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Endovascular Rescue Strategies For Non-opening of Flow Diverter: A Case Report

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ABSTRACT

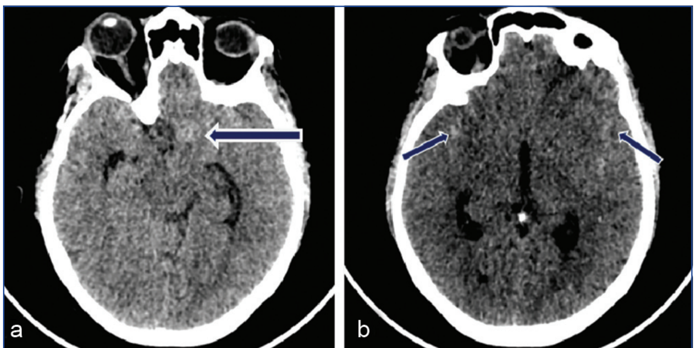
Flow diversion and correction of haemodynamic disturbances are the mainstays of treatment for any intracranial aneurysm. Flow Diverters (FD) are widely accepted as effective treatments for fusiform, wide-necked, large, and giant intracranial aneurysms. Thromboembolic events and intra- and postoperative aneurysmal ruptures are the most frequently encountered complications. Rarely, mechanical, anatomical, and technical challenges can result in deployment failure and incomplete opening of an FD. When these devices fail, they can jeopardise the treatment, necessitating immediate rescue strategies to avoid complications. This is a case of a 40-year-old female presenting with chronic headache that acutely worsened over the preceding two days. Computed Tomography (CT) revealed a large aneurysm in the left supraclinoid internal carotid artery (ICA) with a subarachnoid bleed. FD stent placement and partial coil embolisation of the aneurysm was planned. During deployment, the proximal end of the FD failed to open despite employing standard rescue manoeuvres, including ‘waggling’ and intra-catheter unsheathing. Balloon angioplasty using a monorail coronary balloon successfully restored stent patency and wall apposition. The patient had an uneventful recovery and complete aneurysm occlusion at four months’ follow-up angiography. This case highlights the importance of recognising deployment complications and underscores the need for preparedness with advanced endovascular techniques, such as balloon angioplasty, when standard rescue manoeuvres fail.

Keywords: Balloon angioplasty, Cerebral angiography, Device failure, Endovascular procedures, Intracranial aneurysm, Subarachnoid haemorrhage

CASE REPORT

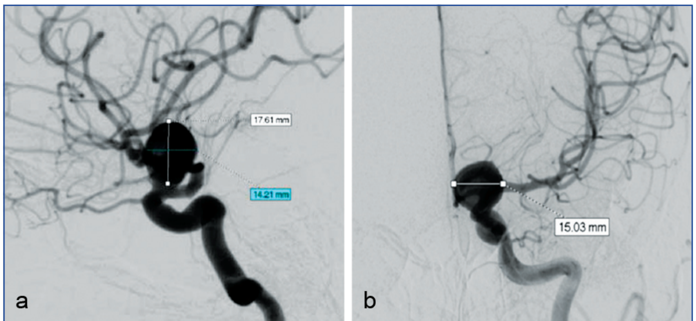
A 40-year-old female presented with a 3-month history of intermittent, moderate-to-severe left frontotemporal headaches, occurring 2-3 times per week and partially relieved with analgesics. Two days prior to admission, she experienced a sudden worsening in headache intensity, which became constant, diffuse, and unresponsive to medication. There were no seizures or history of trauma.

The patient was vitally stable, with no signs of focal neurological deficits. A CT of the brain was performed, revealing subarachnoid haemorrhage in the basal cisterns and a large ovoid hyperdense structure near the left supraclinoid Internal Carotid Artery (ICA), suggestive of an aneurysm [Table/Fig-1a,b]. Immediate cerebral angiography showed a large, wide-necked, superiorly projecting aneurysm measuring 14.2×17.6×15.0 mm (length×height×width) arising from the left supraclinoid ICA, with a neck diameter of 5.2 mm [Table/Fig-2a,b]. The treatment plan was to place a Flow Diverter (FD) across the aneurysm neck and perform coil embolisation of the sac.



[Table/Fig-1]: a) Large ovoid hyperdense structure seen in the region of left supraclinoid Internal Carotid Artery (ICA)- suggestive of aneurysm (arrow); b): Sulcal subarachnoid haemorrhage in bilateral sylvian fissures (arrows).

