Original Article

Factors of Difficult Guiding Catheter Access in Mechanical Thrombectomy for Acute Ischemic Stroke in the Anterior Circulation

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Objective: Insertion of a guiding catheter (GC) system into the desired arterial site is crucial in mechanical thrombectomy (MT). This study assessed the factors of difficult GC access to the target carotid artery in patients with acute ischemic stroke in the anterior circulation.

Methods: In total, 174 patients who had undergone MT were retrospectively reviewed. The incidence of patients who could not undergo GC insertion to the target carotid artery, as well as the characteristics and outcomes of patients requiring a longer groin puncture-to-GC insertion time, were examined. The patients were divided into 3 groups based on the time from groin puncture to insertion into the target carotid artery: group A, within 10 min; group B, within 10–20 min; and group C, >20 min. In this study, the transfemoral catheter access was the primary option, and the approach site was changed based on the operator's discretion. Successful reperfusion was defined as modified Thrombolysis in Cerebral Infarction grade ≥2B. A favorable outcome was defined as a modified Rankin Scale score of 0–2.

Results: Catheterization of the target carotid artery could not be performed in 8 (4.6%) patients, who were older and more likely to be female. The proportion of patients with a height ≤150 cm and the percentage of patients with a type III arch and/or tortuous common carotid artery (CCA) were high. The approach was changed in 4 (2.3%) patients, and GC insertion was successful in all cases. A significant difference was observed among the 3 groups in terms of age and the percentage of patients with a type III arch and/or CCA tortuosity and internal carotid artery occlusion. In addition, the time from groin puncture to recanalization significantly differed. The recanalization rate and the 90-day favorable outcome rate were significantly lower in patients with a groin puncture-to-GC insertion time >20 min.

Conclusion: We need to make an effort to insert the GC within 20 min while actively considering changes in the approach, particularly in older patients and those with a type III arch and/or tortuous CCA.

Keywords ▸ acute ischemic stroke, mechanical thrombectomy, anterior circulation, guiding catheter access

Introduction

Five randomized trials have shown that mechanical thrombectomy (MT) is beneficial over medical therapy alone in patients with acute ischemic stroke (AIS) caused by large-vessel occlusions.[1–5] Regardless of MT for AIS, the insertion of a guiding catheter (GC) system into the desired arterial site is the primary option. Moreover, it is one of the most important steps for successful endovascular treatment, which is typically performed via percutaneous transfemoral access.[6] However, there are only a few studies on GC insertion.[7] Patients with AIS often do not have detailed information about access due to the urgency of their condition. In addition, the target populations for MT are generally older individuals and those with a high incidence of vascular risk factors, including hypertension, hyperlipidemia, and diabetes mellitus. In these cases, GC insertion via the femoral artery is occasionally technically difficult and time-consuming due to vessel tortuosity and

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aortic arch elongation and distortion,[8,9] particularly in patients with AIS in the anterior circulation, which requires a large-diameter GC. These procedures often result in conditions causing delays, including failure to catheterize with large-caliber sheaths despite numerous attempts. Moreover, some patients with severe peripheral arterial disease may not have transfemoral catheter access to the aortic arch.[7]

This study aimed to assess the factors of difficult catheter access to the target carotid artery in patients with AIS in the anterior circulation who underwent MT.

Materials and Methods

We retrospectively reviewed the medical and operative records of patients with AIS undergoing endovascular procedures at our institution between January 2017 and December 2022. This study was approved by the Institutional Review Board of Niigata Prefectural Central Hospital (approval number: 2106) and was conducted in accordance with the principles of the Declaration of Helsinki. Written informed consent and/or opt-out consent was obtained from the patients included in this study.

