Strategies to Improve the Operability/Safety during Embolization of Unruptured Cerebral Aneurysms Using a Balloon-/stent-assisted Technique: Dual Inner Catheter Technique

Naoyuki Arai, Ryuzaburo Kanazawa, Tomoyuki Yoshihara, Manabu Osakabe, Tetsuhiro Higashida, and Takanori Uchida

Purpose: When intending balloon-/stent-assisted embolization of cerebral aneurysms using ≥8 Fr guiding and coaxial 6 Fr inner catheters, operations can be conducted more safely by inserting the inner catheter to a site proximal to the aneurysm. However, tortuous-blood-vessel-related mechanical vasospasm or blood stagnation makes it impossible to insert a 6 Fr inner catheter to a distal site in some patients. For adjunctive techniques, devices may interfere with each other in a 6 Fr inner catheter, reducing the operability.

Case Presentation: In this study, we termed a method of placing two 4.2 Fr FUBUKI catheters (Asahi Intecc Co., Ltd, Aichi, Japan) in parallel in an 8 Fr shuttle sheath (SS) to reduce the resistance to a parent blood vessel and improve the operability during an adjunctive technique, “dual inner catheter technique (DICT)”, and selected the DICT for 10 patients with unruptured cerebral aneurysms.

Conclusion: The DICT reduced the distance from the aneurysm, device-related interference, and risk of blood stagnation/mechanical vasospasm, improving the operability/safety.

Keywords adjuncive technique, 4.2 Fr FUBUKI, dual inner catheter technique, unruptured cerebral aneurysm

Introduction

Balloon-/stent-assisted adjunctive techniques have increased the number of patients for whom embolization of cerebral aneurysms is indicated. For adjunctive techniques, the use of an inner catheter may improve the operability/safety of devices. We previously used a 6 Fr inner catheter for balloon-/stent-assisted adjunctive techniques, but tortuous-blood-vessel-related mechanical vasospasm or blood stagnation made it impossible to insert a 6 Fr inner catheter to a distal site in some patients. In others, interference between devices in a 6 Fr inner catheter was marked. As it was possible to pass the balloon/stent delivery catheters described below, through a 4.2 Fr FUBUKI catheter (Asahi Intecc Co., Ltd, Aichi, Japan), we examined a guiding catheter that allows a 4.2 Fr FUBUKI catheter to be used independently for adjunctive techniques. An 8 Fr shuttle sheath (SS) (Cook Japan, Tokyo, Japan) facilitated the use of two 4.2 Fr FUBUKI catheters in parallel. We termed a method of placing two 4.2 Fr FUBUKI catheters in parallel in an 8 Fr SS “dual inner catheter technique (DICT).” The use of a microcatheter and balloon/stent delivery catheter in two 4.2 Fr FUBUKI catheters facilitated stable catheter operations; this may be an effective method. In this study, we treated 10 patients with unruptured cerebral aneurysms using the DICT, and confirmed the usefulness and safety of this procedure. We present a representative case.
**Case Presentation**

The patient was a 49-year-old female. A medical checkup of the brain indicated an unruptured cerebral aneurysm at the anterior clinoid process beside the left internal carotid artery. The aneurysm measured $5.6 \times 4.5 \times 3.0$ mm, with a neck width of 4.1 mm. In this patient, a balloon or stent was considered to be necessary, but the cervical internal carotid artery was tortuous, and the use of an inner catheter was considered to be appropriate for maintaining the safe operability of a microcatheter or balloon catheter. Considering the risk of blood stagnation related to a standard guiding catheter or 6 Fr Cerulean (Medikit Co., Ltd, Tokyo, Japan) inserted to a distal site based on the tortuosity of the cervical internal carotid artery, we performed coil embolization of the left internal carotid artery aneurysm using the DICT. Dual-antiplatelet therapy (DAPT) was administered from 2 weeks before treatment.

