Balloon-inflation Anchoring Technique for Insertion of a Guiding Catheter in Acute Mechanical Thrombectomy

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Purpose: Anatomical factors involved in the difficulty of inserting a guiding catheter (GC) into the aortic arch include marked arteriosclerosis with severe vessel tortuosity and type-3/bovine aortic arches. For patients with such factors, we have inserted a balloon guiding catheter (BGC) using the balloon-inflation anchoring technique (BIAT). In this study, we introduce the BIAT, and examine its usefulness.

Subjects and Methods: The subjects were 44 patients who underwent acute mechanical thrombectomy for occlusion of the major cerebral artery in anterior circulation between January 2014 and February 2016. Of these, the BIAT was used for BGC insertion in patients, with the above anatomical factors, in whom it was difficult to insert a BGC using the standard method. The BIAT is a technique with a BGC in which an inner catheter is guided to the peripheral side by dilating/anchoring a balloon at maximum at the origin of the brachiocephalic trunk or left common carotid artery, and, subsequently, a BGC is guided to the target blood vessel by slightly deflating the balloon as a flow-guide.

Results: Of the 44 patients, BGC insertion was difficult in eight patients (18%). The mean age of the other patients (control group) was 68.9 years, whereas that of the eight patients was 79.7 years, being significantly more advanced (p = 0.025). The BIAT facilitated BGC insertion in all patients, and the technical success rate was 100%. There were no procedure-related complications. The mean interval from the start of femoral artery puncture until BGC insertion was 15.7 and 20.3 minutes, respectively, in the control and BIAT groups. There was no significant difference between the two groups (p = 0.35).

Conclusion: In 18% of patients who underwent acute mechanical thrombectomy, BGC insertion was difficult. In this group, the proportion of elderly patients was significantly higher. The BIAT facilitated BGC insertion in all patients. The mean interval from the start of puncture until BGC insertion was 20 minutes; a BGC could be guided in a relatively short period. This procedure may be particularly useful for acute mechanical thrombectomy, of which the duration directly contributes to the outcome.

Keywords: balloon-inflation anchoring technique, bovine aortic arch, type-3 aortic arch, acute ischemic stroke, thrombectomy

Introduction

Several studies indicated that acute mechanical thrombectomy for acute ischemic stroke related to proximal occlusion in anterior circulation within 6 hours after onset more markedly improved the functional outcome after 90 days compared with intravenous thrombolysis with recombinant tissue plasminogen activator alone.1-3 Furthermore, the use of a balloon guiding catheter (BGC) as a guiding catheter (GC) facilitates more favorable recanalization, leading to a better outcome in comparison with a standard GC; its use is recommended.4-6 However, a BGC is thicker and harder than a standard GC, making insertion difficult in some cases.

Anatomical factors involved in the difficulty of inserting a GC/BGC into the aortic arch include marked arteriosclerosis with severe vessel tortuosity and type-3/bovine aortic arches.7-9 For carotid artery stenting or coil embolization, in which there is no time restriction, switching to other...
approaches, such as a trans-branchial-artery approach, is possible. However, a BGC should be inserted in a short period in patients in whom the interval until recanalization directly contributes to the results of treatment or outcome, such as those undergoing acute mechanical thrombectomy. In this study, we introduce the balloon-inflation anchoring technique (BIAT) as a management method for patients in whom BGC insertion is difficult during acute mechanical thrombectomy, and examine its usefulness.

Subjects

The subjects were 44 patients who underwent acute mechanical thrombectomy for occlusion of the major cerebral artery in anterior circulation between January 2014 and February 2016. Patients with one of the following anatomical characteristics, such as severe vessel tortuosity and type-3/bovine aortic arches, at the aortic arch in whom it was impossible to insert a BGC using the standard method were regarded as those in whom BGC insertion is difficult. Those with an angle of $\leq 30^\circ$ between the left common carotid artery and aortic arch were regarded as those with severe vessel tortuosity. Furthermore, those in whom the distance from the highest end of the aortic arch to the origin of the brachiocephalic trunk was two or more times longer than the left common carotid artery diameter were regarded as those with type-3 aortic arch. During the same period, the procedure was switched to a trans-brachial-artery approach due to a problem regarding the femoral artery in one patient, but this patient was excluded from the subjects.

