Fracture and migration of a retained wire into the thoracic cavity after endovascular neurointervention: report of 2 cases

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Although extremely rare, retention of foreign bodies such as microcatheters or micro guidewires can occur during various neurovascular procedures due to gluing of the microcatheter tip or entanglement of the micro guidewire tip with intravascular devices. The authors have experienced 2 cases of irresolvable wire retention, one after flow diverter placement for a left cavernous internal carotid artery aneurysm and the other after intracranial stenting for acute basilar artery occlusion. The first patient presented 6 weeks after her procedure with right lung parenchymal hemorrhage due to direct piercing of the lung parenchyma after the retained wire fractured and migrated out of the aortic arch. The second patient presented 4 years after his procedure with pneumothorax due to migration of the fractured guidewire segment into the right thoracic cavity. In this report, the authors discuss the possible mechanisms of these unusual complications and how to prevent delayed consequences from a retained intravascular metallic wire.

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the inflow parent vessel was 3.9 mm, while that of the outflow vessel was 3.8 mm. Flow diversion was subsequently planned.

The patient was premedicated with aspirin and clopidogrel for 5 days. Under general anesthesia and full systemic heparinization, a 4.5 × 20-mm Pipeline Embolization Device (PED, Covidien) was deployed across the neck of the aneurysm without difficulty, extending from the ophthalmic segment to the posterior genu of the cavernous ICA (Fig. 1A). After full deployment of the device, the microcatheter used for the delivery of the device (Marksman, Covidien) was pushed back up to the tip of the lead wire over the push wire through the deployed device lumen.

On the way to the distal part of the push wire, we rotated the push wire clockwise several times to safely capture loose coils, as is instructed in the user manual. While rotating the push wire, we noted a sudden unusual limitation of the tip of the lead wire, which had initially been freely rotated. Furthermore, the tip did not move in response to the push-pull manipulation of the push wire together with the microcatheter. We were unable to retrieve the wire. The subsequent control angiogram demonstrated occlusion of the previously noted large posterior communicating artery (PCoA) from the origin. We found that the lead wire tip was located at the origin of the occluded vessel while the PED was fully deployed, with contrast stasis within the aneurysm sac (Fig. 1B and C).

Initially, we thought that the lead wire tip impinged on the PCoA ostium, causing severe vasospasm that was strong enough to hold the wire tightly. Unfortunately, however, the grabbed wire tip was not released, even after waiting for more than 1 hour. We thus halted the procedure, leaving the push wire within the vessel. The patient was brought back the following day because we expected spontaneous release of the wire due to vasospasm improvement. However, the wire was still stuck and retrieval failed again. We had no choice but to leave the push wire in situ. The guidewire was then transected at the level of the femoral artery puncture point and anchored to the subcutaneous fascia layer with a small monofilament suture. On postoperative neurological examination, the patient showed mild right motor weakness. Diffusion MRI showed acute infarction in the genu portion of the left in-
a few days later, the patient had improved and was discharged without any residual symptoms.

Follow-up chest and skull radiography performed 1 month later did not show any change compared with the immediate postoperative radiography findings (Fig. 1D). About 6 weeks later, the patient returned to our hospital complaining of general malaise, intermittent pleuritic pain, and several episodes of bloody oozing from the femoral puncture site. The wound was swollen with granuloma formation and the puncture hole remained open, suggesting nonhealing of the puncture site.

Skull radiographs did not show any change in either the PED or retained wire. However, the chest radiograph showed a blunting of the right costophrenic angle and a very thin, curvilinear structure from the right paratracheal area to the right lower lateral chest wall (Fig. 1E). Subsequent chest CT scans showed a long metallic wire piercing the right lung from the medial aspect of the right upper lobe to the lateral aspect of the right lower lobe. This 20-cm-long piece of wire was identified as the middle segment of the fractured wire that had migrated from the left common carotid artery into the right thoracic cavity, piercing the lung. About 10 cm of the distal segment of the fractured wire remained in the left ICA, and the proximal part of the wire retained in the aorta was attached to the tagging site at the common femoral artery. We believed that persistent foreign body reaction at the tagging site prevented healing of the puncture site.

