Online March 27, 2021
Journal of Neuroendovascular Therapy 2021; 15: 772–777
DOI: 10.5797/jnet.oa.2020-0117

Original Article

Thoraco-Cervical Computed Tomographic Angiography to Determine an Appropriate Access Route for Mechanical Thrombectomy

Toshimitsu Shimizu,[1] Takahisa Mori,[2] Kazuhiro Yoshioka,[2] and Yuhei Tanno[2]

Objective: We investigated whether thoraco-cervical CTA provided useful information to determine an access route (AR) for mechanical thrombectomy (MT).

Methods: We included acute stroke patients who (1) were admitted between January 2018 and December 2018 and (2) underwent MT for large artery occlusion in the anterior circulation and were able to be treated within 24 hours of the time last known to be well. We evaluated the AR, occlusion site, aortic arch (AA) type, take-off angles (TOA) between the arch and the left common carotid artery (CCA) or the brachiocephalic artery (BCA), successful insertion rate (SIR) of the guiding catheter, puncture-to-initial angiography time (PtIA), and puncture-to-reperfusion time (PtR).

Results: We analyzed 32 patients: femoral-artery access (group F) in 26 and brachial-artery access (group B) in 6 patients. There were no differences in arch types between the two groups, but there were differences in occlusion sites: proximal CCA occlusion in two patients in the B group. Moreover, the TOA of the CCA was less than 25° in two patients in the B group. In the F and B groups, the SIR was 100%, the median PtIA was 9.0 and 9.6 minutes, and the median PtR was 54 and 72 minutes, respectively.

Conclusion: Thoraco-cervical CTA provided useful information to determine the appropriate AR for MT. SIR of 100% and short PtIA were achieved.

Keywords computed tomographic angiography, mechanical thrombectomy, access route

Introduction

Mechanical thrombectomy (MT) for large vessel occlusion (LVO) in anterior cerebral circulation is established as a procedure for ischemic stroke treatment.[1,2] The therapeutic time window has been prolonged to 24 hours after stroke onset by evaluating symptoms, an ischemic core, and penumbra.[3,4] When onset-to-reperfusion time is shorter, the clinical outcome may be better.[5] However, if puncture-to-initial angiography time (PtIA) is delayed, puncture-to-reperfusion time (PtR) is delayed, and the clinical outcome may deteriorate.[6] MT is usually performed through the femoral artery. Still, it is often difficult to reach the target carotid artery via the thoraco-abdominal aorta in obstructive arteriosclerosis, aortic aneurysms, aortic torsion, aortic arch (AA) anatomical shapes of the brachiocephalic or left common carotid arteries (CCA). Clinical outcome deteriorates when puncture-to-guiding-catheter insertion time is delayed into the target carotid artery via transfemoral access. If transfemoral access to reach the target carotid artery fails, carotid artery puncture should be an alternative.[7] We performed cephalic computed pre-contrast CT to diagnose cerebral infarction or rule out hemorrhage, followed by 4-cm-thick dynamic cephalic CTA to find occlusion arteries and evaluate hemodynamics.[8] The access route (AR), femoral or brachial artery puncture, was decided by neuroendovascular surgeons (NES) based on post-contrast thoraco-cervical CT findings. In this study, we retrospectively investigated whether thoraco-cervical CTA was useful for determining an AR of a guiding-catheter into the target carotid artery, successful insertion rate (SIR) of guiding catheters was high, and PtIA and PtR were short.

[1]Department of Radiology, Shonan Kamakura General Hospital, Kamakura, Kanagawa, Japan
[2]Department of Stroke Treatment, Shonan Kamakura General Hospital, Kamakura, Kanagawa, Japan

Received: June 8, 2020; Accepted: February 11, 2021
Corresponding author: Takahisa Mori, Department of Stroke Treatment, Shonan Kamakura General Hospital, 1370-1, Okamoto, Kamakura, Kanagawa 247-8533, Japan
Email: morit-koc@umin.net

Materials and Methods

We included acute stroke patients who (1) were admitted to our institution due to LVO between January and December 2018 and (2) underwent MT based on thoraco-cervical and dynamic brain CTA following pre-contrast CT within 24 hours after stroke onset.

