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Computed tomography angiographic anatomical features for successful transbrachial insertion of a balloon guide catheter for mechanical thrombectomy in acute ischemic stroke

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Abstract:

BACKGROUND AND PURPOSE: When the femoral approach for mechanical thrombectomy (MT) in acute ischemic stroke (AIS) is limited, trans-brachial or-radial access is an alternative. However, transbrachial insertion of a 9Fr (outer diameter [OD]) balloon guide catheter (BGC) into the carotid artery is not feasible. Computed tomographic (CT) angiography (CTA) may provide vascular anatomical information for successful insertion. We investigated CTA anatomical features for successful transbrachial insertion of a 9Fr BGC into the carotid artery.

MATERIALS AND METHODS: We analyzed AIS patients who underwent CTA and transbrachial MT using a 9Fr BGC between 2014 and 2016. We evaluated the successful insertion rate and CT angiographic anatomical features.

RESULTS: Twenty-four patients met our inclusion criteria. We achieved successful insertion in 18 (75%) of 24 cases: 7 (58.3%) of 12 for left carotid arteries and 11 (91.7%) of 12 for right carotid arteries. Successful insertion was achieved in 4 of 4 bovine aortic arch for left carotid occlusion and in 3 of 8 nonbovine aortic arches for left carotid occlusion. We achieved successful insertion in 3 nonbovine cases with takeoff angles ≥23° and failed insertion in 5 cases with takeoff angles <23°. We achieved successful insertion in 10 of the 10 cases with takeoff angles ≥25° in the right common carotid artery. The BGC was broken in 1 of 2 cases with takeoff angles <25°.

CONCLUSIONS: The CTA provided a high likelihood of successful 9Fr OD BGC insertion without an introducer sheath. Successful transbrachial insertion was achieved in bovine left carotid cases, in nonbovine left carotid cases with takeoff angles ≥23°, and in right carotid cases with takeoff angles ≥25°.

Keywords:

Acute ischemic stroke, balloon guide catheter, computed tomographic angiography, trans-brachial approach

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Introduction

Mechanical thrombectomy (MT) has become an essential treatment for acute ischemic stroke (AIS) due to large vessel occlusion.[1,2] The transfemoral approach is standard for introducing a guide catheter. However, aortic or peripheral arterial conditions, such as a tortuous aorta, "bovine" aortic arch, type III aortic arch, or peripheral arterial occlusive lesions, sometimes limit the transfemoral access.[3-5] Difficulties in navigating guide catheters extend procedure time and result

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in poor outcomes.[6-8] Trans-brachial or-radial access is an alternative.[9] Balloon guide catheters (BGCs) with a large internal diameter (ID) and a large outer diameter (OD) are used to prevent distal embolization of thrombus fragments during MT.[10-16] Trans-brachial or radial access using a BGC, however, is not standard[17] and BGCs were used in only 6 of 18 trans-radial cases.[9] To prevent procedure time extension due to difficulties in navigating guide catheters through the transfemoral route, we implemented computed tomographic angiography (CTA) to evaluate the anatomical conditions of the aortic arch before MT. There have been few reports about the anatomical features for successful transbrachial insertion of BCGs with a large ID into the target artery, and transbrachial insertion of BGCs with a large ID was not always successful. It is, therefore, vital to find anatomical features necessary for successful transradial or brachial insertion of BGCs with a large ID into the target carotid artery.

This retrospective study aimed to find the anatomical features on CTA for successful transbrachial insertion of a BGC with a large ID.[17]

Materials and Methods

In this retrospective, cross-sectional study, we included AIS patients who: (1) were admitted to our institution between January 2014 and June 2016 due to internal carotid artery (ICA) or middle cerebral artery (MCA) occlusion, (2) underwent a single-phase CTA from the aortic arch to the intracranial vessels, and (3) underwent transbrachial MT using a BGC with a 9 French size (Fr) OD and a 7Fr ID without an introducer sheath. We evaluated occlusion sites and successful insertion rate of the BGC into the target carotid artery and measured takeoff angles at the turning point of the BGC as aortic arch anatomical features on CTA.

Computed tomographic angiography

We acquired images using an 80-row area detector computed tomographic scanner (Aquilion PRIME, Canon Medical Systems, Otawara, Tochigi, Japan). Acquisition started from the ascending aorta. After injecting 40 mL of a nonionic contrast medium (370 mg/mL iopamidol) at a rate of 3.8 mL/s, helical scans were acquired from the ascending aorta to the intracranial vessels.

