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Case Report

Bailout Technique for Coil Unraveling with a KUSABI Exchange Catheter: A Case Report

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Objective: Coil unraveling is a rare, yet dangerous complication of endovascular coiling. In this study, we report a patient in whom an intraoperatively unraveled coil was successfully retrieved using a KUSABI exchange catheter, which is used in the field of cardiovascular medicine to facilitate catheter exchange in coronary interventions.

Case Presentation: The patient was a 90-year-old woman. To treat an unruptured aneurysm of the right internal carotid artery, endovascular coil embolization was performed. During the filling step, the coil started to unravel. Early attempts to retrieve the unraveled coil using a microsnare were complicated when the ensnared part broke off during the process. The broken tip of the unraveled coil was maneuvered inside the guiding catheter, after which a KUSABI catheter was inflated inside the guiding catheter to press and immobilize the unraveled coil against its inner lumen. This fragment of the unraveled coil was extricated from the patient by retracting the entire guiding catheter assembly. We guided a microsnare along the remaining unraveled coil to capture the intact part of the coil, and eventually retrieval was successful.

Conclusion: To our knowledge, no study has reported retrieval with a KUSABI trapping balloon catheter for the management of coil unraveling. However, this method is considered effective. We report this case and review the literature.

Keywords ▶ endovascular coil embolization, unruptured cerebral aneurysm, coil unraveling, KUSABI exchange catheter

Introduction

While improvements in device and coil technology have enhanced the safety and efficacy of endovascular coil embolization as a treatment for intracranial aneurysms, the risks of severe sequelae remain. Thromboembolism and intraoperative rupture are the most frequently encountered complications during endovascular embolizations,[1] but another less common complication that still cannot be ignored is coil unraveling. According to some reports, despite its low incidence (<2%),[2] prompt management is needed when it occurs because of the danger of the unraveled coil triggering a thrombotic event. Microsnares and dual-guidewires have been typically used as capturing devices.[2] However, using these techniques may cause situations that make it difficult to perform a retrieval. In this study, we report a case with unraveling of a detachable coil that was successfully retrieved using a KUSABI trapping balloon catheter. We also review the available literature on the subject.

Case Presentation

Patient: A 90-year-old woman.
Complaint(s): Unremarkable.
Past medical history: Hypertension, chronic heart failure, diabetes mellitus, and degenerative knee osteoarthritis.
Current medical history: The patient was referred to our department for an unruptured cerebral aneurysm, which was incidentally discovered on MRI conducted to investigate the source of head pain. We decided to treat her using stent-assisted coil embolization.
Present illness: Lucid; no signs of neurological deficits.

Radiological findings

Cerebral angiography revealed that the aneurysm was located on the medial side of the right internal carotid

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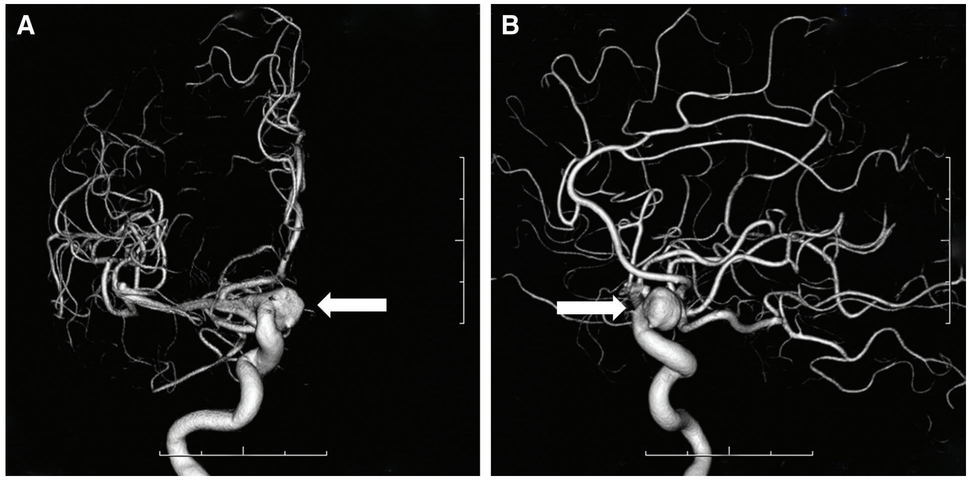

Fig. 1 **A** and **B**: Right internal carotid 3D arteriogram shows unruptured internal carotid aneurysm (arrows).