For thoraco-cervical CTA, the intravenous injection of 38 mL of contrast material (iopamidol, 370 mg/mL) at a rate of 3.8 mL/s was started using an 80-row detector CT system (Canon Medical Systems, Tochigi, Japan), and helical scanning of the ascending aorta to intracranial cavity was performed. Hounsfield unit (HU) value was monitored at the CCA bifurcation, and imaging was started at 100 HU. As the dose of contrast medium was low, images were acquired caudo-cranially and rounded up. The mean number of images was 370, and the duration of imaging on an imaging protocol was approximately 5 seconds. The mean CT dose index (CTDIvol) and dose length produce (DLP) were 6.8 mGy and 296 mGy-cm, respectively.

Transfemoral access was usually used, although transbrachial access was prioritized in patients with obstructive arteriosclerosis of the bilateral femoral or iliac arteries occlusion or those with a history of the aortic aneurysm. Finally, NESs determined the AR, femoral artery (group F) or brachial artery (group B), according to thoraco-cervical CTA findings. In the two groups, the type of AA (type I, II, and III), site of occlusion (CCA, internal carotid artery [ICA], or middle cerebral artery [MCA]), and side (left or right) of the affected ICA system were investigated. Besides, SIR, door-to-imaging time (DtI), door-to-puncture time (DtP), PtIR, and PtR were compared between the two groups. The bifurcation angles between the left CCA, the brachiocephalic artery (BCA), and the AA's superior margin were measured.

Measuring the angle of bifurcation from the AA

Bifurcation angle between the left CCA and AA (CCA-AA angle): 3D maximum intensity projection (MIP) images of throraco-cervical CTA were rotated left anterior obliquely (LAO) by approximately 35° separate the left CCA from the AA. A line was drawn from the left CCA's left-sided orifice to the right-sided orifice of the left subclavian artery (SA). A line is drawn from the left-sided orifice of the left CCA distally along the left CCA. The angle between the two lines is regarded as a bifurcation angle (**Figs. 1B** and **2B**).

Bifurcation angle between the BCA and AA (BCA-AA angle): The 3D-MIP images of thoraco-cervical CTA were rotated LAO by approximately 35° to separate the BCA from the AA. A line was drawn from the BCA's left-sided orifice to the left SA' right-sided orifice. A line is drawn from the BCA's left-sided orifice distally along the BCA. The angle between the two lines is regarded as a bifurcation angle.

Statistical analysis

Fisher's exact test was used to compare the categorical variables. The continuous variables without a normal distribution are expressed as the median (interquartile range). As an unpaired non-parametric test between two groups, the Mann–Whitney test was used. For statistical analysis, JMP software (version 15.1; SAS Institute, Cary, NC, USA) was used.

Ethical approval

All procedures were performed according to the institution's ethical standards (Shonan Kamakura General Hospital, Kamakura, Kanagawa, Japan) and the 1964 Helsinki Declaration. The Tokusyukai Group Ethical Committee approved this retrospective study (TGE01403-024).

Consent to participate

Written informed consent for participation and publication was not required. The study was based on an opt-out model of enrollment, which was approved by the ethical committee.

Results

During the study period, 39 acute stroke patients underwent MT for LVO. Among them, we excluded four patients with posterior circulation occlusion and three patients in whom MRI was performed before dynamic CTA or thoraco-cervical CTA, influencing DtI or DtP. As a result, we analyzed 32 patients, with a median age of 79.5 years (70.5–83 years). There were 17 males (53%). Among them, 26 patients were treated transfemorally (group F) and six transbrachially (group B).

In the F and B groups, the median ages were 78.5 (66.8–83) and 82 years (76.5–88.5). The left carotid artery system was affected in 17 (65.4%) and 4 (66.7%) patients, respectively. Two patients suffered from the proximal CCA occlusion in group B; however, no patients in group F. There were no differences in the AA type between the two groups, and type II arch had the highest rate in the two groups (**Table 1**).

