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Original Article

The "temporary caging" technique for catheter navigation in patients with intracranial wide-necked aneurysms

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Abstract: Endovascular treatment of wide-necked aneurysms with preservation of the parent artery remains a challenge. The authors describe a novel and simple technique to navigate a balloon or stent-delivery catheter across a wide-necked aneurysm in which previously existing methods could have failed to pass the catheter across the neck of the aneurysm, which we have named "temporary caging" technique. The technical results using this method are presented in 6 cases.

Keywords: Aneurysm, balloon-assisted coil embolization, remodeling, stent-assisted coil embolization, wide-necked aneurysm

Introduction

Current endovascular treatments in the management of complex aneurysms with a wide neck include the balloon remodeling technique, [1] stent-assisted coil embolization [2], liquid embolic materials [3, 4] and flow-diversion stents to reconstruct the parent artery [5]. However, in some patients with cerebral aneurysms, navigating the balloon or stent-delivery catheter is difficult because of the anatomy of very wide aneurysm neck configurations, the acute angle formed by the aneurysm with the parent artery, or tortuosity of the parent artery itself. As described here, we have developed a novel "temporary caging" technique for balloon-or stent-assisted treatment of difficult-to-treat aneurysms in which primary bypass using conventional approaches failed in placing the balloon or stent-delivery catheter across the aneurysm neck. We report our preliminary experience using this method, with an emphasis on the potential technical advantages.

Materials and methods

Patients and selection criteria

The study was approved by the institutional review board of St. Marianna University School of Medicine (Approval number: 2954). Inclusion criteria included wide-necked aneurysms with a probability of technical difficulty in navigating balloon or stent-delivery catheters across the neck of aneurysm because of the acute angle between the proximal and distal portions of the parent arteries. A wide-necked aneurysm was defined as having a dome-to-neck ratio of less than 2 or a neck diameter greater than 4 mm [6]. Partially thrombosed, dissected, traumatic, and bacterial aneurysms were excluded. Between December 2013 and September 2014, six cases of aneurysms met the criteria.

Six patients (5 women and 1 man) with wide-neck complex aneurysms were treated using the "temporary caging" technique. The patients' mean age was 69.8 years, with a range from 62 to 74 years. Informed consent was obtained from each patient after careful consultation regarding the risks, benefits, and alternatives, including aneurysm clipping. Four aneurysms were unruptured, 2 were ruptured, and none of them had a mass effect. Four aneurysms were small (<10 mm), and the remaining 2 were large (≥10 mm). In all patients, the "temporary caging" technique was the secondary treatment strategy after attempts at primary catheter navigation with a guidewire failed.

Table 1. Summary of the patient's data

Case No.	Age (y)	Sex	Type	Size of Aneurysm (mm)	D/N ratio	Location	Degree of Occlusion	Procedural Complications	Follow-up Results	Outcome (mRS)	Misc.
1	62	F	R	7.2	1.5	ACoA	CO	None	Stable at 16 mo	0	Balloon
2	74	F	U	7.1	1.1	BA top	CO	None	Stable at 14 mo	0	Stent
3	74	M	U	14.2	1.5	A1	NR	None	Stable at 11 mo	0	Balloon
4	73	F	R	17.8	1.2	BA top	NR	None	Stable at 10 mo	0	Balloon
5	65	F	U	7.6	1.6	BA top	NR	None	Stable at 7 mo	0	Balloon
6	71	F	U	6.0	1.3	BA top	NR	None	Stable at 7 mo	0	Balloon

F = female, M = male, R = ruptured, U = unruptured, D/N = dome-to-neck, ACoA = anterior communicating artery, BA = basilar artery, A1 = A1 segment of anterior cerebral artery, CO = complete obliteration, NR = neck remnant, mo = months, mRS = modified Rankin Scale, Misc = miscellaneous, y = years.