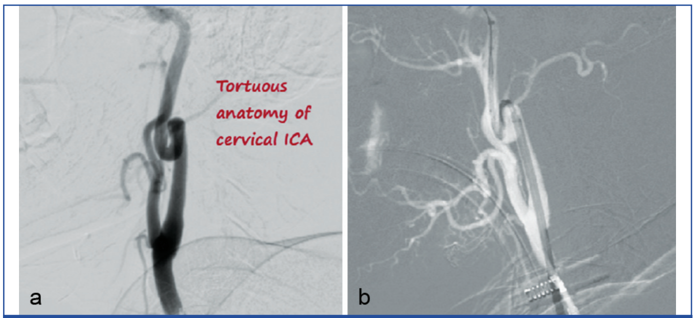
The patient was transferred to an interventional suite. Under general anaesthesia, right femoral access was obtained with an 8-Fr short sheath. The patient exhibited tortuous coiling of the cervical segment of the left ICA and a type II cavernous ICA [Table/Fig-3a,b] [1]. A triaxial configuration of a Neuron Max long sheath, Navian guiding catheter, and Headway microcatheter was used. A 6-Fr Neuron Max long sheath was placed in the proximal segment of the left cervical ICA. A 5-Fr Navian guiding catheter was navigated across the aneurysm and positioned in the supraclinoid segment. The Headway 27 microcatheter was placed in the M1 segment of the left Middle Cerebral Artery (MCA) for FD deployment. A second microcatheter, Echelon 10 (EV3, Irvine, CA, USA), was placed inside the aneurysm sac over a Chikai microwire (0.018 inch). Partial coil embolisation of the aneurysm sac was performed to provide support for stent deployment and thus prevent stent prolapse into the aneurysm [Table/Fig-4a,b]. The FD was traversed across the aneurysm and optimally positioned.



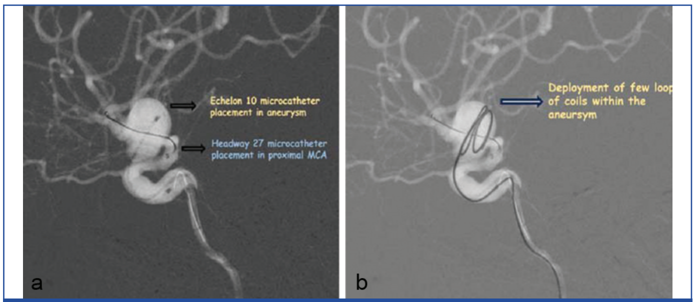
[Table/Fig-2a,b]: Cerebral angiogram in lateral and antero-posterior projection demonstrating a large wide necked superiorly projecting aneurysm arising from the left supraclinoid ICA with neck diameter of 5.2 mm.

During the progressive deployment of the FD, the proximal end of the stent did not open [Table/Fig-5a-c]. Stent twisting was ruled out by correlating the Anteroposterior (AP) and lateral fluoroscopic images.

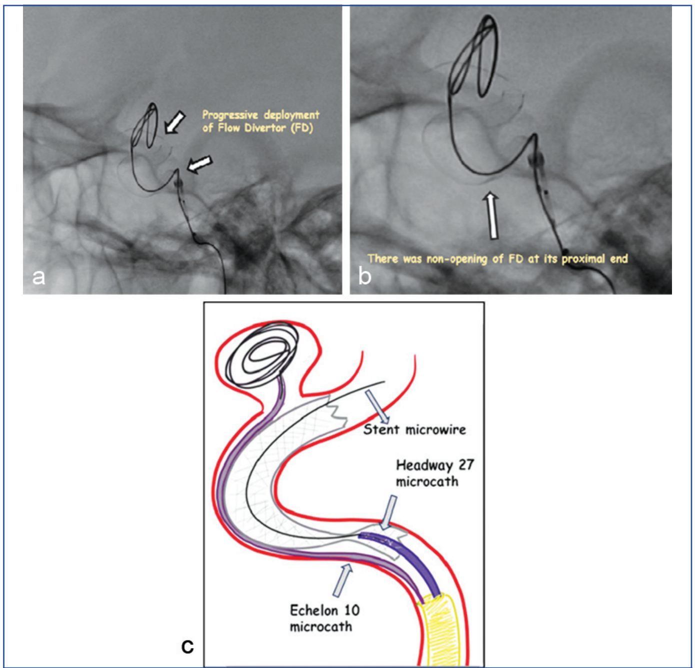
The first manoeuvre, called ‘waggling’, was employed, where the Headway microcatheter and Distal Intermediate Catheter (DIC) were advanced and withdrawn to aid in the deployment of the device;



[Table/Fig-3a,b]: Carotid angiogram demonstrating tortuous anatomy of the left cervical ICA (Type 2- Lin LM et al.,). Triaxial configuration of neuron max long sheath, Navian guiding catheter and Headway used to cross the cervical ICA.