The patient underwent video-assisted thoracoscopic surgery (VATS) for removal of the wire located in the right thoracic cavity. The thoracoscopic image showed a long wire fragment puncturing the visceral pleura of the right lung and resulting in regional hemorrhage and adhesion to the parietal pleura (Fig. 1F). The wire was removed without difficulty and without leaving any significant defect in the pleura. The retrieved segment of the wire was about 22 cm long and its ends were serrated, suggesting fracture at both ends. After VATS, the proximal part of the retained wire was removed after surgical exposure of the femoral puncture site. An approximately a 55-cm-long proximal part of the wire fragment was removed (see Fig. 3A). The patient improved and was then discharged from the hospital and placed on a planned 6-month dual antiplatelet regimen.

Case 2

A 67-year-old right-handed man presented with left-sided motor weakness and dysarthria. The patient was admitted to our emergency department 2 hours and 40 minutes after the onset of symptoms. The patient’s National Institutes of Health Stroke Scale score at presentation was 9 and the modified Rankin Scale score was 3. Multimodal MR imaging showed multiple subtle high-signal-intensity lesions in the pontine base and segmental occlusion of the basilar trunk (Fig. 2A). We believed that the occlusion was due to underlying basilar stenosis and combined de novo thrombosis. We performed emergency revascularization of the basilar artery. A 6-F guiding catheter was introduced into the femoral artery via a guide catheter and advanced to the left vertebral artery. We were able to cross the occluded segment without difficulty, and a 3.5 × 20-mm Wingspan stent (Stryker) was placed along the basilar trunk, covering both the stenosis and thrombotic filling defect after balloon angioplasty (2.0 × 15-mm Gateway Balloon, Stryker).
Subsequent control angiography showed persistent narrowing of the distal basilar trunk due to residual thrombus in the basilar top. Another guidewire (Agility 10, Cordis) was used to navigate an infusion microcatheter (Prowler 14, Cordis) into the basilar top for local fibrolytic therapy. However, the tip of the guidewire became entangled with one of the open-cell stent struts, and we were unable to untangle the knotted wire. We decided to leave the guidewire in situ and successfully used another one to deliver the microcatheter. Eventually, we were able to open the entire basilar artery and its branches, but we could not retrieve the tangled guidewire (Fig. 2B). Various endovascular maneuvers were attempted to remove the wire but none helped. Fortunately, the patient’s degree of weakness improved significantly while the patient was on the operating table. The guidewire was then transected at the level of the femoral artery puncture point and anchored to the subcutaneous fascia layer with a small monofilament suture. The patient successfully recovered from the infarction and was discharged from the hospital 8 days after the initial symptom onset. The patient was informed about the retained guidewire but was reassured that it was not a problem because he required dual antiplatelet therapy anyway.

The patient underwent regular follow-up with chest radiography and head CT angiography on an annual basis. The stented basilar artery stayed open, the guidewire remained in the aorta, and the left vertebral artery did not show any change until the patient presented with unexplained chest pain 3.5 years after the procedure.

At this time, the patient presented to another hospital near his home and complained of intermittent chest pain. A chest CT scan showed a curvilinear radiopaque structure over the apex of the right emphysematous lung, with one end of the structure at the anterior mediastinum and the other end at the posterior costophrenic angle, with minimal unilateral pleural effusion (Fig. 3C). Subsequent VATS revealed a long guidewire fragment that was successfully removed by the local surgeon. The retrieved wire segment was about 85 cm long with a thin, silver shiny body surface that was different from that of the original wire.

The patient visited our hospital after recovery from the removal procedure. CT angiography showed no change in the tangled guidewire in the patent stented segment, but the wire was broken at the C-4 vertebral body level. There was a residual line fragment on abdominal radiography. We believed that the long retained guidewire had fractured at the C-4 segment level and that the proximal body segment had migrated into the left thoracic cavity and had been removed completely. The patient recovered successfully without any sequelae. The patient is on a regimen of aspirin monotherapy at the present time.