Methods

Initially, we introduce BIAT methods. Basically, a 9 Fr OPTIMO catheter (Tokai Medical Products, Aichi, Japan) was used as a BGC, a 6 Fr JB2 catheter (Medikit, Tokyo, Japan) as an inner catheter, and angle type 0.035” radifocus standard-stiff 150 cm wire (Terumo Corporation, Tokyo, Japan) as a guidewire. Using a coaxial system, BGC insertion was conducted. In patients in whom guidewire insertion was difficult before BGC insertion or those in whom the insertion of a 6 Fr JB2 catheter was difficult, a 6 Fr modified Simmons SY6 catheter was initially used. In patients in whom guidewire insertion was difficult before BGC insertion or those in whom the insertion of a 6 Fr JB2 catheter was difficult, a 6 Fr modified Simmons SY6 catheter was inserted. The BIAT consists of two steps. In patients in whom BGC insertion is difficult, when guiding an inner catheter to the brachiocephalic trunk or left common carotid artery, it often slides down into the ascending aorta. Therefore, an inner catheter can be inserted by guiding a BGC in advance beyond the inner catheter, dilating the balloon at maximum at the origin of the brachiocephalic trunk or left common carotid artery, and anchoring the BGC (Fig. 1), which is the first step. Subsequently, the BGC is guided to the target position by guiding the inner catheter to the peripheral side and slightly deflating the balloon as a flow-guide, which is the second step. The combination of these two steps was termed BIAT. Of our series, a BGC was inserted using the BIAT in patients in whom BGC insertion was difficult.

Results

Of the 44 subjects, it was difficult to insert a BGC in eight patients (18%, five males and three females). The mean age of the other 36 patients (control group) was 68.9 years, whereas that of the eight patients was 79.7 years, being significantly more advanced ($p = 0.025$). The background of the eight patients, anatomical characteristics, and BGC systems are presented in Table 1. Severe vessel tortuosity was observed in two patients, type-3 aortic arch in five patients, and bovine aortic arch in one patient. As a GC, a 9 Fr OPTIMO catheter was used in seven of the eight patients, and a 7 Fr OPTIMO catheter in one patient. As an inner catheter, a 6 Fr JB2 catheter was used in five patients, and it was necessary to switch it to a 6 Fr SY6 catheter in one of these patients. In two patients, a 6 Fr SY6 catheter was initially used. In patients in whom a 7F OPTIMO catheter was used as a BGC, a 4 Fr JB2 catheter was used as an inner catheter. In all patients, it was possible to insert a BGC, with a technical success rate of 100%. The mean interval from the start of femoral artery puncture until BGC insertion in the control group was 15.7 minutes. In patients in whom BGC insertion was difficult, it was 20.3 minutes. However, there was no significant difference between the two groups ($p = 0.35$). There were no procedure-related complications.

Discussion

Three randomized comparative studies demonstrated the efficacy of acute mechanical thrombectomy for occlusion of the major cerebral artery, as presented at a meeting of the International Stroke Society in 2015. Thereafter, several studies also verified its efficacy. In Japan, the appearance of new devices, including stent retrievers, has
led to a high recanalization rate and favorable functional outcome. Currently, to further improve the prognosis, the importance of shortening the duration of treatment is emphasized. However, we have often encountered patients in whom a specific interval was required for treatment due to anatomical factors. Ribo et al. examined 130 patients who underwent acute mechanical thrombectomy with a trans-femoral-artery approach, and reported that it was impossible to access the target site using a catheter in 5.1%.

In these patients, the recanalization rate was low, and the outcome was unfavorable. In addition, the median interval from femoral artery puncture until access was 20 minutes in patients with easy access, whereas 30 minutes were wasted in those in whom it was difficult to access the target site due to anatomical factors. According to the Interventional Management of Stroke (IMS)-III subanalysis, the proportion of patients with a favorable prognosis decreased by 12% per 30-minute delay in recanalization.