In 17 patients in group F, the median CCA-AA angle was 55°, ranging from 35° to 79°. In nine patients in group F, the

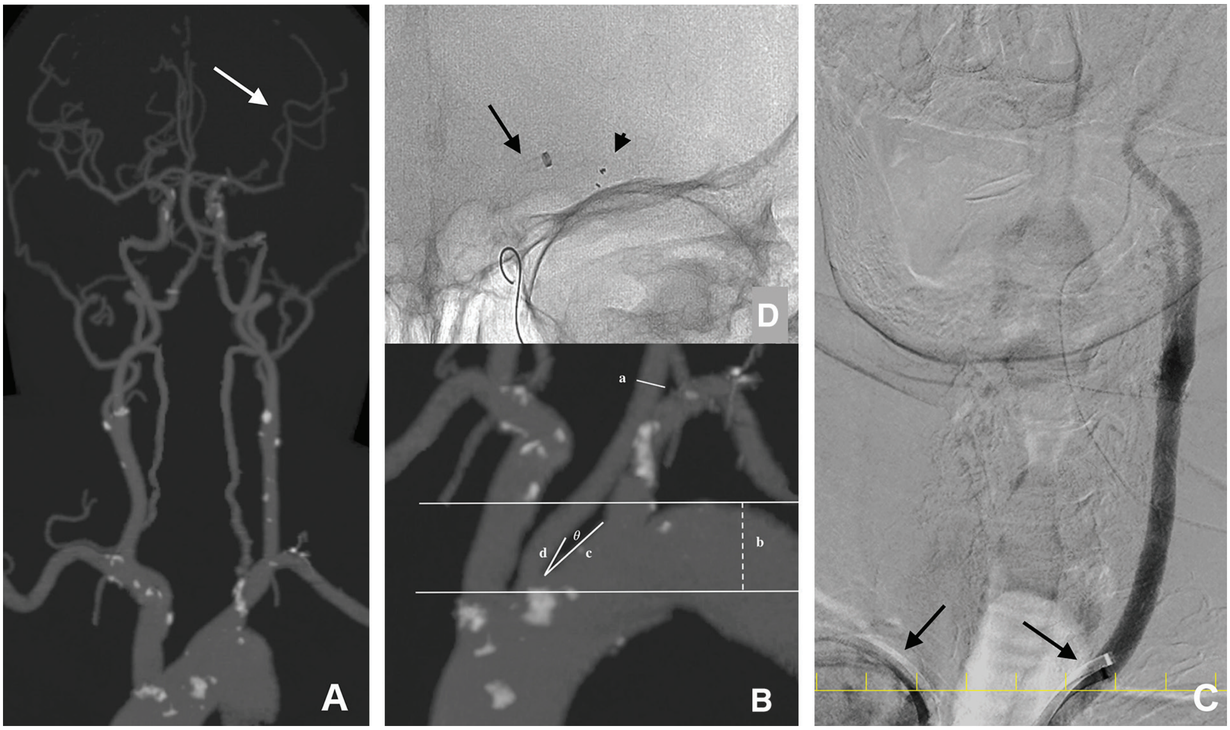

Fig. 1 Left MCA occlusion treated by transbrachial access. (**A**) CTA revealing no visualization of one of the left MCA M2 branches (arrow). (**B**) CTA demonstrating the type III arch (b >3a), and a sharp angle (θ:13°) between the aortic arch (c) and the left CCA (d), (**C**): A guiding catheter (MSK guide [Medikit, Tokyo, Japan], arrows) is introduced transbrachially into the CCA. (**D**) An aspiration catheter (arrow) and a stent retriever (arrowhead) are introduced into the MCA. CCA: common carotid artery; MCA: middle cerebral artery