Discussion

Although it is uncommon, when catheters or wires cannot be removed despite several attempts, they have to be left in the patient’s body. There have been several reports of microcatheters being glued to cerebral arteries during embolization of arteriovenous malformations, but there has only been one report of such a complication with micro guidewires. Konstas et al. reported a case of aortic dissection following retention of a neurointerventional guide- wire due to impaction of the tip in a perforating branch of the right posterior cerebral artery. Furthermore, there have been no relevant reports in the English-language literature of the type of thoracic or lung complications that were seen in our patients.

In contrast to our second case, in which the cause of wire retention was obvious, the exact mechanism of push wire retention in our first case was not clear. As reported previously, it could have been due to impingement of the wire tip at the orifice of the perforator originating from the PCoA, or it could have been due to intramural impingement of the tip after dissection. Another possible mechanism could be entanglement of the tip by twisting of the proximal segment of the PCoA by the intentional rotation of the wire during the advancement of the Marksman catheter over the capture coil. Whatever the mechanism, we were unable to remove the stuck wire, believing that further forceful pulling could be disastrous. To avoid impingement or entanglement of any wire in the vessel, one should be careful when manipulating the wire tip during the procedure. Regarding wire material, a platinum coil-type guidewire tip would be more vulnerable to this problem because it may have a higher chance of becoming entangled in stent mesh or causing vasospasm. This could be one reason why the newer version of the PED (Pipeline Flex) has a hydrophilic polymer jacket covering the lead wire tip.

It is unclear why the wire fractured. There have actually been several reports of guidewire fracture during various endovascular procedures, occurring in approximately 0.1%–0.8% of cases. In contrast to our situation, these reports were of intraprocedural fractures of the guidewire and retention of the fractured distal segment in the body cavity. DerDarian et al. reported a retained whole guidewire in the common femoral artery during endovascular abdominal aortic aneurysm repair. At 1-year follow-up, fortunately, the patient was asymptomatic with no obvious sequelae such as thromboembolism or aortic dissection. Although it is difficult to propose what could be the exact cause of the delayed fracture of the retained wire in our cases, we speculate that the mechanical cause involved chronic fatigue from the pulsation of the aortic arch and supra-aortic arteries and the continuous neck motion. Of note was the difference in time intervals between the 2 cases. The fracture of the PED push wire occurred weeks after retention, whereas the thinner 0.010-inch micro guidewire fractured years later. There were big differences between the 2 wires. The PED push wire is thicker, stouter, and made of nitinol strand, while the Agility wire is much thinner and more flexible and has a stainless steel body. The durability of the thinner guidewire could be due to higher compliance of the thin stainless steel. There were differences in the fractured ends between the two and the difference was obvious on scanning electronic microscopy (AIS1800C, A1800C, Seron Technology) (Fig. 3). Both ends of the fractured segment of the PED push wire (Fig. 3A and B) were sharply cut with rough surfaces, while those of the Agility wire showed relatively smooth surfaces with a blunted end and a sharp end (Fig. 3C and D). The differences of the cut surface margin morphology
could be due to 1) the characteristics of the composition of the metal, 2) acuteness of the fracture, and 3) biological response (for example, endothelial or inflammatory cell coverage) to the cut margins. Of note, all fractured ends showed at least 2 different surface characteristics, suggesting that at least 2 different mechanisms are involved in the eventual fracture process. We thought that a rather smooth surface portion was due to a preexisting or fatigue-related chronic defect and irregular cut surface due to acute fracture caused by sudden severe bending of the wire.