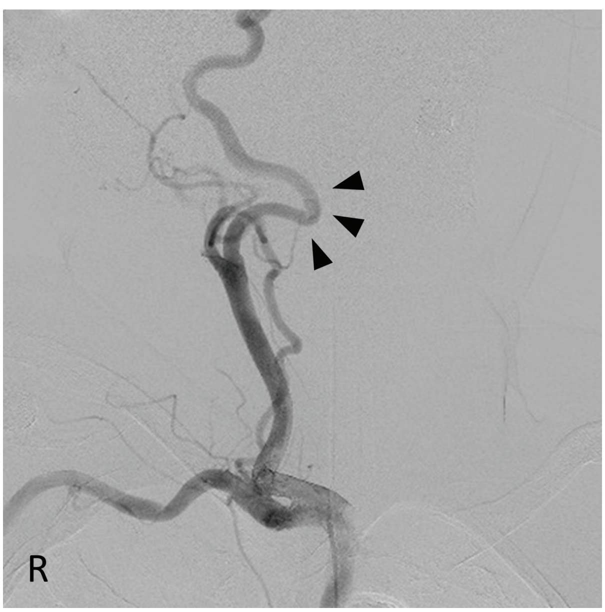

Fig. 2 Right common carotid arteriogram from the right oblique direction shows tortuosity of the right cervical internal carotid artery (arrowheads).

artery (C2). Its size was 11.3 × 6.7 × 8.4 mm with a neck measuring 6.3 mm (**Fig. 1**).

Intraoperative findings

Fourteen days before the embolization, the patient started taking aspirin (100 mg/day) and clopidogrel (75 mg/day) orally. On the day of the operation, a 7 Fr shuttle sheath was inserted into the right common femoral artery under general anesthesia. Systemic heparin administration (3000 U) achieved an activated clotting time (ACT) of 268 sec. Because of the highly tortuous cervical portion of the right internal carotid artery (**Fig. 2**), we inserted a 7 Fr FUBUKI 100 cm (Asahi Intecc, Aichi, Japan) such that its tip was just proximal to this portion. Through a TACTICS 120 cm (Technocrat, Aichi, Japan), we guided a Headway 21 straight microcatheter (MicroVention, Tustin, CA, USA) led by a CHIKAI black 14 soft tip microguidewire (Asahi Intecc) to the horizontal portion of the right middle cerebral artery (M1). Next, we guided a Headway 17 pre-shaped angle 45° microcatheter (MicroVention) led by a CHIKAI black 14 soft tip into the aneurysm sac. A LVIS Blue 5.5 × 30 mm (MicroVention) was then introduced via a Headway 21 straight microcatheter and deployed to cover the aneurysm's neck. A Target XL 360 10 × 400 mm, 9 × 300 mm (Stryker, Kalamazoo, MI, USA) was inserted into the aneurysm without incident. However, in the next filling step, a HydroSoft 3D soft 8 × 330 mm (MicroVention) protruded into the parent artery, so we pushed and pulled it a few times to try to reposition it. Subsequently, the coil unraveled. We attempted to retrieve this unraveled coil; however, during this process, a Headway 17 pre-shaped angle 45° microcatheter was accidentally displaced by an operator error further away from the aneurysm site, making it difficult to guide it back. Hence, we removed the microcatheter and attempted to capture the coil using a Goose Neck snare 4 mm (Medtronic, Minneapolis, MN, USA) with an Excelsior 1018 straight microcatheter (Stryker), which advanced along with the unraveled coil to the part that was still intact. During this procedure, we recognized the coil had been cut in the unraveled part (**Fig. 3A**). After retrieving the proximal fragment of the cut coil, we again attempted to capture the residual coil fragment, but our efforts were unsuccessful because of the

