Disconnection of a stent retriever’s pushwire caught by an accordion-like deformed aspiration catheter during mechanical thrombectomy: illustrative case

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BACKGROUND In mechanical thrombectomy for acute large vessel occlusion, a combined technique of using both a stent retriever and an aspiration catheter has been widely used. The authors report a case in which a stent retriever’s pushwire and a microcatheter were caught and disconnected by an accordion-like deformed aspiration catheter.

OBSERVATIONS A 74-year-old man underwent mechanical thrombectomy for a left M1 occlusion. A stent retriever was deployed from the left M2 to the left distal M1, and an aspiration catheter was advanced to the left distal M1. When the stent retriever and microcatheter were pulled into the aspiration catheter at the distal M1 without releasing the deflection, traction resistance of the stent retriever occurred, and the aspiration catheter contracted and deformed like an accordion distal to the tip of the guiding catheter. The stent retriever’s pushwire and the microcatheter were caught and disconnected.

LESSONS When a stent retriever is pulled into a flexible aspiration catheter in a case with vascular tortuosity, it may be caught by an accordion-like deformed aspiration catheter and disconnected. It is necessary to release the deflection of the aspiration catheter once traction resistance of the stent retriever and deflection of the aspiration catheter occur.

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KEYWORDS device breakage; aspiration catheter; stent retriever; ischemic stroke; thrombectomy

Mechanical thrombectomy for acute large vessel occlusion has been rapidly adopted and performed since its efficacy was demonstrated in several randomized controlled trials in 2015. Currently, the combined technique of using both a stent retriever and an aspiration catheter is widely used and can be divided into two main methods: (1) a method in which the stent retriever and the aspiration catheter are retrieved as a single unit and (2) a method in which the stent retriever is pulled into the aspiration catheter that is guided proximally to the thrombus. Reports of device breakage related to the combined technique are scarce. To the best of our knowledge, this is the first detailed report of a case in which a stent retriever’s pushwire and a microcatheter were caught and disconnected by an accordion-like deformed aspiration catheter during mechanical thrombectomy.

Illustrative Case

History and Examination

A 74-year-old man with a history of atrial fibrillation, hypertension, and diabetes mellitus suddenly developed aphasia and right-sided paralysis and was brought to our hospital by ambulance. On admission, he had a Glasgow Coma Scale score of 6 (E2V1M3), right hemiplegia, and global aphasia (National Institutes of Health Stroke Scale score of 22). Diffusion-weighted imaging (DWI) of the head showed focal fresh ischemic changes in the left middle cerebral artery region, and the DWI-Alberta Stroke Program Early CT Score (DWI-ASPECTS) was 5 (Fig. 1A). Head magnetic resonance angiography (MRA) showed an occlusion in the distal M1 of the left middle cerebral artery (Fig. 1B). Although 15 hours had elapsed since the last known well, the penumbra area in the left middle cerebral artery region...
appeared relatively extensive, and mechanical thrombectomy was performed.

Treatment

A 9-French Optimo (Tokai Medical Products) was placed in the left internal carotid artery via the right femoral artery with the patient under local anesthesia. Left internal carotid arteriography showed strong tortuosity of the left cervical internal carotid artery, contrast defect in the left distal M1, slight antegrade blood flow in the left M2 superior trunk, and occlusion of the M2 inferior trunk (Fig. 2A). In the first pass, a microguidewire (Traxcess, Terumo) and a microcatheter (Phenom 21, Medtronic) were guided into the M2 inferior trunk. An EmboTrap III (5 × 37 mm, Cerenovus) was deployed from the left M2 inferior trunk to the left distal M1 (Fig. 2B). The React 71 (Medtronic) was guided to the proximal end of the thrombus in the left distal M1 (Fig. 2C). The EmboTrap III and the Phenom 21 were pulled together into the React 71, with aspiration applied under temporary occlusion of the internal carotid artery with the Optimo (Fig. 2D). The thrombus was aspirated by the React 71, and recanalization of the left distal M1 and the left M2 superior trunk was obtained (Fig. 2E). The same device was used for the second pass, but no effective recanalization was obtained.