Criteria for mechanical thrombectomy

Our criteria of MT for AIS were: (1) >6 on the National Institutes of Health Stroke Scale, (2) >6 on the diffusion-weighted image (DWI)-Alberta Stroke Program Early CT Score, (3) no signal in the ICA or the MCA on magnetic resonance angiography, and (4) DWI/perfusion-weighted images mismatch.[13]

Measurement of takeoff angles on computed tomographic angiography

We drew straight lines in the center of the orifices of two involved arteries in a direction parallel to the arterial directions. A turning point was defined as an intersection of the two lines while a takeoff angle was defined as an angle between two lines at the turning point [Figure 1]. We measured the takeoff angle between the right common carotid artery and the right subclavian artery in cases of right carotid insertion [Figure 1a and Figure 2], and the takeoff angle between the left common carotid artery and the brachiocephalic artery in cases of left carotid insertion [Figure 1b and Figure 3].

Direct transbrachial insertion of a balloon guide catheter with a 9Fr outer diameter

The catheter with a 9Fr OD and a 7Fr ID was compatible with a 7Fr ID introducer sheath. The 9Fr OD is approximately 3 mm, and the ID of the brachial artery is about 5 mm. Therefore, we used the right brachial artery for direct insertion without an introducer sheath. We used a 22G needle for the right brachial artery puncture, subsequently inserting a 3F introducing sheath for dilatation of the puncture, inserted a 0.035-inch standard guidewire (Radifocus, Terumo, Tokyo, Japan) into the brachial artery, and replaced the 3F sheath with a 9Fr OD BGC (Optimo, 90 cm in length, 0.090-inch ID, Tokai Medical Products, Aichi, Japan). We inserted the 9Fr OD BGC directly into the brachial artery without a 9Fr ID introducing sheath. We advanced a 130-cm long 5Fr OD Simmons-type catheter through the BGC and a 0.035-inch guidewire into the target carotid artery [Figures 4a, b and 5a, b]. Then, we coaxially advanced the BGC [Figures 4c and 5c]. Once the BGC has been positioned, we inflated the balloon and started MT [Figures 4d and 5d].

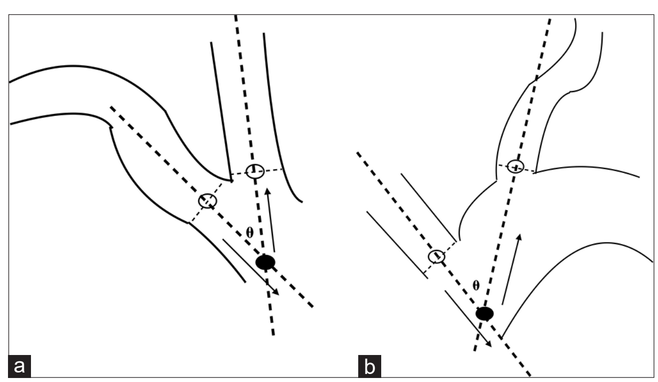

Figure 1: Measurement of the take-off angles. (a) In cases of right common carotid and subclavian arteries. (b) In cases of left common carotid and brachiocephalic arteries. Straight lines (broad dotted lines) are drawn at the center (white circles) of arterial orifices (thin dotted lines) in a direction parallel to the artery. The turning point (black circle) of a catheter (arrows) is the intersection of two lines. The take-off angle (θ) is the angle between the two lines

Figure 2: Computed tomography angiogram showing the take-off angle between the left common carotid artery and the brachiocephalic artery

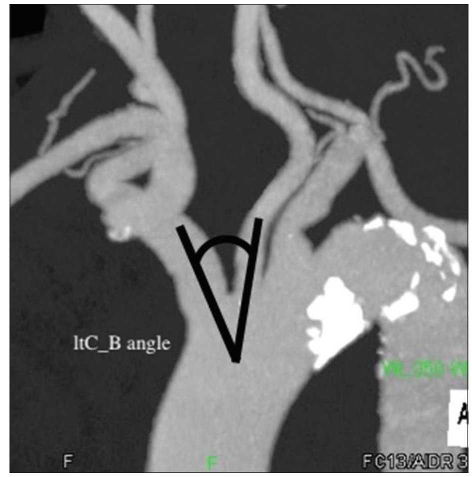

Figure 3: Computed tomography angiogram showing the take-off angle between the right common carotid artery and the right subclavian artery