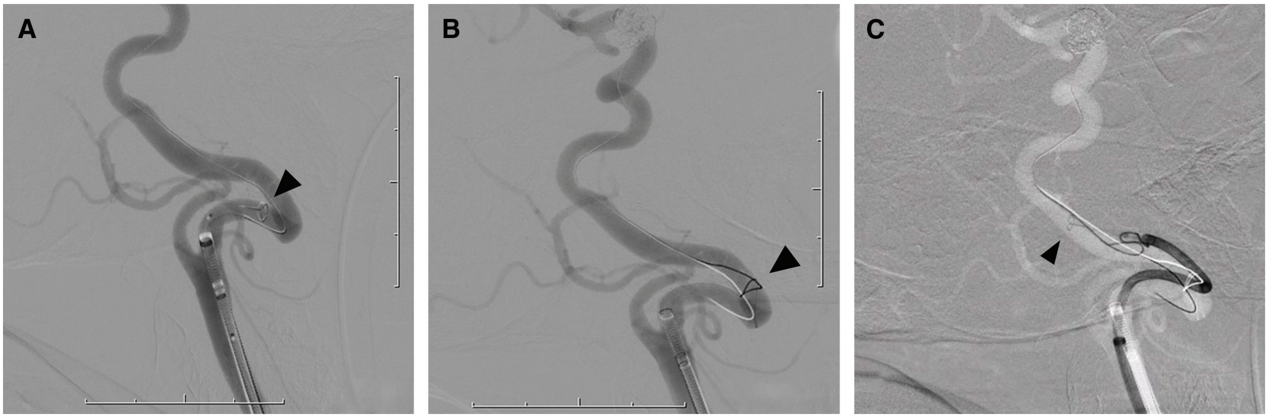

Fig. 3 Right common carotid arteriogram. (**A**) The microsnare was advanced with the 18 microcatheter (arrowhead) toward the right internal carotid artery. (**B**) The fragment of the cut coil (arrowhead) was carried to a distal location by the circulation. (**C**) After navigating the guiding catheter, we could advance the microsnare to the intact portion of the coil (arrowhead) and successful pulled the coil inside the guiding catheter.

artery's severe tortuosity, and the fragment was carried to a more distal location by the circulation (**Fig. 3B**). After managing to navigate the guiding catheter past the highly tortuous segment of the right internal carotid artery, we attempted to advance the microsnare to the intact portion of the coil and grasped it somehow (**Fig. 3C**). Our efforts were successful in pulling a part of the coil inside the guiding catheter using the microsnare. We tried to retrieve the coil by retracting the microsnare in this state, but it unraveled again. This series of mishaps led us to retrieve the unraveled coil by advancing a balloon catheter in the guiding catheter, inflating it to immobilize the unraveled coil against the guiding catheter's inner lumen, and then retracting the entire guiding catheter assembly to retrieve the unraveled coil. We advanced a Scepter XC 4 × 11 mm (MicroVention) through the guiding catheter to the unraveled coil and then inflated it to its maximum diameter (5.9 mm) to press the unraveled coil in the guiding catheter. However, the unraveled coil slipped when we tried to retract them together. Retrieving the unraveled coil seemed difficult at this point, but we speculated that it might still be possible to pull the coil out if it could be pressed more firmly against the inner lumen of the guiding catheter. Therefore, we inserted a KUSABI exchange catheter (Kaneka Medix, Osaka, Japan), intended for use in coronary interventions, through the guiding catheter and then trapped the unraveled coil against the inner lumen by inflating the balloon to its maximum pressure (i.e., rated burst pressure: 14 atm). When we retracted the guiding catheter assembly, the unraveled coil was pulled out along with it. This part further unraveled during the retraction. Observing this, we left the shuttle sheath in place and then extracted the unraveled coil from the patient together with the guiding catheter. During these actions, the intact segment of the coil descended to a position that the microsnare could reach; therefore, we next advanced the microsnare along with the unraveled coil toward the aneurysm as close as possible, trapped it, and then retrieved the coil in full (**Fig. 4**). A 7 Fr FUBUKI 100 cm was placed again in the right internal carotid artery, and intracranial angiography was performed. Coil embolization was resumed after confirmation of no obvious signs of vascular occlusion or extravasation. A Headway 17 pre-shaped 45° microcatheter was guided into the aneurysm, a Target 360 XL soft 6 × 200 mm and 6 × 200 mm, Target 360 XL soft 4 × 120 mm, and Target 360 ultrasoft 4 × 80 mm, 4 × 80 mm, and 4 × 80 mm (Stryker) were inserted, and complete embolization of the aneurysm was confirmed (**Fig. 5**). Continuous argatroban hydrate (60 mg) infusion was administered after an intrastent thrombus formed during embolization. We finished the procedure after we confirmed that the thrombus had disappeared. On the day of the operation, we decided to manage the patient with mechanical ventilation under sedation and analgesia.