Table 1 Summary of eight cases who used balloon inflation anchoring technique

<table>
<thead>
<tr>
<th>Age/sex</th>
<th>Occlusion vessel</th>
<th>Anatomical feature</th>
<th>Guiding catheter</th>
<th>Inner catheter</th>
<th>P2BGC (min)</th>
<th>P2R (min)</th>
<th>TICI</th>
</tr>
</thead>
<tbody>
<tr>
<td>73/M</td>
<td>Lt. MCA M2</td>
<td>Tortuous</td>
<td>9F OPTIMO</td>
<td>6F SY6</td>
<td>NA</td>
<td>105</td>
<td>3</td>
</tr>
<tr>
<td>92/F</td>
<td>Lt. MCA M1</td>
<td>Tortuous</td>
<td>9F OPTIMO</td>
<td>6F JB2</td>
<td>13</td>
<td>61</td>
<td>3</td>
</tr>
<tr>
<td>75/M</td>
<td>Rt. MCA M1</td>
<td>Type 3</td>
<td>9F OPTIMO</td>
<td>6F JB2</td>
<td>11</td>
<td>90</td>
<td>2a</td>
</tr>
<tr>
<td>69/M</td>
<td>Lt. MCA M2</td>
<td>Type 3</td>
<td>7F OPTIMO</td>
<td>4F JB2</td>
<td>NA</td>
<td>NA</td>
<td>2a</td>
</tr>
<tr>
<td>85/M</td>
<td>Rt. ICA</td>
<td>Type 3</td>
<td>9F OPTIMO</td>
<td>6F JB2 → 6F SY6</td>
<td>35</td>
<td>161</td>
<td>3</td>
</tr>
<tr>
<td>87/F</td>
<td>Rt. MCA M1</td>
<td>Type 3</td>
<td>9F OPTIMO</td>
<td>6F JB2</td>
<td>19</td>
<td>29</td>
<td>3</td>
</tr>
<tr>
<td>81/F</td>
<td>Rt. MCA M1</td>
<td>Type 3</td>
<td>9F OPTIMO</td>
<td>6F SY6</td>
<td>35</td>
<td>78</td>
<td>3</td>
</tr>
<tr>
<td>71/M</td>
<td>Lt. MCA M1</td>
<td>Bovine</td>
<td>9F OPTIMO</td>
<td>6F JB2</td>
<td>9</td>
<td>30</td>
<td>3</td>
</tr>
</tbody>
</table>

MCA: middle cerebral artery; TICI: thrombolysis in cerebral infarction
mechanical thrombectomy, the operation time directly contributes to the results of treatment and outcome; therefore, it is necessary to insert a GC in a short time.

According to the subanalysis of a post-marketing survey regarding Solitaire FR (Medtronic, Minneapolis, MN, USA) in North America, the North American Solitaire Acute (NASA) Stroke Registry, a BGC was used in 44% of 338 patients who underwent acute mechanical thrombectomy, and the proportion of patients requiring additional treatment in the BGC group was significantly lower than in the GC group (20% vs. 28.6%, respectively; p = 0.05). In the former, the operation time was shorter (120 ± 28.5 vs. 161 ± 35.6 minutes, respectively; p = 0.02), and the revascularization in cerebral infarction grade 3 (TICI 3) recanalization rate was higher (53.7% vs. 32.5%, respectively; p = 0.05). In addition, the proportion of patients with a favorable outcome was higher (51.6% vs. 35.8%, respectively; p = 0.02). It was reported that BGC use was an independent factor involved in a favorable prognosis, recommending that a BGC should be used, if possible, for acute mechanical thrombectomy.

Thus, BGC insertion in a short time is important for acute mechanical thrombectomy, but it is often difficult to insert a GC in clinical practice. Anatomical aortic arch factors that make BGC/GC insertion difficult include severe vessel tortuosity and type-3/bovine aortic arches. Although the definition of severe vessel tortuosity varies, Madhwal et al. defined lesions with an angle of ≤30° between the left common carotid artery and aortic arch as severely tortuous, and reported it as an anatomical factor that makes carotid artery stenting difficult. Furthermore, the aortic arch is classified into three types (types 1 to 3) based on the distance between the aortic arch peak and origin of the brachiocephalic trunk or left common carotid artery in comparison with the left common carotid artery diameter: brachiocephalic trunk and left common carotid artery originating at the same height (type 1), those originating at a height within 1- to 2-fold of the left common carotid artery diameter (type 2), and those originating at a height more than 2-fold of the left common carotid artery diameter (type 3). In the presence of type-3 aortic arch, GC insertion is the most difficult. Bovine aortic arch is classified into two types: a pattern in which the brachiocephalic trunk and left common carotid artery branch from a common trunk, and a pattern in which the left common carotid artery branches from the brachiocephalic trunk. The frequency of each type varies among studies, but the former accounts for approximately 13%, and the latter for approximately 9%. In this study, BGC insertion was difficult in approximately 18% of the subjects. The mean age was 79.7 years; the proportion of elderly patients was significantly higher. In all eight patients in whom BGC insertion was difficult, the use of the BIAT facilitated BGC insertion. This technique was a standard transfemoral-artery approach, making insertion possible using a BGC to be selected for acute mechanical thrombectomy without delaying the duration of treatment. Therefore, this technique should be adopted for patients with the difficulty of BGC insertion, as often encountered.