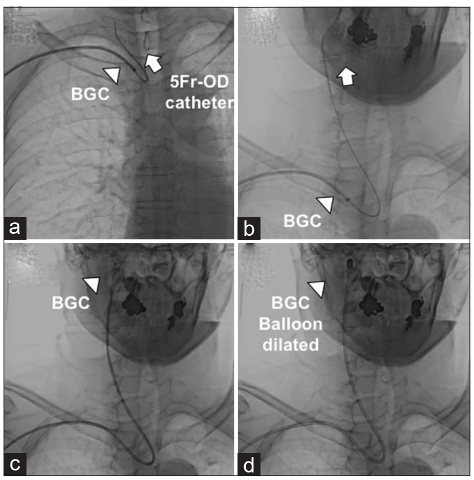

Figure 4: Sequential radiolucent images showing how to insert a balloon guide catheter into the right carotid artery with a take-off angle >to 25° between the right common carotid artery and the right subclavian artery. (a) Both the 5F catheter and the 0.035-inch guidewire were introduced into the right common carotid artery. (b) The 5F catheter was advanced into the right internal carotid artery. (c) A 9F balloon guide catheter was advanced coaxially into the right internal carotid artery. (d) The 5F catheter was withdrawn and the balloon was dilated

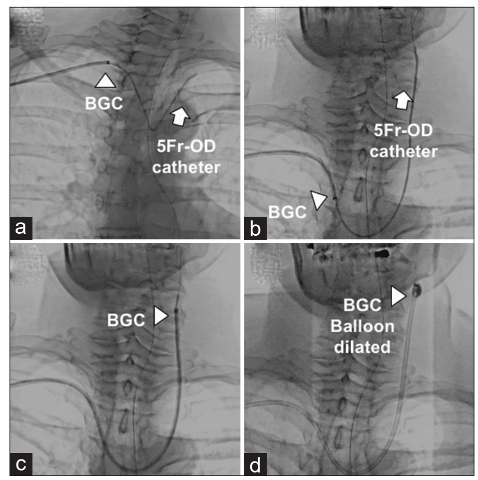

Figure 5: Sequential radiolucent images showing how to insert a balloon guide catheter into the nonbovine left carotid artery with a take-off angle >to 23° between the left common carotid artery and the brachiocephalic artery. (a) A 5F catheter and a 0.035-inch guidewire were introduced into the left common carotid artery. (b) The 5F catheter was advanced into the left internal carotid artery. (c) A 9F balloon guide catheter was advanced coaxially into the left internal carotid artery. (d) The 5F catheter was withdrawn and the balloon was dilated

Ethics approval

All procedures performed in the study were in accordance with the ethical standards of the institution and with the 1964 Helsinki Declaration. The Institutional Ethical Committee approved our retrospective analysis (TGE01009-024).

Patient consent for publication

Written informed consent was not required because the procedure was routine medical care, the medical records of elderly patients treated several years ago were accessed retrospectively, and anonymization was done.

Statistical analysis

Nonnormally distributed continuous variables are expressed as medians and interquartile ranges (IQRs). Differences between two groups were compared using Fisher's exact test for categorical variables. $P < 0.05$ was considered statistically significant. The JMP software (version 15.1; SAS, NC, USA) was used for all the statistical analysis.

Results

Twenty-four patients met our inclusion criteria [Tables 1 and 2]. The median age was 81 (77–86) (IQR). Four of the 12 patients with left carotid occlusion had bovine arch demonstrated by CTA while the others suffered peripheral artery diseases. Four of the 12 patients with right carotid occlusion had Type III arch demonstrated by CTA while the others suffered from peripheral artery diseases. Operators determined transbrachial access in cases of the bovine arch for left carotid occlusion and in cases of Type III arch for right carotid occlusion, except for peripheral artery diseases [Tables 1 and 2].

The overall transbrachial insertion success rate was 75% (18/24). We successfully advanced the BGC in only 7 (58.3%) of the 12 left carotid cases. We achieved successful insertion in 4 (100%) of the 4 bovine aortic arch cases, but in only 3 (37.5%) of the 8 nonbovine aortic arch cases. In 3 nonbovine cases with takeoff angles ≥23°, we achieved successful insertion. In 5 cases with takeoff angles <23°, we failed to insert (sensitivity: 100%, specificity: 100%, positive predictive value: 100%) ($P < 0.05$) [Table 3]. We successfully advanced the BGC in 11 (91.7%) of the 12 right carotid cases. We achieved successful insertion in 10 (100%) of 10 cases with take-off angles ≥25° (sensitivity: 91%, specificity: 100%, positive predictive value: 100%). In 1 of 2 cases with takeoff angles <25°, the BGC was broken immediately after the withdrawal of the coaxial 3Fr catheter [Table 3]. No puncture-site complications occurred in the 24 patients.

Discussion

Our results demonstrated that takeoff angles at the turning point of the BGC on the CTA are critical for successful BGC transbrachial insertion. The CTA, which covered the aorta to the distal carotid arteries before MT, provided useful information for successful BGC transbrachial insertion.