Posttreatment course

The day after the operation, an MRI revealed new diffuse ischemic changes in the right cerebral hemisphere, but no obvious hemorrhagic changes. While awake, the patient exhibited muscle weakness in the upper and lower left extremities, corresponding to a manual muscle testing (MMT) grade of approximately 1–2. She could perform

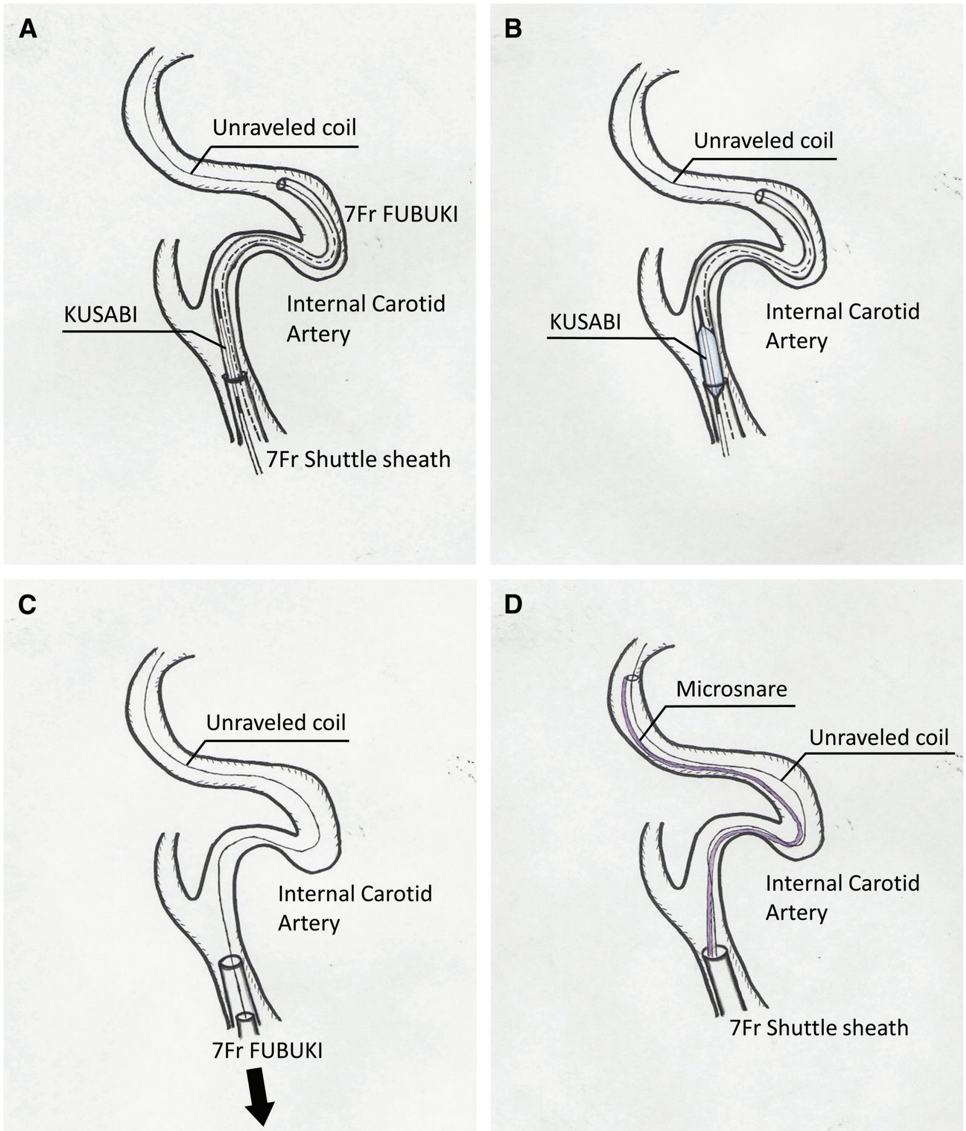

Fig. 4 Schematic of the retrieval procedure. (**A**) After pulling back the unraveled coil into the 7 Fr GC, KUSABI catheter was inserted to fix the coil. (**B**) KUSABI catheter was inflated to rated pressure in the 7 Fr GC. (**C**) The 7 Fr GC was pulled back with a KUSABI catheter outside the body to retrieve the unraveled coil. (**D**) The microsnare was inserted again on the axis of the unraveled coil and then grasped intact portion of the coil. GC: guiding catheter