In the third pass, the stent retriever was changed to a Solitaire X (4 × 40 mm, Medtronic) and was deployed from the M2 inferior trunk to the distal M1 trunk (Fig. 2F). When the React 71 was guided to the left distal M1, it was deflected more strongly than in the first pass (Fig. 2G). Without releasing the deflection, the Solitaire X and the Phenom 21 were pulled together into the React 71, with aspiration applied under temporary occlusion of the internal carotid artery. During retraction, relatively strong resistance occurred, the tip of the Optimo was lifted, and the React 71 was contracted and deformed like an accordion distal to the tip of the Optimo (Fig. 2H, I). The Solitaire X and the Phenom 21 continued to be retracted into the React 71 without the accordion-like deformation of the React 71 being recognized. The Solitaire X's pushwire and the Phenom 21 were caught by the accordion-like deformation of the React 71 (Fig. 2J). Although stronger resistance occurred, the Solitaire X and the Phenom 21 were already inside the React 71, so the retraction was continued. The Solitaire X's pushwire and the Phenom 21 were disconnected at the accordion-like deformed part of the React 71 and left in the React 71, and the Solitaire X's traction resistance disappeared (Fig. 2K). Because the Solitaire X and the Phenom 21 were completely retracted into the React 71, no device was left in the vessel when the React 71 was removed. Final angiography showed peripheral occlusion of the angular artery and thrombolysis in cerebral infarction grade 2b recanalization (Fig. 2L). The time from puncture to recanalization was 94 minutes.

Observation of Devices Used for Thrombectomy

When a section 110 mm from the tip of the React 71 was cut with scissors, the Solitaire X was cut simultaneously, and the Solitaire X and the Phenom 21 remaining in the React 71 were recovered from the cut section (Fig. 3A). The React 71 showed a color change in appearance at 140 to 200 mm from the tip. Comparing the color change between the used and unused React 71, there was no difference in the arrangement of the blades and coils, but the inner and outer layers of the used React 71 were peeled away from the blades and coils (Fig. 3B–E). The Solitaire X had a pushwire break at 160 mm from the tip and at 125 mm from the marker tip side of the pushwire (Fig. 3F). The Phenom 21 was broken at 65 mm from the tip (Fig. 3G).

Postoperative Course

No procedure-related subarachnoid hemorrhage was observed postoperatively. DWI on the day after surgery showed no obvious enlargement of the cerebral infarction, and MRA showed good visualization of the left middle cerebral artery (Fig. 4), but the patient's symptoms did not improve, and paralysis of the right upper and lower limbs and motor aphasia remained. On the 30th day after symptom onset, he was transferred to a rehabilitation hospital with a modified Rankin Scale score of 4.

Discussion

Observations

This is the first report of a stent retriever's pushwire and a microcatheter that were disconnected during mechanical thrombectomy by an accordion-like deformed aspiration catheter. In this case, we found two strong flexions in the cervical internal carotid artery. In the third pass, the Solitaire X was first deployed from the left M2 inferior trunk to the left distal M1 (Fig. 5A). When the Optimo's balloon was inflated and the deployed Solitaire X was used as an anchor to guide the React 71 to the left distal M1, strong deflection occurred because the React 71 ran on the greater curvature side of the vessel (Fig. 5B). It is considered that the strong tortuosity of the internal carotid artery caused the deflection of the React
Fig. 2. Imaging during thrombectomy, frontal view. The red lines (B–D and F–H) indicate the React 71’s travel routes. Native images from the first pass (B–D) and the third pass (F–K). Left internal carotid arteriography (A) before thrombectomy showing strong tortuosity of the internal carotid artery, contrast defect in the left distal M1, slight antegrade blood flow in the left M2 superior trunk, and occlusion of the M2 inferior trunk. In the first pass (B), an EmboTrap III (5 × 37 mm) was deployed from the left M2 inferior trunk to the left M1. The React 71 (C) was guided to the proximal end of the left M1 thrombus. The EmboTrap and the Phenom 21 were pulled into the React 71 (D). Left internal carotid arteriography after the first pass showed occlusion of the left M2 inferior trunk (E). In the third pass, a Solitaire X (4 × 40 mm) was deployed from the left M2 inferior trunk to the left M1 (F). When the React 71 was guided to the left distal M1 (G), it was deflected more strongly than in the first pass. When the Solitaire X and the Phenom 21 were pulled together into the React 71, the tip of the Optimo was lifted, and the React 71 was contracted and deformed like an accordion (arrowheads; I) distal to the tip of the Optimo. Enlarged findings (I) of the white rectangle in (H). The Solitaire X’s pushwire (arrow; J) and the Phenom 21 caught in an accordion-like deformed React 71. The Solitaire X’s pushwire (arrow; K) and the Phenom 21 were disconnected at the accordion-like deformed part of the React 71 and moved distally, leaving their remnants in the React 71. Left internal carotid arteriography (L) after thrombectomy showed recanalization of thrombolysis in cerebral infarction grade 2b.