**Endovascular treatment**

Under general anesthesia, treatment was performed. After systemic heparinization, the activated clotting time (ACT) was maintained at 200–300 seconds. After an 8 Fr SS passed over the diaphragm, it was introduced into the origin of the left internal carotid artery coaxially to a PC kit (Togo Medikit Co., Ltd., Tokyo, Japan), and connected with a triple connector. Two 4.2 Fr FUBUKI catheters were guided to the C4-C5 areas using 0.035-inch guide-wires (Togo Medikit Co., Ltd.), respectively. Embolization was performed using the balloon remodeling technique with a Headway17 (Terumo Corporation, Tokyo, Japan) and Scepter C4 × 10 mm (Terumo Corporation) inserted through the two 4.2 Fr FUBUKI catheters, respectively. Complete occlusion was achieved, and treatment was completed. There was no blood stagnation or vasospasm related to the insertion of the two FUBUKI catheters (Fig. 1). For hemostasis, an 8 Fr Angio-Seal (Terumo Corporation), was used.
Course after embolization

On the day of surgery, extubation was conducted. Diffusion-weighted MRI did not reveal any infarcted focus the day after surgery. The course was favorable, and the patient was discharged 3 days after surgery.

Discussion

It is important to secure operability/stability during coil embolization for achieving successful aneurysm treatment, but anatomical factors for access routes may hamper this.\(^1,2\)\(^\) Several studies indicated that a multiple coaxial system was effective for flexed/tortuous proximal blood vessels\(^3,4\) because it facilitates an access to a flexed/tortuous parent blood vessel, stabilizing intracranial device operations. In our institution, a 6 Fr Cerulean had been used with a 6 Fr inner catheter. As the 6 Fr Cerulean has favorable trackability/bearing properties, it is routinely used as an inner catheter. The diameter of its lumen is 1.83 mm, and a triple coaxial system using this is useful for embolization of distal cerebral aneurysms or those to which access routes are markedly flexed.\(^5\) This system is commonly used. However, a study reported that the risk of mechanical vasospasm of a parent blood vessel was 38% when inserting an inner catheter, targeting the petrous portion of internal carotid artery.\(^6\) In such cases, it is difficult to insert an inner catheter to a distal site, and the distance from the aneurysm may be prolonged, reducing operability/stability during treatment.

On the other hand, the DICT aims at inner-catheter guiding to the siphon site, and wide-diameter catheter guiding into intracranial blood vessels may induce arterial dissociation or vasospasm.\(^7,8\) However, according to a few studies, 4.2 Fr FUBUKI catheters were inserted into the anterior cerebral/basilar arteries\(^9\) or middle meningeal artery\(^10\) during treatment, but there was no mechanical vasospasm or complication. In our patients (n = 10) treated using the DICT, it was also possible to guide two 4.2 Fr FUBUKI catheters to the siphon site, and there was no blood stagnation or mechanical vasospasm (Table 1).

We have examined whether the DICT should be indicated in accordance with individual patients, considering the safety of operating an 8 Fr SS based on the results of preoperative CT angiography and angiography on admission for examination. This technique has been selected for patients requiring the use of a balloon/stent due to the tortuosity of the cervical internal carotid artery, considering the risk of blood stagnation related to the use of a standard guiding catheter or 6 Fr inner catheter.

Concerning complications, ischemic complications related to the use of two inner catheters, and puncture-site complications related to the use of a wide-diameter sheath should be considered. However, a symptomatic ischemic complication related to the DICT was noted in 1 of the 10 patients, whereas previous studies reported that the incidence of symptomatic ischemic complications related to endovascular treatment for unruptured cerebral aneurysms ranged from 3.2 to 12.0%\(^11-13\). The incidence of symptomatic complications in our series was not higher than previously reported. Furthermore, hemostasis methods on removal of an 8 Fr SS consisted of pressure hemostasis in three patients and hemostasis with an 8 Fr Angio-seal in seven patients. There was no puncture-site complication. As a wide-diameter sheath was used, the interval until hemostasis was considered. There was no problem in comparison with patients treated using other methods.

