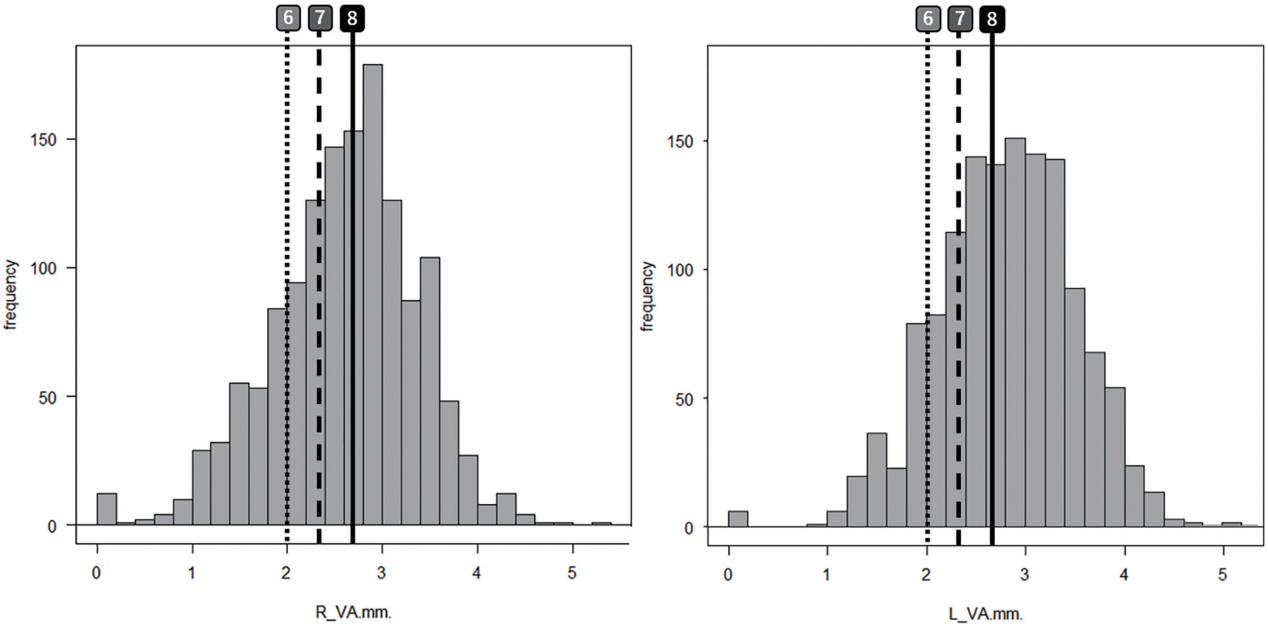

Fig. 2 VA diameter distribution and its relationship to each size GC. The dotted line shows the 6-French GC OD. The dashed line shows the 7-French GC OD. The solid line shows the 8-French GC OD. GC: guiding catheter; L: left; OD: outer diameter; R: right; VA: vertebral artery

6, 7, and 8-French GCs were available in 79.9% and 85.3%, 68.5% and 74.9%, and 53.7% and 60.9%, for left and right VAs, respectively (**Fig. 2**). In 6-French to 8-French, 24.4% were present on the left VA and 26.2% on the right VA.

Discussion

In this study, although the targeted vessel is cervical VA, the results do not deviate significantly from previous reports regarding intracranial VA diameter. All the previous studies have reported that the left VA is slightly larger than right (**Table 2**).[3–10] In the clinical setting of MT, the GC tip is expected to be placed distal to the V2 portion, and therefore, we investigated the vessel diameter of the cervical VA. The findings of this study will serve as a reference index for GC size selection.

Because of the possibility of omitting 3D-CTA and MRA and performing MT from the viewpoint of time-saving, it would be useful to have a reference value for GC conforming to VA. When a 7-French GC is set into the target vessel, a large-bore AC with a 0.060-inch lumen such as Catalyst 6 (Stryker Neurovascular, Fremont, CA, USA) or Penumbra ACE60 (Penumbra, Alameda, CA, USA) can be available. However, if 6-French GC is selected, the large-bore ACs that have become available in recent years are incompatible. When performing a direct aspiration-first pass technique prior to thrombus[11] with a large-bore AC or MT using a combined technique with a stent retriever and AC, a GC of 7-French or greater is also required. Thus, recent MT techniques require the placement of 7-French or larger GCs in VA. The results of our study showed that we can set a 7-French or larger GCs in approximately 70% of cases.