The temporary caging procedure

In all cases, we first attempted aneurysm bypass using conventional methods. After induction of general anesthesia and heparin anticoagulation to maintain the activated clotting time at more than twice that of the control, a 6F guiding catheter with femoral access was introduced into the proximal parent artery where the wide-necked aneurysm was located. Then, rotational angiograms and 3D reconstructions were obtained for all of the patients, demonstrating the complex anatomy of the aneurysms. The procedure was subsequently performed under roadmap guidance. After the endovascular treatment approach was selected, bypass of the aneurysm neck was attempted with a guidewire through the balloon or stent-delivery catheter with different tip shapes.

If the primary negotiation of the guidewire across the aneurysm neck failed, the "temporary caging" technique was used. In this technique, a catheter for coil embolization was initially advanced over the guidewire and positioned within the aneurysm, and the first coil was then temporarily deployed without detachment even if the coil protruded into the parent artery. At this point, the angled guidewire through the balloon or the stent-delivery catheter was advanced along the coil surface at the orifice of the aneurysm until it reached into the parent artery distal to the aneurysm. The balloon or stent-delivery catheter was then advanced over the guidewire to the level of the aneurysm neck or sufficiently distal from the parent artery. Then, the first framing coil was safely embolized again with the balloon-or stent-assisted technique after the deviated coil from the aneurysm was retrieved.

The aneurysms were coiled with a variety of bare platinum coils; however, complex and long coils were preferred in the first coil, serving as a temporary cage to minimize the interspaces of coils at the orifice of the aneurysm to prevent the guidewire from prolapsing into the aneurysm. Dense packing was attempted in all patients. The femoral access sites were closed with an Angio-Seal Vascular Closure Device (St. Jude Medical, Minnetonka, MN). The patients' clinical and radiographic data are shown in **Table 1**.

Results

In all of the patients in this series, adequate navigation of the balloon or stent-delivery catheter crossing wide aneurysm orifices to distal parent arteries was achieved with no technical failures or undesirable events. Moreover, we were able to coil the aneurysm to a satisfactory degree. There were no procedural or postprocedural neurologic complications in any of the patients. All of the patients underwent 1-, 3-, 6-, and 12-month routine magnetic resonance angiograms. No recanalizations were observed in any of the follow-up examinations.

Case 2

A 74-year-old woman was admitted for endovascular treatment of an unruptured basilar artery aneurysm identified by magnetic resonance angiogram. Conventional angiography revealed a wide-necked aneurysm that measured 7.1 × 6.2 × 4.0 mm with a 6.5-mm neck, with the left posterior cerebral artery originating from the acute-angled basilar artery. The patient was premedicated with dual antiplatelet therapy with 100 mg of aspirin and 75 mg of