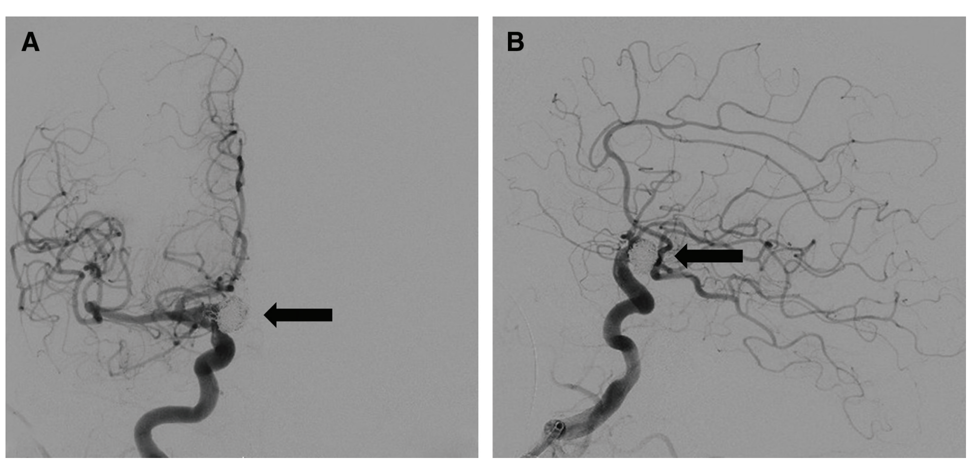

Fig. 5 **A** and **B**: Right internal carotid arteriogram shows complete occlusion of the unruptured internal carotid aneurysm in the coil embolization (arrow).

activities of daily living (ADLs) with partial assistance after the operation. During follow-up surveillance, she developed cholecystitis and was therefore transferred to a different hospital at day 20 post-operation.

This study was approved by the ethical committee of Nishijima hospital.

Discussion

Various techniques for bailing out unraveled coil have previously been reported, but they can prove difficult in some situations. Conditions complicated our recovery of unraveled coil in the present case as well, but finally succeeded by using a KUSABI exchange catheter. Here, we will describe how we successfully bailed out the unraveled coil whose initial recovery proved difficult.