median BCA-AA angle was 58°, ranging from 27° to 95°. In group B, four patients underwent MT for occlusion in the left carotid circulation, and two of them had the type III arch, where the CCA-AA angles were <25° (**Fig. 1**), whereas the CCA-AA angles were ≥50° in the other two patients. In one of the two, the proximal left CCA was occluded (**Fig. 2**). In two patients with occlusion in the right carotid circulation, the BCA-AA angle was ≥50°, and one of them suffered from the proximal right CCA occlusion. Patients with the proximal left or right CCA occlusion were treated transbrachially. Two patients with the type III arch and the CCA-AA angle <25° were treated transbrachially for the left MCA occlusion. Two patients with occlusion of the intracranial MCA were treated transbrachially regardless of the bifurcation angle, and one of the two had a history of aortic aneurysm surgery (**Table 1**). In the other patient with right MCA occlusion, the BCA-AA angle was 75°, and NES treated the patient transbrachially, although transfemoral access was an alternative. Of the six patients in group B, one had a history of the aortic aneurysm surgery; two had type III arch with a sharp CCA-AA angle of <25°, two suffered from the proximal CCA occlusion, and one had the right MCA occlusion without particular conditions. The process of AR determination is summarized in **Fig. 3**.

In group F, a balloon-guided catheter (9Fr Optimo; Tokai Medical Products, Aichi, Japan) was used in all 26 patients. In group B, a Simmons-type guiding catheter (6Fr MSK-guide, Medikit, Tokyo, Japan) was used in five patients, a Brite Tip sheath (Cardinal Health Japan, Tokyo, Japan) in one, and no balloon-guided catheter was used. First, aspiration procedures with an aspiration catheter (AC) were performed in the two groups, and MT was finished when complete recanalization was achieved. When complete recanalization was not achieved, a stent retriever (SR) was inserted through the AC, and MT using SR was performed while aspirating thrombi with the AC.

In the 32 patients, the median DtI and DtP were 23.4 and 84 min, respectively. In the F and B groups, the median DtI was 26.4 and 21 min (ns), respectively, and median DtP was 84 and 72 min (ns), respectively (**Table 1**). The SIR was 100% in both groups. The median PtIR was 9 and 9.6 min (ns), respectively, and the median PtR was 54 and 72 min (ns), respectively. There were no differences in the PtIR and PtR between the F and B groups (**Table 1**).

Discussion

Our results demonstrated that thoraco-cervical CTA provided useful information of the bifurcation angle or