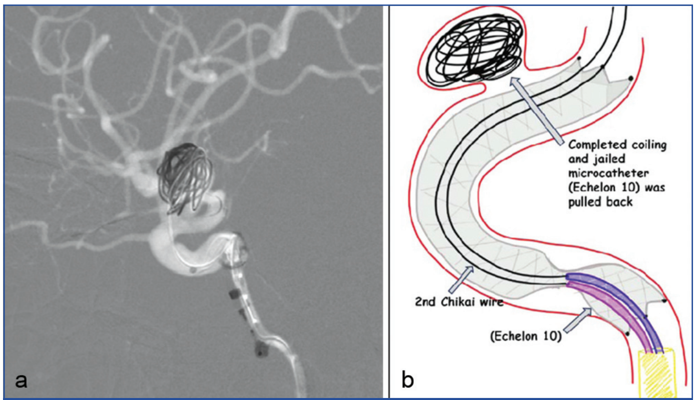
[Table/Fig-4a,b]: Placement of Echelon 10 microcatheter inside the aneurysm with placement of Headway 27 microcatheter across the aneurysm in the M1 segment of the Middle Cerebral Artery (MCA). Few loops of coils deployed within the aneurysmal sac to provide structural support for subsequent flow divertor placement.



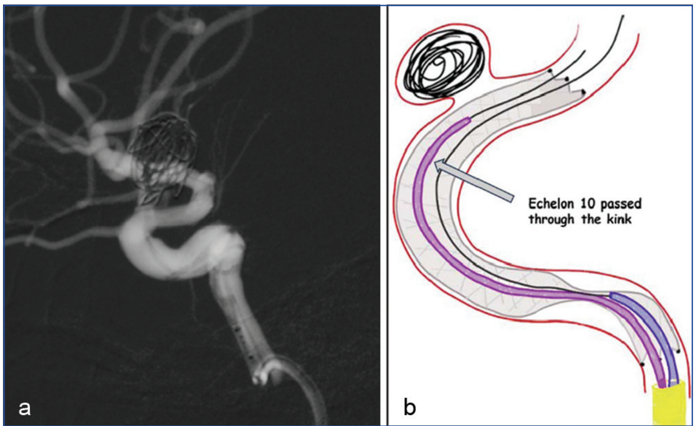
[Table/Fig-5a-c]: Progressive deployment of Flow Diverter (FD) from distal to proximal direction. Non opening of proximal end of FD. Partial deployment of coils within the aneurysm sac using Echelon 10 microcatheter. Illustrative diagram depicting the same.

however, this was unsuccessful. The second manoeuvre involved 'unsheathing the FD within the DIC' while synchronously pushing and pulling the Headway microcatheter to facilitate stent opening; unfortunately, this also did not yield success. Complete coiling of the aneurysm sac was performed, and the 'jailed' microcatheter (Echelon 10) was pulled back from the side of the stent [Table/Fig-6a,b]. A second single-length Chikai 0.018" microwire and Echelon 10 microcatheter were successfully navigated across the stent constriction to secure distal access [Table/Fig-7a,b].

At this stage, a check angiogram was performed, which showed complete occlusion of the supraclinoid ICA and slow filling of the MCA branches [Table/Fig-8]. After the failure of the initial two manoeuvres, we attempted a third manoeuvre involving balloon angioplasty. The Headway 27 microcatheter was exchanged for

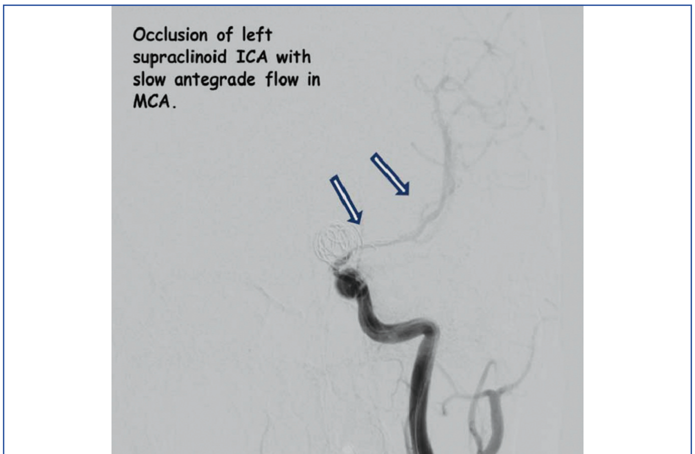


[Table/Fig-6a,b]: Echelon 10 microcatheter pulled back after complete coil embolisation of aneurysm sac and subsequent placement of 2nd Chikai 0.018' wire across the kink.