Table 2 Summary of VA diameter

Study	Year	Country	Number	Age (years)	Measured segment	VA (mm)	L_VA (mm)	R_VA (mm)	Modality
Kocak et al.[3]	2021	Turkey	199	48.55 ± 15.82 (range 18–91)	V4		3.14	2.82	CTA
Wijesinghe et al.[4]	2020	Sri Lanka	73	67.7 ± 9.96 (range 51–89)	V4		2.26 ± 0.065	2.21 ± 0.084	Cadaver
Vitosevic et al.[5]	2019	Serbia	120	52.90 ± 15.47 (range 12–76)	V4		2.36 ± 0.81	2.14 ± 0.79	CTA
Iwata et al.[6]	2015	Japan	32	58.7 (range 26–83)	V1			3.97	DSA
Rai et al.[7]	2013	USA	100	57.4 ± 13.6 (≥40)	V4 proximal	3.6 ± 0.6			CTA
					V4 distal	3.1 ± 0.5			
Pai et al.[8]	2007	India	15	58.96 (range 40–84)	V4		3.4	2.9	Cadaver
Yang et al.[9]	2003	China	30		V1		4.37 ± 1.21	3.22 ± 1.64	DSA
Shrontz et al.[10]	1986	USA	27		V4 proximal		3.2 ± 0.1	2.7 ± 0.1	Cadaver
					V4 distal		2.9 ± 0.2	2.6 ± 0.2	
Our study	2022	Japan	1394	70.77 ± 13.54 (range 18–98)	V2		2.82 ± 0.75	2.65 ± 0.75	MRA

L_VA: left vertebral artery; R_VA: right vertebral artery; VA: vertebral artery

In contrast, approximately 30% of cases had difficulty with 7-French GC placement, making the use of large-bore ACs difficult. In these cases, we should be flexible and change the MT strategy based on the VA diameter. In contrast to the situations where there is sufficient time for GC size selection before starting the treatment, such as coil embolization for cerebral aneurysm, a quick decision is also required in cases of MT. If a suitable GC is selected at the start of treatment, excessive device use will be reduced, contributing to shorter procedure times, reducing complications, and lowering medical costs.

In the setting of MT for internal carotid artery (ICA), which has a wider caliber compared to GC, we should apply a variety of techniques with balloon guiding catheters (BGCs) to block antegrade blood flow. Combined techniques such as ASAP (a stent-retrieving into an AC with proximal balloon)[12] and CAPTIVE (continuous aspiration before intracranial vascular embolectomy)[13] fall under this category. However, because VA vessels have smaller diameters than ICA, GC placement in VA alone may reduce antegrade blood flow and there may be no need for BGC. While the small difference in caliber between VA and GC has the benefit of improving GC fixation in these cases, caution should be required not to dissect the VA during the GC induction. Understanding the merits and demerits of size selection, appropriate GC size selection for each case will contribute to improved treatment outcomes.

In this study, VA is set to be eligible for placement if its diameter exceeds the GC's outer diameter by even 0.1 mm, but in practice, selecting a GC that is nearly consistent with the vessel diameter is difficult. Although it is difficult to establish clear conformity criteria, the conformity rate is expected to be slightly lower than the results of this study. Besides the vascular diameter, meandering of the VA origin or vasospasm during catheter manipulation may make it difficult to use even a small catheter diameter. The results of this study should only be regarded as a reference value based on the GC's outer diameter.

The limitations of the study include the following four points: 1) it was a single-center retrospective study, 2) the data were not specific to patients requiring posterior circulation revascularization because most of the study subjects had clinical conditions other than cerebrovascular diseases, 3) since this study was conducted on Japanese cases, it may not apply to other races, and 4) vessel diameter measured by MRA is considered to be less accurate and smaller than that measured by CTA or angiography because of the reduced inflow effect near the vessel wall.[14] The accumulation of cases at multiple centers in the world will reveal real-world conformity data.

Conclusion

We demonstrated that 7-French GC placement, with which large-bore AC can be applied, is achievable in approximately

70% of cases. The results of this study will serve as a reference for selecting GC size when placing a GC in a VA for endovascular treatment.

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Disclosure Statement

The authors declare no conflicts of interest.

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