Patients

Primary treatment was conducted according to the Japanese guidelines for MT from the Japan Stroke Society, the Japan Neurosurgical Society, and the Japanese Society for Neuroendovascular Therapy.[10] In this study, there was no age limit. All patients underwent CT scans and CTA or MRI with MRA to validate ischemic changes and occluded vessels. Intravenous tissue plasminogen activator (IV-t-PA, 0.6 mg/kg dose, 10% bolus, and 90% continuously infused over 60 min) was administered as the first-line treatment within 4.5 h of symptom onset in accordance with the standard protocol in Japan.[10] Eligible patients were treated with IV-t-PA before the endovascular procedure. Clinical outcomes were evaluated using the modified Rankin Scale (mRS) upon admission and at 90 days after onset. A favorable outcome was defined as an mRS score of 0–2.

Endovascular procedure

In this study, even if the onset time was unknown, an endovascular procedure was indicated if an Alberta Stroke Program Early Computed Tomography Score (ASPECTS) or diffusion-weighted image-ASPECTS of ≥6 was observed. Endovascular procedures were performed under local anesthesia in all cases, with mild sedation used as required. Heparin, at an intravenous bolus of 3000–5000 units, was administered after femoral artery puncture. In anterior circulation cases, a 9-Fr balloon guiding catheter (BGC) was used in all cases. Optimo (Tokai Medical Product, Aichi, Japan) or Branchor (Asahi Intecc, Aichi, Japan) was commonly used based on the discretion of the operator. A 9-Fr BGC was generally inserted into the affected vessels with a 6-Fr inner catheter (Medikit, Tokyo, Japan) and a 0.035-inch guidewire. If BGC insertion was challenging to perform using the above-mentioned conventional methods, the Simmons-type inner catheter and 0.035 half-stiff or stiff wires were used based on the discretion of the operator. In addition to device selection, previously reported techniques were actively used.[6,11] The femoral approach was the primary option. If BGC insertion via the femoral artery was challenging to conduct, the approach site was changed based on the discretion of the operator.

In principle, MT was performed using a combination of a stent retriever and an aspiration catheter. If vessel occlusion remained after the first pass, repeated thrombectomy, direct aspiration, percutaneous transluminal angioplasty, or carotid artery stenting with the loading of dual antiplatelet agents was performed based on the discretion of the surgeon.

On cerebral angiography, reperfusion was classified using the modified Thrombolysis in Cerebral Infarction grading system.[12] Successful reperfusion was defined as grade ≥2B using the previously mentioned grading system.

Statistical analysis

In patients with anterior circulation stroke, in addition to patient characteristics, the supra-aortic arteries of the affected side (i.e., vascular access for thrombectomy) were analyzed. These vessels were individually classified with or without tortuosity as defined in the previous study of Sidiq et al.[13] Hence, vessel tortuosity was defined as S- or C-shaped elongation or undulation in the course of the artery, kinking with acute angulation of the vessel, or coiling with elongation or redundancy of the vessel occurring as an exaggerated S-shaped curve or in a circular structure.

The time elapsed from groin puncture to GC insertion was defined as the time to guiding access. The timing of all other procedural steps was also prospectively recorded. Impossible cases were defined as cases in which the operators could not catheterize the carotid artery after several attempts. As in a previous study,[7] the patients were divided into 3 groups according to the time from groin puncture to insertion into the target carotid artery, with an interval of

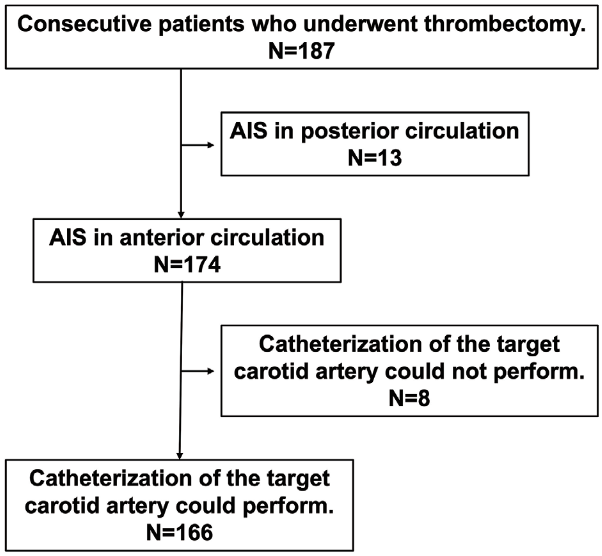

Fig. 1 Flowchart demonstrating the number of patients included in the analysis. AIS, acute ischemic stroke

10 min: group A, within 10 min; group B, within 10–20 min; and group C, >20 min.