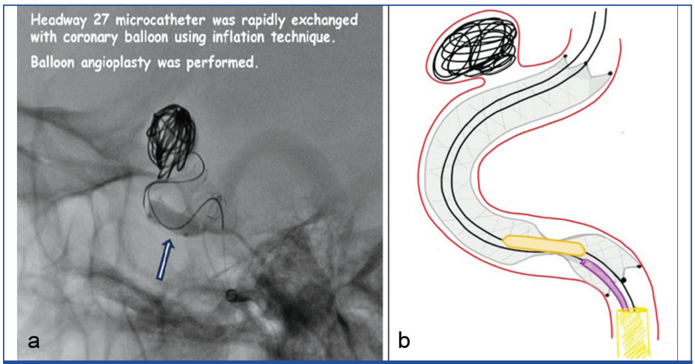
[Table/Fig-7a,b]: Successful navigation of Echelon 10 microcatheter through the kink over Chikai microwire.

a monorail coronary balloon using an inflation technique over the single-length Chikai wire. The microcatheter exchange manoeuvre with the inflation technique involves inflating a saline-filled device to 20 atmospheres while withdrawing the microcatheter. This is performed under continuous fluoroscopic control to prevent the distal tip of the wire from migrating. Angioplasty was carried out using a 4×40 mm monorail coronary balloon [Table/Fig-9a,b].

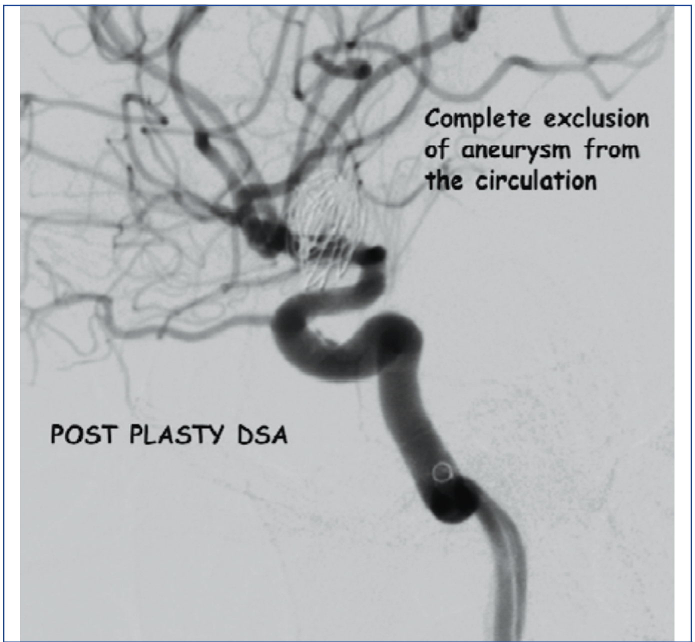


[Table/Fig-8]: Left common carotid angiogram showing complete occlusion of supraclinoid Internal Carotid Artery (ICA) with slow contrast opacification of Middle Cerebral Artery (MCA) (arrows).

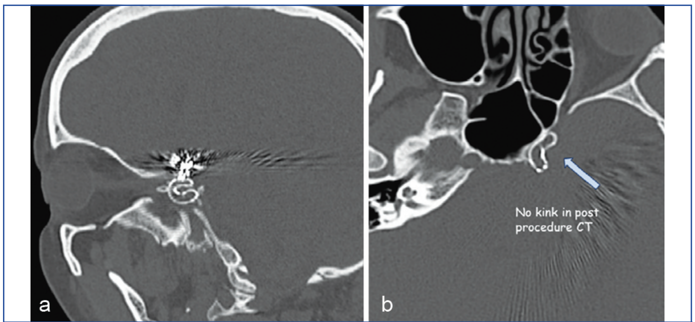
Post-angioplasty, there was complete opening of the FD with good wall opposition. A check angiogram showed complete filling of the left supraclinoid ICA and complete exclusion of the aneurysm from circulation. A small linear flap-like filling defect was observed along the superior wall of the cavernous ICA, which could correlate with a small non-opposed portion of the stent, a strut fracture, or a non-flow-limiting wall dissection [Table/Fig-10]. Post-procedure CT showed complete wall opposition of the stent, with no signs of acute bleeding [Table/Fig-11a,b].



[Table/Fig-9a,b]: Balloon angioplasty was performed using monorail coronary balloon (4×40 mm) (arrow) by exchanging Headway 27 microcatheter (using inflation technique) over single length Chikai wire.