### Table 1 Aneurysm location, used device, and other result of Dual inner catheter technique

<table>
<thead>
<tr>
<th>AN location</th>
<th>Placement of FUBUKI</th>
<th>Spasm</th>
<th>Micro</th>
<th>Assist device</th>
<th>Interference</th>
</tr>
</thead>
<tbody>
<tr>
<td>R IC paracloind/R M1</td>
<td>C4, C5</td>
<td>no</td>
<td>SL-10</td>
<td>Scepter C/Neuroform</td>
<td>no</td>
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<tr>
<td>R IC paracloid</td>
<td>C5</td>
<td>no</td>
<td>SL-10</td>
<td>Scepter C</td>
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<td>R IC paracloid</td>
<td>C4, C5</td>
<td>no</td>
<td>SL-10</td>
<td>Scepter C/Enterprise</td>
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<td>R IC paracloid</td>
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<td>XT-17</td>
<td>SYOURYU SR</td>
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<td>R IC paracloid</td>
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<td>Scepter C</td>
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<td>R M1M2 compaction</td>
<td>C4, C5</td>
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<td>SL-10</td>
<td>Scepter C</td>
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<td>Scepter C</td>
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R: right; L: left; IC: internal carotid artery; M1: middle cerebral artery; M1M2: middle cerebral artery M1-M2 bifurcation; Pcom: posterior communicating artery; Enterprise: Codman & Shurtleff, Inc., Miami, FL, USA; FUBUKI: Asahi Intecc Co., Ltd, Aichi, Japan; Headway 17: Terumo Corporation, Tokyo, Japan; Neurdeo: Medico Hirata, Osaka, Japan; Neuroform: Stryker Japan, Osaka, Japan; Scepter C: Terumo Corporation, Tokyo, Japan; SYOURYU SR: Kaneka Medix Corp., Osaka, Japan
A 4.2 Fr FUBUKI catheter, which is primarily used in our hospital, measures 120–130 cm in effective length, with a soft tip length of 25 cm. Hydrophilic coating involves a 15-cm area from the tip. The transverse lumen diameter of an 8 Fr SS is 2.87 mm, and the outer diameter of a 4.2 Fr FUBUKI catheter is 1.4 mm; it is possible to insert two 4.2 Fr FUBUKI catheters into the 8 Fr SS. The transverse lumen diameter of a 4.2 Fr FUBUKI catheter is 1.1 mm. The balloon catheters used in this study, Scepter C/SHOURYUSR (Kaneka Medix Corp., Osaka, Japan), passed through FUBUKI catheters without problems regardless of the balloon length. Neither a Scepter XC (Terumo Corporation), nor super-compliant balloon measuring 7 × 7 mm passed due to resistance. As stent delivery catheters, we used a Prowler Select Plus (Codman & Shurtleff, Inc., Johnson & Johnson, Raynham, MA, USA)/Excelsior XT-27 (Stryker Japan, Osaka, Japan). They passed, with no resistance.

The residual lumen diameter/area when the DICT was used or when an adjunctive technique with a 6 Fr Cerulean inner catheter, which was primarily used in our hospital, was adopted are shown in Fig. 2. When placing a microcatheter in parallel with a balloon/stent delivery catheter in the 6 Fr Cerulean inner catheter, the residual lumen area was 1.38–1.43 mm² (Fig. 2A and 2B). On the other hand, it was 3.38 mm² (Fig. 2C) when placing two 4.2 Fr FUBUKI catheters in parallel in an 8 Fr SS. When the
DICT was used, the residual lumen area was greater. In all patients, such a large area of the residual lumen facilitated imaging through an 8 Fr SS even after inserting two 4.2 Fr FUBUKI catheters. When placing a 4.2 Fr FUBUKI catheter coaxially to an Excelsior XT-27, of which the diameter was the largest among the devices used in this study, the residual lumen diameter was 0.13 mm. When placing a microcatheter and Excelsior XT-27 coaxially in a 6 Fr Cerulean inner catheter, it was 0.058 mm, suggesting its involvement in resistance during operations.

Although the DICT is not a universal method, it may shorten the distance from an aneurysm, contributing to treatment through improvements in operability/stability.

### Conclusion

The DICT may shorten the distance from an aneurysm, contributing to an improvement in the operability of microcatheters. The incidence of events related to guiding-system insertion to a distal site, such as blood stagnation and mechanical vasospasm, is low. This technique may be an option for safer treatment through preoperative examination of patients in whom an 8 Fr SS can be safely elevated.

### Disclosure Statement

There is no conflict of interest for the main author or coauthors.

### References