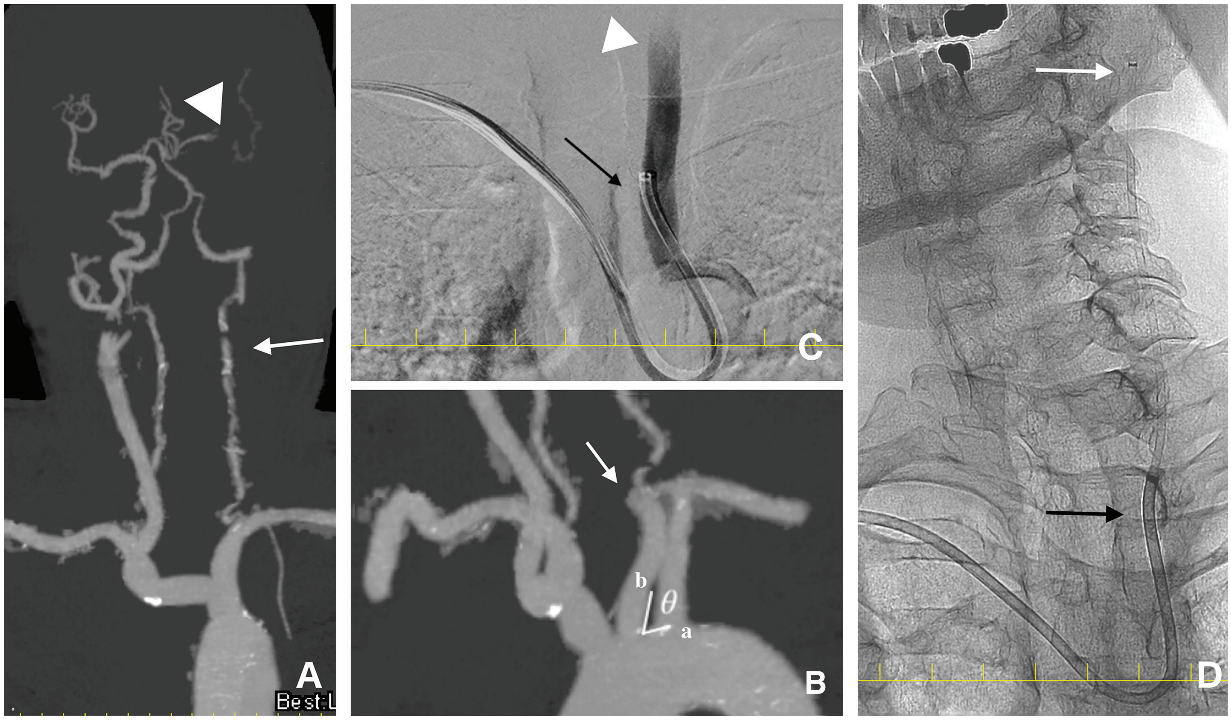

Fig. 2 Left CCA occlusion treated by transbrachial access. (**A**) CTA revealing no visualization of the left CCA occlusion (arrow) and MCA occlusion (arrowhead). (**B**) CTA demonstrating occlusion of the left CCA (arrow), the type I arch, and a dull angle (θ: 58°) between the aortic arch (a) and the left CCA (b). (**C**) A guiding catheter (MSK guide [Medikit, Tokyo, Japan], arrow) is introduced transbrachially into the CCA, demonstrating CCA occlusion (arrowhead). (**D**) An aspiration catheter (white arrow) is introduced into the CCA through the guiding catheter (MSK guide) (black arrow). CCA: common carotid artery; MCA: middle cerebral artery

Table 1 Patients' characteristics

	Transfemoral access	Transbrachial access	p
N	26	6	
Age, median (IQR) years	78.5 (66.8–83)	82 (76.5–88.5)	ns
Male (sex, n [%])	3 (50 %)	14 (53.9 %)	ns
Target carotid artery			
Right CA	9	2	ns
Left CA	17	4	
Occlusion site			
Common CA	0	2 (1 left CA, 1 right CA)	
Internal CA	12	0	
MCA	14	4 (3 left MCA. 1 right MCA)	
Aortic arch type			
I	1 (3.9 %)	1 (16.7 %)	
II	16 (61.5 %)	3 (50.0 %)	
III	9 (34.6 %)	2 (33.3 %)	
Take-off angle from the aortic arch			
Brachiocephalic artery as the target, median	58 (mini 27, max 95)°	64.5 (mini 54. max 75) °	
Left carotid artery as the target, median	55 (mini 35, max 79)°	41 (mini 13, max 58) °	
<25°, n	0	2 (left MCA occlusion)	
Time			
DtI, median (IQR) min.	26.4 (18–35.4)	21 (13.2–54)	ns
DtP, median (IQR) min.	84 (60–126)	72 (66–84)	ns
PtIA, median (IQR) min.	9 (4.8–10.2)	9.6 (6–12.6)	ns
PtR, median (IQR) min.	54 (36–83.4)	72 (45.6–88.2)	ns

CA: carotid artery; DtI: door-to-imaging time; DtP: door-to-puncture time; IQR: interquartile range; max: maximum; MCA: middle cerebral artery; min: minute; mini: minimum; ns: not significant; PtIA: puncture-to-initial angiography time; PtR: puncture-to-recanalization time