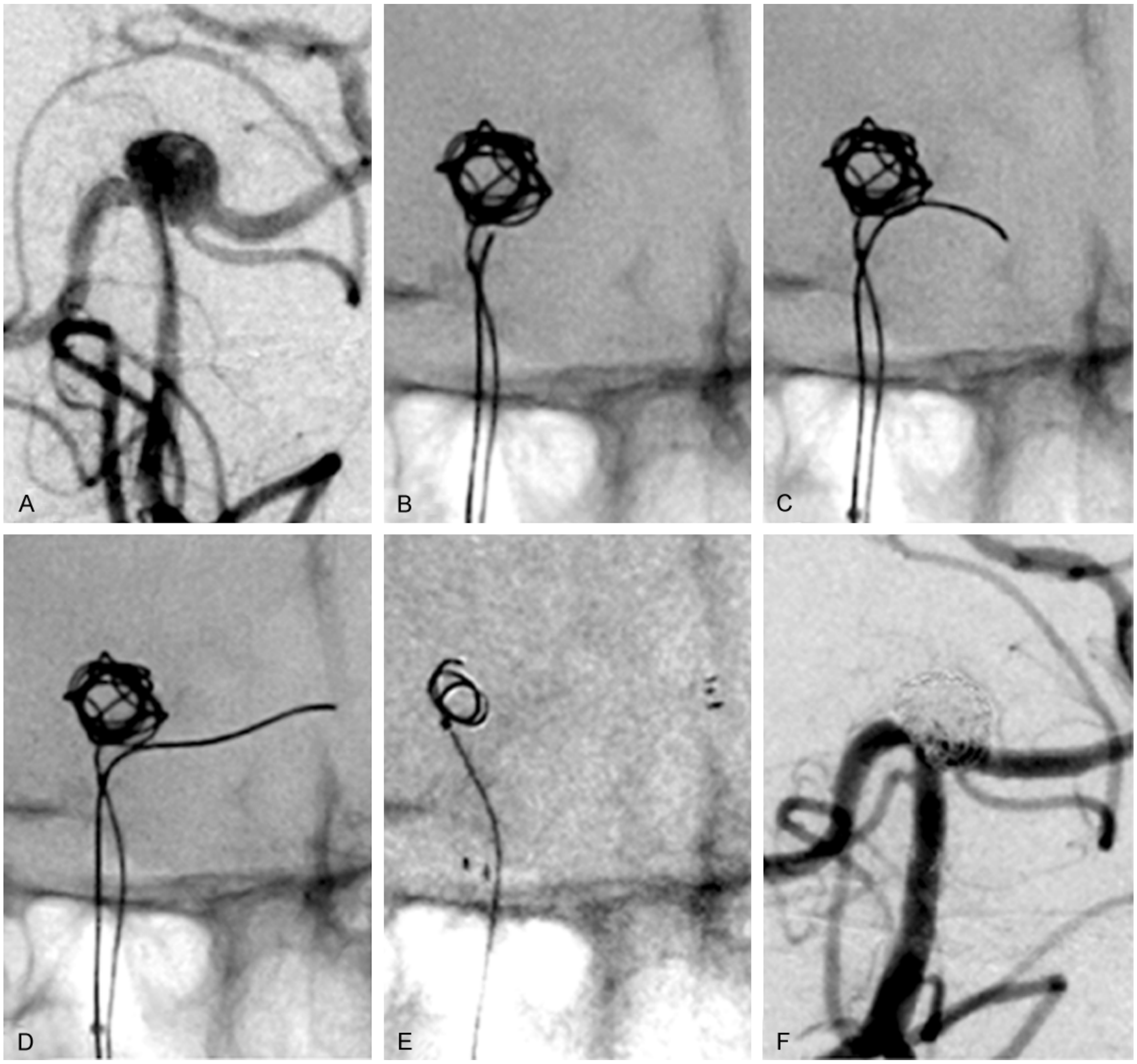

Figure 1. Case 2. A: Preoperative anteroposterior left vertebral artery angiogram of a 7.1-mm unruptured basilar artery aneurysm with a 6.5-mm neck. Note how the aneurysm extends mostly to the left posterior cerebral artery. B-E: Angiograms showing temporarily embolized coil in the aneurysm with protrusion to the parent artery. The guidewire through the catheter for stent delivery was passed along the surface of a herniated coil loop and reached a sufficiently distal portion of the left posterior cerebral artery. The stent was then placed across the aneurysm neck after the deviated coil was retrieved. Additional coils were then inserted into the aneurysm. F: Final angiogram showing complete occlusion of the aneurysm, with parent artery preservation.

clopidogrel per day for 1 week prior to the procedure. As the very wide neck of the aneurysm extended mostly to the left posterior cerebral artery, a stent-assisted technique was required. Primary bypass of the aneurysm neck failed because of guidewire prolapse into the aneurysm, despite the use of different tip angles of the Traxcess (MicroVention, Terumo, Tokyo, Japan) guidewire through an Excelsior XT-27 Flex (Stryker, Kalamazoo, MI) catheter. Therefore, the temporary caging technique was performed. First, an Excelsior SL-10 (Stryker) catheter for coil embolization was advanced coaxially using a Chikai 14 (Asahi Intecc, Aichi, Japan) guidewire navigated into the aneurysm. Next, a framing Target (Stryker) coil was embolized with a loop herniating into the parent artery. A Traxcess guidewire was then advanced coaxially through the Excelsior XT-27 Flex catheter and, on the first attempt, successfully navigated along the surface, which was structured by a coil loop to the left posterior cerebral artery. After the protruded coil was retrieved from the aneurysm, a Neuroform EZ 2.5 × 20