Baseline characteristics were expressed as mean and standard deviation for continuous variables with a normal distribution, median and interquartile range for skewed continuous variables, and number (%) for categorical variables. Unpaired 2-sample *t*-test, X^2-test, and Fisher's exact test were used to compare the baseline characteristics of 2 groups, whereas the Kruskal–Wallis test was used for comparing the baseline characteristics of 3 or more groups. Since this study was an exploratory study, multiple comparisons were not performed. A nominal p-value of 0.05 was used as the threshold indicating statistical significance. All statistical analyses were conducted using the Statistical Package for the Social Sciences software version 24.0 (IBM, Armonk, NY, USA).

Results

Between January 2017 and December 2022, 187 patients underwent thrombectomy. Thirteen patients were excluded because they had AIS in the posterior circulation. In this study, 174 patients were included. The target carotid artery could not be catheterized in 8 (4.6%) patients. Finally, 166 patients were analyzed (**Fig. 1**). The approach was changed in 4 (2.3%) patients, and GC insertion was successful in all cases.

Baseline characteristics of the participants are shown in **Table 1**. Patients with unsuccessful GC insertion tended to be older and more likely to be female. In addition, the proportion of patients with a height of ≤150 cm and the percentage of patients with a type III arch and/or common carotid artery (CCA) tortuosity were higher. In patients with an accessible carotid artery, the median time from groin puncture to carotid catheterization and the median time from groin puncture to recanalization were 10 and 45 min, respectively. A comparison of groups A, B, and C revealed that there was a significant difference in terms of age and the percentage of patients with type III arch and/or CCA tortuosity (p <0.001, p = 0.001, and p = 0.027, respectively). Patients with internal carotid artery (ICA) occlusion had a longer GC insertion time than those with other types of vessel occlusion (p = 0.002). There was no significant difference in the time from onset to door and time from door to puncture between each group (p = 0.607 and p = 0.729). However, the time from groin puncture to recanalization significantly differed (p = 0.001). Group C had a longer time from GC insertion to recanalization than groups A and B; however, the results did not significantly differ (p = 0.290). Furthermore, if the time to GC insertion was >20 min, the successful reperfusion rate and favorable outcome rate significantly decreased (**Figs. 2** and **3**).

In patients with AIS on the left side, the bovine arch was considered and compared in each group. The results showed no significant difference in the proportion of patients with a bovine arch (**Table 2**).

Discussion

In this study, when GC insertion took >20 min, the recanalization rate and favorable outcome rate were significantly lower. GC insertion can be challenging in older patients and those with a type III arch and/or tortuous CCA.

There are no previous studies proposing a specific time for GC insertion. Ribo et al. reported that vessel tortuosity caused more than a 30-min delay in GC delivery to the target carotid artery in 25% of their patients.[7] These patients presented not only with a longer procedural time but also lower recanalization rates. Therefore, difficult catheter access to the parent vessel was found to be an independent predictor of long-term disability.[7] Jeong et al. reported that GC location has a significant impact on recanalization in patients with AIS and that the GC should be positioned as distally as safely possible.[14] In patients with a type III arch and/or CCA tortuosity, the inability to insert the GC distally may have led to poor outcomes. In cases of ICA occlusion, the procedure was

Table 1 Baseline characteristics of patients according to difficulty of guiding catheter insertion to the affected carotid artery