As we usually do in the case of microcatheter retention, we tagged the proximal part of the wire at the femoral puncture site after cutting the most proximal segment at the puncture site to stabilize the wire and avoid any migration problem of the wire within the artery lumen. However, after observing our 2 cases, we believe that tagging of the wire might facilitate chronic fatigue of the metallic wire by preventing its free movement. This could be another reason why the Agility guidewire was fractured only at one point in the foraminal segment of the left vertebral artery, because the femoral tagging was already freed. The rule must be to leave no foreign material, but, if there is no other option, then it might be better to leave the wire in the femoral artery lumen without any tagging suture.

The most striking part of our current case experience was that the complication consisted of thoracic problems, which we regarded as a critical issue. The freed segment of the PED wire pierced the lung parenchyma, resulting in pulmonary hemorrhage and inflammation. The long released proximal segment of the Agility guidewire was found in the thoracic cavity and caused pneumothorax by rupturing the small blebs of the emphysematous lung. It is thus unclear how the wire migrated into the thoracic cavity. When we consider the position of the fractured PED wire in the right lung (Case 1), we conclude that the proximal fracture occurred first and that the change in the axis of the distal fractured segment along the left common carotid artery axis then allowed the fractured segment to puncture the adjacent aortic arch. Once the artery was punctured, the extravasated segment was able to move farther with continuous pulsation of the aortic arch, further puncturing the right lung until the entire fractured segment was completely out of the aorta. In our second case, however, the mechanism of extravasation of the long freed guidewire segment into the right thoracic cavity cannot be explained in the same way. Since the wire was fractured just above the foraminal segment of the left vertebral artery, the freed distal part of the main wire could have

**FIG. 3.** Scanning electron microscopic findings of the fractured ends. A: The distal end of the fractured PED pusher wire shows a very rough margin on the majority of its surface with a deep crater-like defect in the center. A crescent-shaped portion arrow shows a rather smooth surface with a bent portion. There is a possibility of preexisting defect of the wire material. B: The proximal end of the PED wire shows a clean cross cut, which is covered by multiple cellular layers. This surface could be created by a sudden fracture at the junction between the aortic arch and the left common carotid artery. C: The distal end of the fractured segment of the Agility wire shows an oblique, sharp cut suggesting abrupt cut just above the foraminal segment of the left vertebral artery. D: The proximal end of the Agility wire shows a tapered end with blunted margin covered by thick cellular layers, suggesting a very long duration of free exposure within the vessel.
migrated down into the aortic arch. Then, the fractured distal end pointed to the proximal portion of the ascending aortic arch and punctured the anterior wall of the aortic arch. Once the tip was out of the aorta, the guidewire could further migrate into the free space of the mediastinum and right pleural cavity. At any rate, the presence of the retained wire segment in the right thoracic cavity was a surprising consequence of intravascular foreign body retention.

With these unusual experiences of retained guidewires, we believe that surgical material, such as metallic wires, that is left in the artery could cause serious problems in the long run. The timing of wire fracture can vary significantly according to the mechanical properties and metallic components of the wire. If there is an unavoidable retention of a wire in the vessel, especially across the aortic arch, close observation of the integrity of the entire segment of the wire and its position or shape is vital to ensure that the fractured wire can be removed before it migrates out of the vessel.

**Conclusions**

We have experienced extremely rare complications from retained intravascular wires after neurovascular procedures. The retained wires in question were fractured and were found in the right thoracic cavity, resulting in either direct ipsilateral lung injury or pneumothorax. Care must be taken while manipulating platinum-tipped wires in the artery to avoid entanglement with intravascular devices or vasospasm.

If a micro guidewire cannot be removed, it might be better to leave the wire in the femoral artery lumen without any tagging suture. Close radiographic follow-up is mandatory to observe any late migration of the retained micro guidewire with or without fragmentation.

**References**


**Disclosures**
The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

**Author Contributions**

Conception and design: Lee, Koo. Acquisition of data: Lee, Koo. Analysis and interpretation of data: Hwang. Drafting the article: Lee, Koo. Critically revising the article: Lee, Koo. Reviewed submitted version of manuscript: Lee, Koo. Study supervision: Lee, Yang, W Park, JC Park, Ahn, Kwon.

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