71 to be easily generated in order to advance the React 71. The Solitaire X’s pushwire and the Phenom 21 were pulled into a strongly tortuous React 71 for retrieval. Because of the frictional resistance among the Solitaire X, the retrieved thrombus, and the vessel wall, the Solitaire X was almost fixed at the M2 until it started to move. Therefore, the Solitaire X’s pushwire and the Phenom 21 ran on the lesser curvature side of the vessel, and the tip of Optimo was elevated. At this time, the traction of the Solitaire X’s pushwire and the Phenom 21 showed resistance, but the deflection of the React 71 was not released, so that the React 71 contracted and deformed like an accordion distal to the tip of Optimo (Fig. 5C). The lumen of the accordion-like deformed React 71 was...
narrowed, and the Solitaire X's pushwire and the Phenom 21 got caught (Fig. 5D). Therefore, even though the Solitaire X and the Phenom 21 were pulled into the React 71, it was considered that even stronger resistance was generated to pull the Solitaire X and the Phenom 21 inside the React 71. Finally, the Solitaire X's pushwire and the Phenom 21 were disconnected at the proximal side of the area where they were caught.

In endovascular treatment, device breakage leads to treatment failure, and device remnants in the vessel pose a risk of thrombosis.6 Reports of device breakage in mechanical thrombectomy for acute large vessel occlusion include a broken aspiration catheter in a direct aspiration first-pass technique and the detachment of the Solitaire at the junction of the pushwire and stent,7,8 and in a combined technique-related case, a coil of the aspiration catheter support layer got broken when the stent retriever was retracted.5 There have been no reports of disconnection of the stent retriever's pushwire, but there have been reports of microcatheter and microguidewire disconnection due to twisting or excessive tension9,10 and stenosis of the lumen of the passing vessel.11 In this case, the Solitaire X and the Phenom 21 were caught when they passed through the accordion-like deformation of the React 71, and it is considered that the continued pulling without it being noticed that they were caught caused an unreasonable extension force, resulting in disconnection. The retrieval technique for devices left in blood vessels leads to a prolonged operative time. When device retrieval is not possible, the procedure is often converted to direct surgery, which

FIG. 3. A: From the top, the React 71 before use, the React 71 used in this case, the Solitaire X, and the Phenom 21 are shown. The React 71 used in this case was cut 110 mm from the tip with scissors (black arrow), and the Solitaire X was cut simultaneously (black arrow). The Solitaire X was broken at 160 cm from the tip and at 125 mm from the marker tip side of the pushwire (white rectangle; f). The Phenom 21 had a tear at 65 mm from the tip (white rectangle; g). The position of the tip of the Optimo when the Solitaire X and the Phenom 21 were disconnected is indicated by white arrows. An enlarged view of the black rectangle b in panel A (B). There were no abnormalities in the arrangement of the blades and coils. A view of the React 71 from panel B, cut open along its long axis (C); the inner and outer layers of the React 71 had detached from the blade and coil (white arrowheads). An enlarged view of the white rectangle d in panel A (D); the arrangement of blades and coils is normal. A view of React 71 from panel D, cut open along its long axis (E); the inner and outer layers of the React 71 did not detach from the blade and coil (black arrowheads). Enlarged findings of the white rectangle f in panel A (F). Enlarged findings of the white rectangle g in panel A (G).
is highly invasive. In this case, the disconnection occurred after the Solitaire X and the Phenom 21 were completely retracted into the React 71, so that there were no device remnants in the vessel after the React 71 was removed. However, if the disconnection occurred before complete retraction, serious complications that required a conversion to a direct surgery may have occurred. In addition, the lumen was narrowed by the accordion-like deformation of the aspiration catheter, which could have led to failure of thrombus retrieval due to lack of effective aspiration to the React 71. When further thrombus retrieval was required, a new device would be needed, and recanalization could have taken more time.