Characteristic	All patients (n = 174)	All patients who had an unsuccessful GC insertion (n = 8)	All patients who had a successful GC insertion (n = 166)	Group A PTG ≤10 min (n = 94)	Group B 10 min <PTG ≤20 min (n = 56)	Group C 20 min <PTG (n = 16)	p-value*
Age (years)							
Median (IQR)	80.0 (30.0–85.0)	85.5 (78.0–92.5)	80.0 (30.0–85.0)	78.0 (30–82.8)	83.0 (48.0–86.3)	83.5 (49.0–86.0)	<0.001
Female, n (%)	81 (46.6)	7 (87.5)	74 (44.6)	41 (43.6)	23 (41.1)	10 (62.5)	0.302
NIHSS on admission							
Median (IQR)	22 (2–28)	20 (16–27)	22 (2–28)	22 (4–28)	11 (2–29)	24 (6–26)	0.971
Laterality left, n (%)	88 (50.6)	4 (50.0)	84 (50.6)	47 (50.0)	28 (50.0)	9 (56.3)	0.893
ICA occlusion, n (%)	64 (36.8)	3 (37.5)	61 (36.7)	25 (26.6)	27 (48.2)	9 (56.3)	0.002
Risk factors, n (%)							
Smoking	51 (29.3)	2 (25.0)	49 (29.5)	29 (30.9)	17 (30.4)	3 (18.8)	0.609
Alcohol	77 (44.3)	1 (12.5)	76 (45.8)	45 (47.9)	24 (42.9)	7 (43.8)	0.825
Hypertension	133 (76.4)	5 (62.5)	128 (77.1)	69 (73.4)	47 (83.9)	12 (75.0)	0.325
Diabetes mellitus	36 (20.7)	0 (0.0)	36 (21.7)	26 (27.7)	7 (12.5)	3 (18.8)	0.089
Hyperlipidemia	56 (32.2)	1 (12.5)	55 (33.1)	35 (37.2)	19 (33.9)	1 (6.3)	0.051
Atrial fibrillation	102 (58.6)	7 (87.5)	95 (57.2)	51 (54.3)	34 (60.7)	10 (62.5)	0.748
Height (cm)							
Median (IQR)	1.58 (1.34–1.65)	1.52 (1.44–1.62)	1.58 (1.34–1.65)	1.59 (1.34–1.67)	1.56 (1.40–1.62)	1.55 (1.45–1.67)	0.226
≤150 cm, n (%)	47 (27.0)	3 (33.3)	44 (26.5)	19 (20.2)	20 (35.7)	5 (31.3)	0.120
Body mass index							
Median (IQR)	21.9 (14.0–24.2)	19.0 (16.2–22.1)	21.9 (13.9–24.3)	21.9 (14.0–24.4)	21.8 (14.0–24.2)	22.3 (14.6–23.4)	0.894
Type III arch, n (%)	39 (22.3)	5 (62.5)	34 (20.5)	11 (11.7)	15 (26.8)	8 (50.0)	0.001
Tortuosity, n (%)							
CCA	59 (33.7)	6 (75.0)	53 (31.9)	22 (23.4)	24 (42.9)	7 (43.8)	0.027
Proximal ICA	43 (24.6)	3 (33.3)	40 (24.1)	19 (20.2)	19 (33.9)	2 (12.5)	0.086
IV-t-PA, n (%)	77 (44.3)	4 (50.0)	73 (44.0)	42 (44.7)	25 (44.6)	6 (37.5)	0.860
Time metrics (min), median (IQR)							
Onset to door			127 (0–257)	121 (0–220)	135 (0–436)	178 (0–368)	0.607
Door to puncture			50 (6–81)	48 (6–80)	47 (9–90)	51 (7–87)	0.729
Puncture to guiding insertion			10 (0–13)	7 (0–9)	12 (11–15)	30 (20–36)	0.000
Guiding insertion to recanalization			37 (5–65)	37 (5–62)	34 (7–54)	72 (20–87)	0.290
Puncture to recanalization			45 (12–71)	43 (12–64)	47 (22–68)	85 (43–110)	0.001

*Kruskal–Wallis test between group A, group B, and group C.