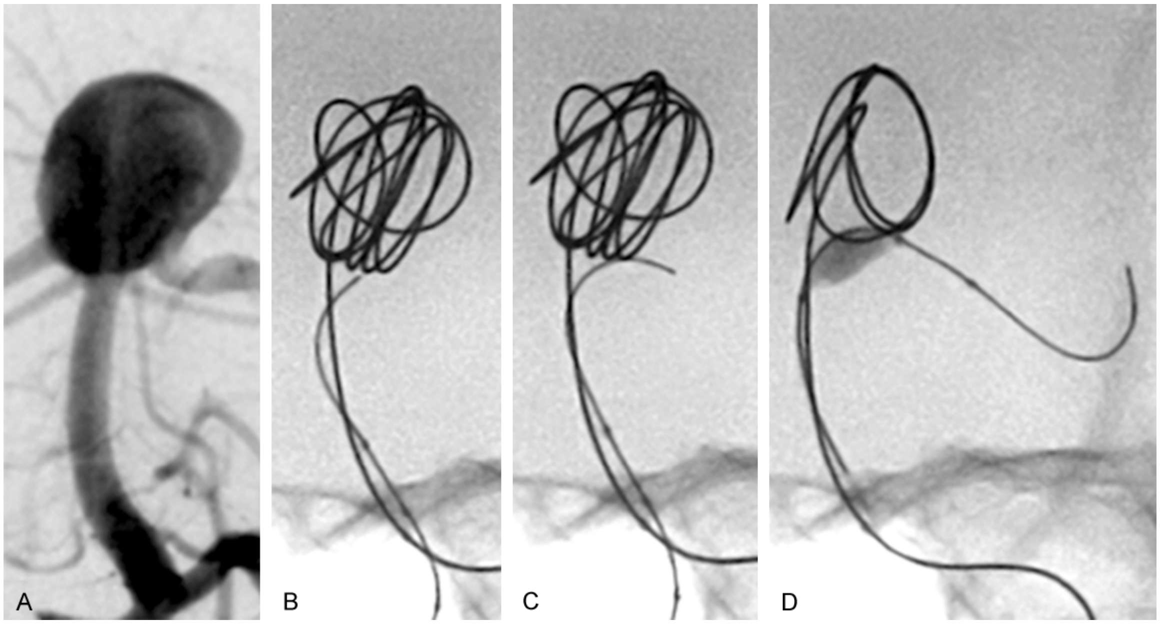

Figure 2. Case 4. A: Preoperative anteroposterior left vertebral artery angiogram of a 17.8-mm ruptured basilar artery aneurysm with a 9.2-mm neck. B-D: Angiograms demonstrating an embolized coil protruding into the parent artery, which enabled passage of the guidewire through the balloon catheter across the aneurysm neck. Then, the aneurysm was coiled using the balloon-assisted technique.

stent (Stryker) was placed between the basilar and left posterior cerebral arteries, including a sufficient portion of the aneurysm neck. The retrieved coil was reinserted and additional Target and Axium (Covidien Neurovascular, Irvine, CA) coils were inserted to fill the entire sac of the aneurysm using a stent-assisted technique, achieving an excellent angiographic and clinical outcome (**Figure 1**).

Case 4

A 73-year-old woman presented with a subarachnoid hemorrhage caused by a ruptured basilar artery aneurysm measuring 17.8 × 12.7 × 11.3 mm, with a 9.2-mm neck. The proximal and distal portions of the parent arteries formed an acute angle. As the broad neck of the aneurysm was located between the basilar and the left posterior cerebral arteries, a balloon-assisted technique was necessary. After navigation of a 4 × 11-mm Scepter XC balloon (MicroVention) across the neck of aneurysm with multiple guidewires failed, the "temporary caging" technique was used successfully with a single pass (**Figure 2**). The aneurysm was then properly embolized with Target coils using the balloon-assisted technique, resulting in a favorable angiographic and clinical outcome.