Concerning the limitations of the BIAT, it is frequently performed for patients with marked arteriosclerosis; therefore, balloon dilation may lead to plaque destruction or vascular dissection. On the other hand, the BGC end is located at the vascular center by dilating the balloon; inner catheter-related plaque or vascular wall injury may be reduced. In this study, there were no complications. Concerning bovine/type-3 aortic arches, several studies reported that the incidence of carotid artery stenting-related complications increased. The BIAT may also increase the incidence of complications, but BGC insertion should be regarded as a priority when performing acute mechanical thrombectomy for occlusion of the major cerebral artery, that is, under the circumference that treatment must be completed in a short duration; it may not be necessary to hesitate the BIAT.

In addition to the BIAT used in this study, procedures to be adopted when GC insertion is difficult include the carotid-compression technique, a method to hold a GC using a Goose-neck snare, and direct puncture of the common carotid artery. Yoshimura et al. selected the carotid-compression technique for patients in whom GC insertion was difficult, and reported that the technical success rate was 83%, and that the incidence of procedure-related complications was 0%. This technique is safe and simple, and it can be performed without spending time; therefore, it may be useful for acute mechanical thrombectomy. In the method with a Goose-neck snare, it is necessary to add a trans-brachial-artery approach, and the procedure is relatively complex; therefore, this method may be inappropriate for acute mechanical thrombectomy. Furthermore, a study indicated that a transcervical access through direct puncture of the carotid artery was useful in patients in whom a trans-femoral-artery approach was difficult. According to this report, a transcervical access facilitated treatment in all patients, and carotid artery puncture was performed in 5 to 15 minutes. In addition, recanalization of
the occluded blood vessel was achieved 7 to 49 minutes after carotid artery puncture. A transcervical access facilitates an approach to the target site without being influenced by anatomical factors of the aortic arch. On the other hand, subcutaneous hematoma formation requiring endotracheal intubation was observed in approximately 14%; the procedure may be invasive. In addition, 20 minutes or more were required for switching from a trans-femoral-artery approach. From the viewpoint of treatment time, a transcervical access may be a final countermeasure. Haussen et al. reported the usefulness of a trans-radial-artery approach for acute mechanical thrombectomy in patients in whom a trans-femoral-artery approach is difficult due to anatomical factors of the inguinal region and aortic arch. Of 1001 patients, a trans-radial-artery approach was adopted in 15 patients (1.5%). There were no procedure-related complications, and treatment was completed. However, 1.9 ± 1.3 hours (mean) were required until a trans-femoral-artery approach was switched to a trans-radial-artery approach. In addition, the mean interval from puncture of the radial artery until recanalization of the occluded blood vessel was 2.2 ± 1.0 hours, suggesting a prolonged waste of time in the duration of acute mechanical thrombectomy. A trans-radial-artery approach is selected only when a trans-femoral-artery approach is impossible.

As a limitation of this study, the number of patients was small. In our series, the use of the BIAT facilitated treatment in all patients. However, the number of patients was limited, and we cannot conclude that all patients can be managed using the BIAT. However, this technique should be selected before switching to a trans-brachial-artery approach requiring a specific time or direct puncture of the carotid artery.

## Conclusion

Of patients who underwent acute mechanical thrombectomy, it was difficult to insert a BGC in 18%, and the proportion of elderly patients was significantly higher. The use of the BIAT facilitated BGC insertion in all patients. The mean interval from the start of puncture until BGC insertion was 20 minutes; it was possible to insert a BGC in a relatively short duration. The BIAT may be particularly useful for acute mechanical thrombectomy, in which the treatment time directly contributes to the outcome.

## Disclosure Statement

There is no conflict of interest for the author and coauthors.

## References