To prevent distal migration of clots during MT procedures, proximal blood flow blockade using a BGC is standard for MT.[11-16] When a trans-brachial or-radial approach is necessary because of vascular conditions that limit femoral access, CTA provides a high likelihood of successful 9Fr (OD) BGC insertion. If the take-off angle at the turning point is very sharp, the BGC is abandoned for a 6Fr guide sheath without proximal flow blockade.[18-20]

Fortunately, we experienced no complications in the artery puncture site, such as arm ischemia, arterial occlusion, nerve injury, pseudoaneurysm, or hematoma, requiring treatment. We used a 22G needle for the brachial artery puncture and subsequent dilatation technique. We did not use any vascular closure devices,

Table 1: Patients characteristics in the right carotid artery

Case	Occlusion site	rtC_rtS angle (°)	BGC insertion	Arch type	Reason of brachial access
1	Right MCA	72	Success	I	Severe ASO
2	Right ICA	65	Success	III	Type III arch
3	Right MCA	63	Success	II	A_aneurysm
4	Right MCA	43	Success	II	A_aneurysm
5	Right ICA	35	Success	I	A_aneurysm
6	Right ICA	32	Success	I	Severe ASO
7	Right ICA	31	Success	III	Type III arch
8	Right ICA	31	Success	III	Type III arch
9	Right ICA	30	Success	II	A_aneurysm
10	Right ICA	25	Success	II	Severe ASO
11	Right ICA	12	Success	II	Severe ASO
12	Right ICA	22	Failure	III	Type III arch

ICA: Internal carotid artery, MCA: Middle cerebal artery, rtC_rtS angle: Angle between the right common carotid artery and the right subclavian artery, BGC: Balloon guide catheter, A_aneurysm: Abdomincal aneurysm, ASO: Arteriosclerosis obliterans

Table 2: Patients characteristics in the left carotid artery

Case	Occlusion site	ltC_B angle (°)	BGC insertion	Arch type	Reason of brachial access
1	Left ICA	57	Success	Bovine	Bovine arch
2	Left ICA	111	Success	Bovine	Bovine arch
3	Left ICA	62	Success	Bovine	Bovine arch
4	Left MCA	59	Success	Bovine	Bovine arch
5	Left ICA	38	Success	I	Severe ASO
6	Left MCA	25	Success	II	A_aneurysm
7	Left ICA	23	Success	II	A_aneurysm
8	Left ICA	3	Failure	II	A_aneurysm
9	Left ICA	7	Failure	II	Severe ASO
10	Left ICA	18	Failure	I	Severe ASO
11	Left MCA	−8	Failure	II	Severe ASO
12	Left MCA	8	Failure	II	Severe ASO

ICA: Internal carotid artery, MCA: Middle cerebal artery, ltC_B angle: Angle between the left common carotid artery and the brachiocephalic artery, BGC: Balloon guide catheter, A_aneurysm: Abdomincal aneurysm, ASO: Arteriosclerosis obliterans

Table 3: Computed tomography angiographic features and successful insertion

	Insertion of a 9Fr BGC		*P*
	Success	Failure	
The left carotid artery			
Bovine aortic arch cases	4	0	
In nonbovine cases			
Take-off (ltC_B) angle (°)			
≥23	3	0	<0.05
<23	0	5	
The right carotid artery			
Take-off (rtC_rtS) angle (°)			
≥25	10	0	NS
<25	1	1	

ltC_B angle: Take-off angle between the left common carotid artery and the brachiocephalic artery, rtC_rtS angle: Take-off angle between the right common carotid artery and the right subclavian artery, BGC: Balloon guide catheter

such as the Angio-Seal STS Plus (St. Jude Medical, Minneapolis MN, USA).[21,22] These are probably why no brachial artery or median nerve injuries occurred. Indeed, there are potential risks of brachial artery puncture complications, but the brachial or radial artery approach rarely leads to fatal complications, such as retroperitoneal hematomas, which are occasionally caused by femoral artery puncture.[23,24] The trans-brachial or-radial approach seems to be safer because of few life-threatening complications.

Limitations

Our study had several limitations, including its small number of patients and the retrospective cross-sectional study design. Operators' decision on the transbrachial access was dependent on their experiences. A prospective study with a large sample size is required to confirm our results.

Conclusions

The CTA provided a high likelihood of successful 9Fr OD BGC insertion without an introducer sheath. Successful transbrachial insertion was achieved in bovine left carotid cases, in nonbovine left carotid cases with takeoff angles ≥23°, and in right carotid cases with takeoff angles ≥25°.

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Conflicts of interest

There are no conflicts of interest.

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