Device-related innovations and quality enhancements have improved the outcomes and safety of endovascular treatment of intracranial aneurysms, and the number of procedures performed continues to rise with each passing year. However, endovascular surgery still carries risks of serious complications as well as death. For example, 7.3% of patients in the prospective International Study of Unruptured Intracranial Aneurysms (ISUIA) developed severe complications, and 1.8% died within 1 month of endovascular treatment, while Japanese research has reported corresponding rates of 0.5%–3.7% and 0.0%–2.4%, respectively.[3] Surgical complications of neuroendovascular therapy can be broadly classified as either ischemic or hemorrhagic. Some studies have reported respective rates of 5.8% and 2.1% in the perioperative period.[3,4] Coil unraveling is an unpredictable intraoperative complication. It is not especially common, occurring in fewer than 2% of procedures.[2] However, once it does occur, it can lead to thromboembolic events and other serious complications, forcing endovascular surgeons to make rapid decisions. Nearly all embolization coils are designed with a stretch resistance (SR) mechanism and structural components that protect it from unraveling during typical manipulations. However, pushing and pulling coils too quickly can make it susceptible to unraveling.[5] Unraveled coils are typically retrieved using a microsnare and dual-guidewire devices.[2] Some studies have reported fixing of an elongated coil to the vascular wall using a neck bridge stent, or extirpation under open surgery. However, these approaches have several issues such as the need for continuous administration of antiplatelet drugs and high invasiveness. In addition, some studies have reported leaving an unraveled and stretched coil inside the body, for example, while relocating it to the ipsilateral external carotid artery, trapping it underneath a stent near the catheterization site, or burying it in subcutaneous tissue.[5,6]

In the present case, it was the filling coil that unraveled when we tried to pull back coil protruding from the stent struts. This coil is composed of an internal hydrogel matrix. The damage may have resulted from the intense friction between the hydrogel matrix and the stent. Since we had already removed a Headway 17 coil delivery microcatheter due to the intraoperative accident, we could no longer introduce the microsnare along with the microcatheter. Subsequently, we advanced the guiding catheter distally to the tortuous segment of the right internal carotid artery, the microsnare could access beyond it, allowing us to capture the coil and retract it inside the guiding catheter. At this point, we decided to try to trap the coil against the catheter's inner lumen and then pulled out the intact part of the coil. Our initial attempts to trap the coil using a neck-remodeling balloon were insufficient. Instead, we used a KUSABI exchange catheter, which proved successful in extricating the unraveled coil.

A KUSABI is an auxiliary catheter used to facilitate the exchange of over the wire (OTW) catheters in percutaneous coronary interventions and was developed to overcome the complexity and difficulty of techniques involving the use of an extension guidewire, while maintaining approximately the same economic viability. In addition, the materials used for the balloon, and its strong design, were approximately the same as for percutaneous transluminal angioplasty (PTA) balloons. So, the device is frequently used in the field of cardiovascular medicine, with which it allows a single operator to complete a catheter exchange. Classifying the product as percutaneous transluminal coronary angioplasty (PTCA) Guidewire, Japan's medical insurance system offers reimbursement of ¥18700 (as of April 2020), and it is not covered by insurance for use in intracranial endovascular therapy. It is designed to be inserted into a guiding catheter (recommended outer diameter: 6Fr or 7Fr) by itself. Because of its long effective length (107 cm), the device has an orange position marker on its shaft to prevent over-extension when using a guiding catheter with a maximum length of 90 cm. In addition, it has a blind tip, but no guidewire lumen (**Fig. 6**). Briefly, the instructions for use are as follows: 1) retract the OTW catheter to the rear end of the guidewire; 2) guide the KUSABI catheter beyond the OTW catheter; 3) inflate the balloon to immobilize the guidewire; and 4) exchange the OTW catheter. The strength of the balloon press on the