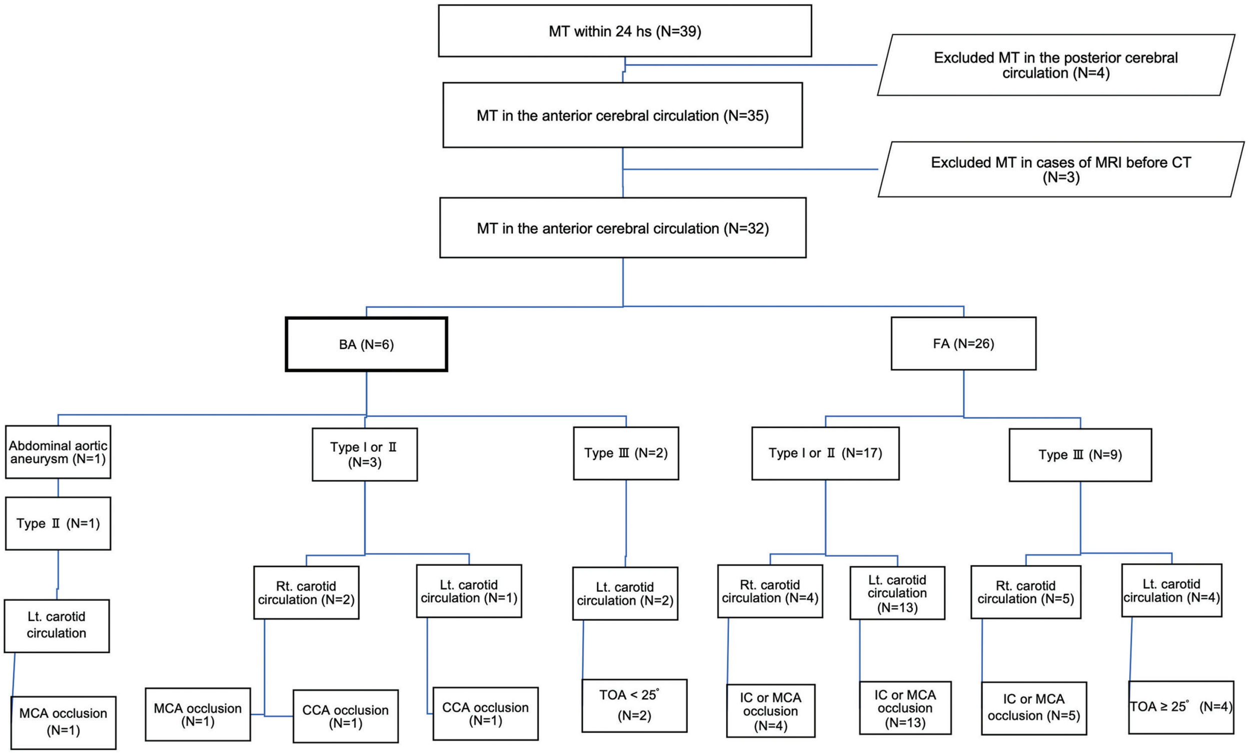

Fig. 3 The flow of access route selection. BA: brachial access; CCA: common carotid artery; FA: femoral access; IC: internal carotid artery; MCA: middle cerebral artery; MT: mechanical thrombectomy, TOA: take-off angle

proximal CCA occlusion to determine an AR. The SIR of 100% and short PtIR were achieved in all patients.

In several randomized controlled trials regarding the MT in the anterior circulation, post-contrast MRI or CT was used to identify candidates.[1–4] However, it was not described how to determine an AR. We use transfemoral access usually for MT in the anterior circulation; however, transbrachial access is prioritized in patients with aortic aneurysm history. Finally, NESs determine the AR based on the thoraco-cervical CTA findings (**Fig. 3**).

Thoraco-cervical CTA requires approximately an additional 40 mL of contrast medium before MT, leading to contrast-medium loading. However, we could obtain useful information on vascular anatomies such as the AA type, the proximal CCA occlusion, and the bifurcation angle. According to the imaging protocol, the acquisition time is 5 s and the image processing time is approximately 5 min. Therefore, CTA images were viewed on the picture archiving and communication systems (RapideyeCore; Canon Medical Systems, Tochigi, Japan) in the angiography room when patients arrived there, and there was no delay in DtP in the group B.

Patients with the proximal CCA occlusion were treated transbrachially regardless of the bifurcation angle. Patients with type III arch with the CCA-AA angle of <25° were treated transbrachially. Patients with type III arch with the CCA-AA angle of ≥25° were treated transfemorally because transfemoral access provides advantages such as guiding catheters with large internal diameter, indicating a large number of device options. Indeed, transbrachial access was used in cases of the sharp CCA-AA angle in type III arch, but it is unclear whether transbrachial access must be used.

The proximal CCA occlusion is rare but may be refractory because there may be a large volume of thrombi with a long distance of occlusion, and peripheral embolization, therefore, may occur during MT. In cases of the proximal CCA occlusion, transbrachial access was used. A Simmons-type guiding catheter (Medikit) was placed proximal to the occlusion, and thrombi were aspirated because inserting a guiding catheter into the target artery through the femoral artery may push thrombi to the intracranial arteries. In the future, how to remove thrombi in the proximal CCA safely and sufficiently must be established.