Discussion

Here, we report a novel technique called "temporary caging" as an effective alternative technique to navigate either a balloon or a stent-delivery catheter across wide-necked aneurysms for coil embolization. No complications were noted while using this technique. Endovascular treatment of wide-necked, complex, and large or giant aneurysms with preservation of the parent artery may be precluded by the inability to navigate across the aneurysm neck. There are several recently developed procedures for these aneurysms, such as balloon remodeling [1], stent-assisted coil embolization [2], and flow-diversion stents to reconstruct the parent artery [5]. Although these advanced methods provide improved anatomical and clinical results over the long term, they require access across the aneurysm neck.

However, in cases with very wide aneurysm neck configurations, negotiation of the aneurysm neck to place a balloon or stent-delivery catheter across it is one of the main difficulties leading to technical failures [7]. Moreover, proximal acute-angled loops or tortuosity of the parent artery make these cases even more difficult because they reduce guidewire torquability.

The reported failure rate for navigating a balloon catheter across the aneurysm neck in large or giant wide-necked aneurysms ranges from 11% to 25% [7, 8]. Generally, an exchange maneuver is used for tortuous or angulated arteries, which may be difficult to access with a balloon or stent-delivery catheter. However, such exchange maneuvers carry a risk of >3% for distal wire perforation [9] and may subsequently lead to death in 1.3% to 4.6% of patients receiving antiplatelet therapy [10-12]. In such settings, we have found an alternative technique to successfully navigate either a balloon or a stent-delivery catheter across wide-necked aneurysms for coil embolization. Using this temporary caging technique, we have not experienced any complications.

Some alternative methods to avoid exchange maneuvers were reported previously [13]. For instance, Nakahara et al. [14] and Chapot et al. [13] described the double-wire and sheeping techniques, respectively. In both procedures, a guidewire or a well-curved catheter is advanced past the aneurysm to straighten the course of an acute-angled parent artery and reduce friction between the arterial wall and the balloon or stent-delivery catheter, thereby facilitating their advancement and placement. These improved techniques have enabled coil embolization in previously ineligible aneurysms with difficult configurations. However, these techniques require passing a guidewire or well-curved catheter across the neck of the aneurysm to allow the balloon or stent-delivery catheter to be positioned. The presence of very wide-necked aneurysms, extreme vessel tortuosity, or complex vascular anatomy may prohibit the distal passage of any type of guidewire or catheter into the involved vessels.

Cekirge, et al. [15] described a balloon-assisted bypass technique for bypassing a wide-necked aneurysm, in which a balloon catheter is advanced over a guidewire into the aneurysm and the guidewire is advanced until it makes a complete loop and exits into the distal parent artery. The balloon catheter is then advanced into the parent artery distal to the aneurysm. Wolfe et al. [16] described a balloon bounce technique to bypass a wide-necked aneurysm, in which a Hyper Form balloon was maneuvered over a guidewire into the aneurysm and inflated adequately at the neck of the aneurysm. Next, a HyperGlide balloon was navigated over the guidewire into the parent artery. The Hyper Form balloon in the aneurysm allowed the HyperGlide balloon to be gently "bounced" across the aneurysmal neck into the distal parent artery. Although these techniques require no distal accession of a guidewire, they carry potential risk. When manipulating a guidewire or balloon catheter within an aneurysm, unexpected rupture of the lesion could occur because of perforation or over-inflation. These techniques limit the area in the intra-aneurysm cavity sufficiently to securely control the devices but carry risks of displacement of an intra-aneurysmal thrombus, resulting in cerebral infarction.

In conclusion, this new and simple "temporary caging" technique requires no risky manipulations within an aneurysm and can be used safely not only for large or giant aneurysms but also for small aneurysms. Although our clinical series is small, this novel technique has proven safe and effective in every case. The "temporary caging" technique has enabled us to successfully perform endovascular treatment of very wide-necked and complex aneurysms in which conventional techniques have failed.

Disclosure of conflict of interest

None.

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