The React 71 is made of nitinol, a shape-memory alloy, and is formed by two types of blades and coils with different shapes of support layers. Nitinol has the property of recovering its original shape immediately after being deformed at temperatures above its transformation point. Therefore, the blades and coils of the accordion-like deformed part of the React 71 in this case recovered its original shape. On the other hand, the React 71 had a color

![FIG. 4. A: DWI after thrombectomy showing no obvious enlargement of the infarction site. B: MRA after thrombectomy showing recanalization of the left middle cerebral artery.](image)

![FIG. 5. Schematic of device breakage in this case. The black line indicates the Optimo, the green line the React 71, the gray line the Solitaire X, and the blue line the Phenom 21. A: The Solitaire X was deployed from the left M2 inferior trunk to the left distal M1. There was strong tortuosity of the cervical internal carotid artery. B: When the Optimo was inflated and the Solitaire X was used as an anchor to guide the React 71 to the distal M1, strong flexion was observed as the React 71 ran on the greater curvature side of the vessel. C: When the Solitaire X and the Phenom 21 were retracted together into the React 71, the Optimo was lifted (arrow) so that the Solitaire X’s pushwire and the Phenom 21 would run on the lesser curvature side of the vessel, and the React 71 contracted and deformed like an accordion distal to the tip of the Optimo. D: The Solitaire X’s pushwire and the Phenom 21 caught in the React 71, with its lumen narrowed by the accordion-like deformation of the React 71 (arrowheads).](image)
change, and the inner and outer layers detached from the blade and coil at 140 to 200 mm from the tip, and this area was deformed like an accordion. The inner layer of the React 71 is made of thermoplastic elastomers that have the properties of rubber and plastic, so the React 71 is highly flexible. This high flexibility is considered to have caused strong deflection of the React 71 when it was guided to the distal M1. Evaluation of the frictional force exerted by the stent retriever on the vessel wall has been reported in animal experiments, including evaluation of vascular damage and histological evaluation of a retrieved thrombus. Experiments on silicon models suggest that the Solitaire has greater vascular deviation and stronger frictional force than EmboTrap. In this case, device breakage occurred not in the first and second passes using the EmboTrap, but in the third pass using the Solitaire, which may have been caused by the relatively large frictional force between the Solitaire and the vessel wall. Moreover, the device was deflected more strongly by pressing the React 71 too much in the third pass than in the first and second passes. It has been pointed out that in thrombus retrieval using a stent retriever, residual thrombus that is not retrieved changes to a fibrin-rich state. Therefore, it is possible that the traction resistance of the stent retriever may have been stronger in the third pass to retrieve the residual thrombus than in the first and second passes.

We performed thrombectomy using an Optimo, a balloon guide catheter. In this case, the balloon was inflated, so the Optimo was only slightly lifted when the Solitaire X was retracted into the React 71. If the balloon had been deflated when the Solitaire X was retracted into the React 71, the Optimo would have been lifted higher, and the accordion-like deformation of the React 71 distal to the tip of the Optimo would have been stronger. Also, advancing the guide catheter higher before retracting the Solitaire X into the React 71 shortens the distance between the Solitaire X and the guide catheter. Therefore, deflection of the React 71 is reduced, and accordion-like deformation is less likely to occur.

In this case, the stent retrieval device was damaged because traction was continued despite resistance to traction of the stent retriever to the aspiration catheter. If the surgeon feels resistance to traction of the stent retriever, releasing the deflection of the aspiration catheter will reduce the resistance to traction of the stent retriever to the aspiration catheter. In addition, if the stent retriever and the aspiration catheter had been retrieved as a single unit, device breakage may not have occurred.

Lessons
When a stent retriever is pulled into a flexible aspiration catheter in a case with vascular tortuosity, it may be caught by an accordion-like deformed aspiration catheter and disconnected; it is necessary to release the deflection of the aspiration catheter once the traction resistance of the stent retriever and the deflection of the aspiration catheter occur.

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References

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