The median age in group B was slightly higher, although there was no statistical difference. Aging-related atherosclerosis may be more severe in group B. Transfemoral access has the following advantages: the vascular diameter is large, facilitating large-diameter catheters and several devices, and many NESs are accustomed to the procedure.

However, fatal complications, such as cholesterol embolism and retroperitoneal hemorrhage, may occur.[9] On the other hand, transbrachial access has the following disadvantages: complications, such as median nerve injury at the site of puncture and vascular injury or occlusion related to a small vascular diameter, may occur; and the number of devices is limited, but the risks of fatal complications are relatively low.

In group B, no balloon-guided catheters were used, which influenced clinical outcome after MT. However, the clinical outcome following transradial MT was similar to that following transfemoral MT.[10] As balloon-guided catheters may not always be necessary for MT involving contact aspiration, it must be investigated whether there may be differences in clinical outcome following SR or contact aspiration between the B and F groups. Furthermore, a previous study reported that transbrachial MT was performed with balloon-guided catheters under specific vascular anatomical conditions,[11] and transbrachial MT using balloon-guided catheters is likely to be an alternative to transfemoral MT.

We used thoraco-cervical CTA to obtain vascular information to determine an AR before MT, no patient needed transfemoral to transbrachial or transbrachial to transfemoral AR switch during MT, and there were no significant differences in DtI, DtP, PtIR, and PtR between the F and B groups.

Limitation

As the limitation of this study, the number of subjects was small, and we were unable to identify factors to determine an AR by using thoraco-cervical CTA. In the future, a larger number of patients must be prospectively investigated, and factors to determine appropriate AR should be identified.

Conclusion

Thoraco-cervical CTA provided useful information to determine an AR. SIR of 100% and short PtIA were achieved.

Acknowledgment

We would like to thank Mr. Satoshi Sekine for his advice, Nozomi Chiba, BA, for her secretarial assistance, and the specialized support of the radiographers and nurses at our comprehensive stroke center.

Disclosure Statement

The authors declare no conflict of interest.

References

1) 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.
2) 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.
3) Nogueira RG, Jadhav AP, Haussen DC, et al: Thrombectomy 6 to 24 hours after stroke with a mismatch between deficit and infarct. *N Engl J Med* 2018; 4: 11–21.
4) Albers GW, Marks MP, Kemp S, et al: Thrombectomy for stroke at 6 to 16 hours with selection by perfusion imaging. *N Engl J Med* 2018; 22: 708–718.
5) Goyal M, Jadhav AP, Bonafe A, et al: Good outcome after successful recanalization is time dependent in the swift prime randomized controlled trial. *Stroke* 2016; 47: A2.
6) Knox JA, Alexander MD, McCoy DB, et al: Impact of aortic arch anatomy on technical performance and clinical outcomes in patients with acute ischemic stroke. *AJNR Am J Neuroradiol* 2020; 41: 268–273.
7) Jadhav AP, Ribo M, Grandhi R, et al: Transcervical access in acute ischemic stroke. *J Neurointerv Surg* 2014; 6: 652–657.
8) Mori T, Yoshioka K: A practical protocol for shortening reconstruction time of volumetric data and imaging bilateral middle cerebral arteries for thrombectomy in acute ischemic stroke using an 80-row computed tomography scanner. *Neuroradiology* 2020; 62: 97–100.
9) Sajnani N, Bogart DB: Retroperitoneal hemorrhage as a complication of percutaneous intervention: report of 2 cases and review of the literature. *Open Cardiovasc Med J* 2013; 7: 16–22.
10) Chen SH, Snelling BM, Sur S, et al: Transradial versus transfemoral access for anterior circulation mechanical thrombectomy: comparison of technical and clinical outcomes. *J Neurointerv Surg* 2019; 11: 874–878.
11) Mori T, Kasakura S, Yoshioka K: Computed tomography angiographic anatomical features for successful transbrachial insertion of a balloon guide catheter for mechanical thrombectomy in acute ischemic stroke. *Brain Circ* 2020; 6: 169–174.