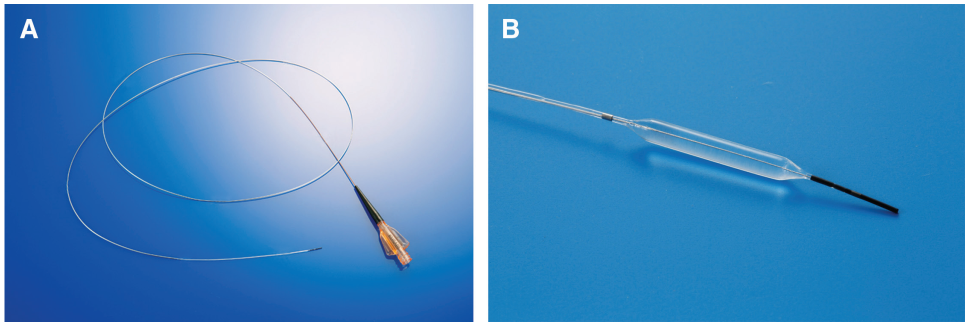

Fig. 6 Picture of a KUSABI exchange catheter. (**A**) Full picture. (**B**) Enlarged image of the balloon part.

guidewire is proportional to its inflation pressure (≥8 atm recommended). Polyamide resins are used for the balloon parts of KUSABI, and PTA catheters in general. Polyamides are usually referred to as nylon and are characterized by having high abrasion resistance, and not readily undergoing deformation. These properties result in sufficient fixation strength and also enable reliable catheter replacement. On the other hand, the Scepter balloon catheter uses thermoplastic materials, especially polyurethanes, and are therefore characterized by high flexibility and extensibility. In the case of the present patient, fixation with Scepter XC was insufficient, but the fact that with the KUSABI catheter the unraveled coil fixed firmly inside the catheter provides support for the theory that there was a difference in balloon strength.

As a device for intracranial use, on the other hand, two items that can be put forward as options for use as recovery mechanisms are SoutenirNV (Asahi Intecc), which is a microbasket-type foreign-body removing device, and a stent retriever. To our knowledge, there are no previous reports of retrieval of unraveled coils using these devices. There are several reports of bailing out in response to coil migration[7–9]; it is therefore considered that if the unraveled coil becomes tangled with the device, it can be collected by being drawn into a microcatheter. Therefore, this technique should be considered. In terms of the advantages of a KUSABI catheter, the grip for fixing the unraveled coil firmly on the surface is highly reliable. Moreover, unlike other intracranial devices such as microsnare, the KUSABI catheter does not come into direct contact with the vascular walls, so the risk of vascular wall damage at the time of recovery is considered to be low. And in actual practice during neuroendovascular interventions, when a guiding sheath is not used, retrieving the unraveled coil becomes very difficult if there is no undamaged coil inside the guiding catheter. In such situations, after extricating the unraveled coil together with the guiding catheter need to use other options such as burying the loose coil at the catheterization site.

That being said, there is no clinical evidence regarding its use beyond the indicated criteria. Furthermore, coil fracture or distal coil migration may occur during the procedure. Based on these aspects, we consider that this device should be utilized as a second option, but not as a first option in the case of emergency; it should be taken into consideration in patients in whom coil retrieval with a microsnare or other devices is difficult.

In the present case, issues to be reflected first on deviation of the microcatheter. If it had been securely placed beforehand, we probably could have retrieved the unraveled coil by advancing the snare along this microcatheter. To be sure, our discovery of a means to retrieve an unraveled coils without a microcatheter is a fortunate one, but this case made us aware of the need to keep calm in times of emergency because of the risk of hasty actions leading to further complications. Another issue is that when used in combination with a neck bridge stent, the embolization coil may protrude into the parent artery from the stent's struts. To prevent it from unraveling, especially while using hydrogel-coated coils, operators should keep in mind not to manipulate it roughly.

Conclusion

We successfully retrieved an endovascular coil that had unraveled during an embolization procedure by using a KUSABI trapping balloon catheter designed to exchange OTW catheters in coronary interventions. This method may be one of the useful options to deal with dislodging of the unraveled coil in patients in whom coil retrieval with a microsnare or other devices is difficult.

Disclosure Statement

All authors have no conflicts of interest to declare.

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