CCA, common carotid artery; GC, guiding catheter; ICA, internal carotid artery; IQR, interquartile range, IV-t-PA, intravenous tissue plasminogen activator; NIHSS, National Institutes of Health Stroke Scale; PTG, puncture-to-guiding insertion time

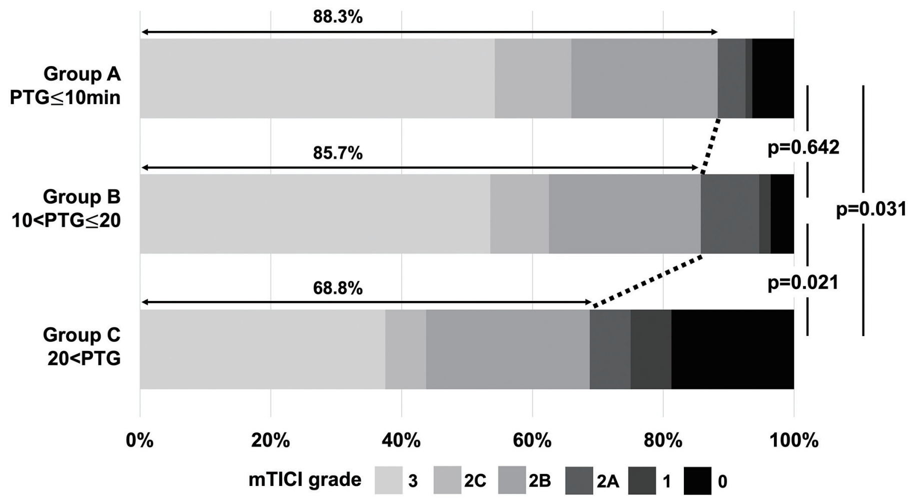

Fig. 2 If the time from puncture-to-guiding catheter insertion was ≤20 min (groups A and B), the successful reperfusion rate was >80%. However, if the time to guiding catheter insertion was >20 min (group C), the successful reperfusion rate was significantly lower. mTICI, modified thrombolysis in cerebral infarction, PTG: puncture-to-guiding insertion time

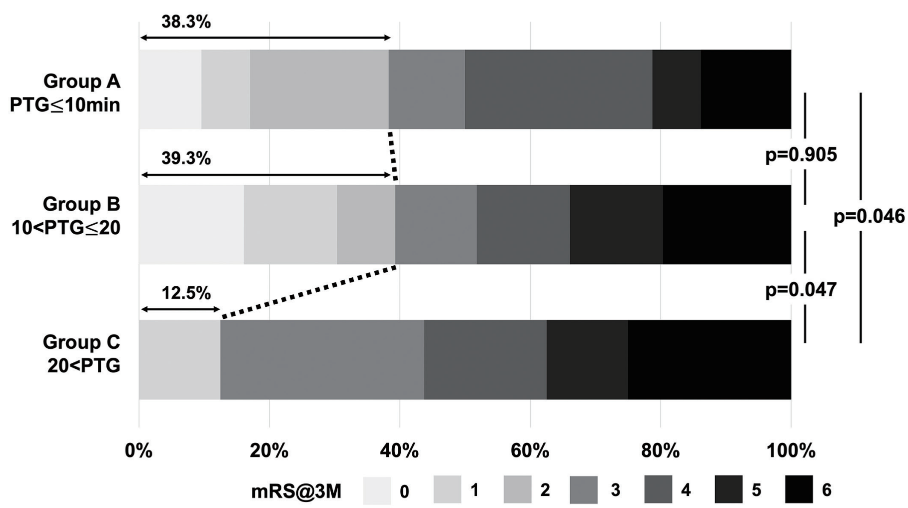

Fig. 3 The proportion of favorable outcomes did not differ between groups A and B. However, if the time to guiding catheter insertion is >20 min (group C), the rate of favorable outcomes was significantly lower. mRS, modified Rankin Scale; PTG, puncture-to-guiding insertion time

Table 2 Baseline characteristics of patients according to difficulty of guiding catheter insertion to the affected left carotid artery

Characteristic	All patients (n = 84)	PTG ≤10 min (n = 47)	10 min <PTG ≤20 min (n = 28)	20 <PTG (n = 9)	p-value
Bovine arch, n (%)	14 (16.7)	6 (12.8)	4 (14.3)	4 (44.4)	0.107

PTG, puncture-to-guiding insertion time

longer, as the distal target vessels could not be properly evaluated. The strategy used after GC insertion is important, but complete and stable GC insertion within a short time is even more important.

Patients with acute stroke are commonly aged over 70 years and have a high incidence of vascular risk factors, leading to a high prevalence of elongated and tortuous vessels that often make catheter navigation to the target vessel difficult and time-consuming.[7] Ribo et al. examined 130 patients (with a mean age of 72 ± 12 years) who underwent MT with the transfemoral artery approach. The results showed that the target site could not be accessed using a catheter in 5.1% of cases.[7] MT is typically performed via percutaneous transfemoral access.[15]

The risk of transfemoral access failure increases with age, with up to 20% failure in patients aged over 80 years, which is likely attributed to age-related changes in the vasculature.[7,15] In this study, almost all patients had access via the femoral artery, despite a median age of 80.0 years and the use of BGC in all cases, which is generally thicker and harder than the standard GC. In most cases, the GC can be inserted, even if a BGC is utilized, using the methods described in previous studies[6,11] or various devices.

In a few cases, the GC cannot be inserted into the target carotid artery via the femoral artery. In this study, patients with difficult access were more likely to be older, female, and short and they had a type III arch and/or CCA tortuosity. In patients with these characteristics, GC stability is poor, and the guidewire can be difficult to guide to the affected vessel. If the guidewire is challenging to guide to the affected vessel, the Neuro-EBU catheter (SILUX, Saitama, Japan) can be used to increase stability.[16] Vessel information should be evaluated using whole-body CTA before puncture, and the anatomical features of the aortic arch and CCA are particularly important. Additionally, hypertension and arteriosclerosis, kyphosis and scoliosis, which can occur with age and may lead to short stature, can cause aortic tortuosity,[17,18] making GC insertion more difficult.

In this study, the approach was changed in 4 (2.3%) cases. In all cases, the target vessels were accessible. Alternative strategies, including different puncture sites such as the radial, brachial, or direct CCA, have been reported. Moreover, these approaches are worth investigating because they can significantly reduce procedural time frames and facilitate the procedure.[7] Transradial approaches have rapidly become the primary access point for neurointerventional procedures because of their lower rate of access site complications and improved ease of access.[19] However, if the radial artery is small, the consistent use of larger thrombectomy catheter systems may be limited.[20] Moreover, based on an early cross-institutional experience, the failure rate of primary transradial thrombectomies and conversion to the transfemoral approach were 18% and 6.9%, respectively. The transfemoral approach might be the better primary option. Cord et al. performed a retrospective study on carotid direct puncture, which showed that the use of transcarotid MT was associated with higher recanalization rates, smaller final stroke volumes, improved National Institutes of Health Stroke Scale scores, and better functional outcomes.[15] By contrast, in transcarotid MT, vascular issues can lead to life-threatening complications. In addition, sheath removal and hemostasis after percutaneous transcarotid access remain controversial.[15] However, considering its efficacy, it should be selected if the approach is changed. In this study, there were no cases in which GC insertion was impossible in patients with changes in the approach site. If catheterization of the target carotid artery is impossible via the femoral artery, an access change should be actively considered. While the transradial approach is more acceptable from the viewpoint of puncture-site problems and stress reduction in patients, a subset of patients will remain for whom both transfemoral and transradial approaches are suboptimal, and a transcarotid approach may be the most clinically appropriate treatment.[15,20]

The current study had several limitations that should be considered. First, the sample size was small, and the study was conducted retrospectively at a single institution. Second, the experience of the physicians who performed the procedure might have influenced the outcomes. The self-adjusted outcomes were also a limitation of our study. Future prospective studies in a larger cohort are warranted.

Conclusion

In almost all patients, the GC was accessible via the femoral artery using various techniques. However, GC insertion can be challenging in older patients and those with a type III arch and/or tortuous CCA. We need to make an effort to insert the GC within 20 min, with active consideration of changes in approach.

Disclosure Statement

The authors declare that they have no personal, financial, or institutional interest in any of the drugs, materials, or devices described in this article.

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