[Table/Fig-10]: Post balloon angioplasty check angiogram demonstrating complete opening of Flow diverter (FD) with normal opacification of supraclinoid ICA, ACA and MCA branches. A small linear flap-like filling defect was observed along the superior wall of cavernous ICA.

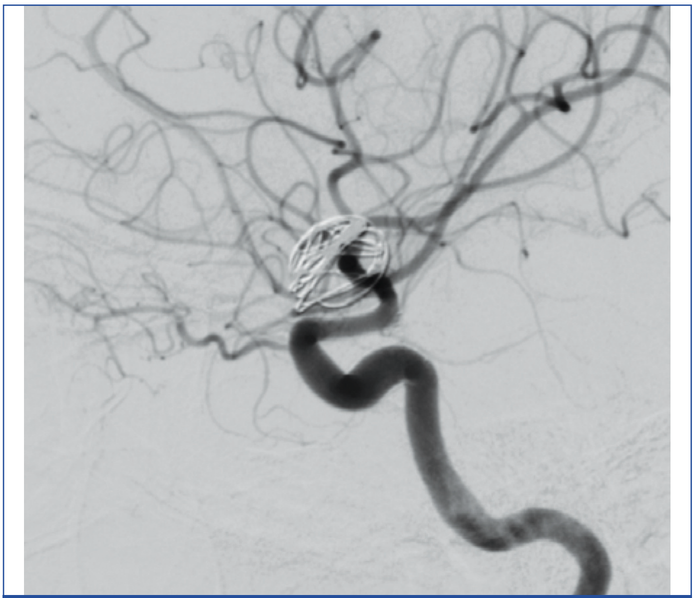


[Table/Fig-11a,b]: Immediate post procedure CT brain images in axial and coronal sections demonstrating complete opening of Flow Diverter (FD) (arrow).

The patient improved symptomatically and was discharged within one week on antiplatelet medication. The patient was followed up at four months with Digital Subtraction Angiography (DSA), which showed complete exclusion of the aneurysm from the main circulation, with smooth wall opposition of the stent [Table/Fig-12].

DISCUSSION

An FD stent is an intra-arterial placement aimed at reducing blood flow to the aneurysm. It is a braided, self-expanding mesh structure with 30-35% metal surface coverage that reduces the flow vector to the dome and neck of the aneurysm, promoting gradual thrombosis and subsequent neointimal remodelling of the arterial wall, while maintaining blood outflow to perforators and side branches [2,3]. A stent design with greater metal coverage and deployment through



[Table/Fig-12]: Follow-up DSA after one year shows complete thrombosis of aneurysm with no residual filling.

a push-pull technique, resulting in greater mesh compaction, leads to enhanced aneurysmal flow diversion [4]. Due to the convoluted anatomy of intracranial arteries, a sophisticated delivery system is necessary to strike a balance between stability and flexibility.

Deployment failures—including incomplete expansion, poor wall apposition, and device migration—can compromise outcomes and necessitate prompt intervention. A device may be improperly deployed (migration or foreshortening) or poorly expanded due to characteristic limitations, malpositioning, or kinking of tortuous vessels. Among the vessel-related factors, a sharp bend or calcification may hinder the device's close adherence. Operator-triggered factors for non-opening FDs include inappropriate deployment techniques and incorrect estimations of vessel size. The most commonly reported causes of device failure are incomplete or suboptimal opening of the FD and inadvertent proximal migration of the device [5].

A study by Ferrigno AS et al., demonstrated that adjunctive aneurysmal coiling is a viable rescue strategy in cases of device prolapse or foreshortening, as it acts as a mechanical scaffold, helping to anchor the stent and prevent further migration [6]. Complementing this, Zenteno M et al, provided a case illustration where incomplete opening or improper wall apposition of an FD can lead to persistent aneurysmal flow and thromboembolic complications [7].

Preprocedural planning is of utmost importance to achieve the best outcome. The following criteria should be fulfilled before selecting an FD: (a) the diameter of the FD should be equal to the diameter of the proximal segment of the parent vessel; (b) foreshortening should be anticipated by approximately 50% to 60% (depending on the nominal diameter of the FD expansion and the diameter of the parent); and the length of the FD should be 6 mm or longer than the neck of the aneurysm; (c) 2 to 3 mm of the device should cover either end of the parent artery surrounding the aneurysm, preferably in a straight segment to better anchor the device [5].

Several rescue manoeuvres can be utilised in succession to ensure correct device operation and patient safety when an FD stent malfunctions. This can range from providing mechanical assistance to placing additional stents, as discussed below.

a) **'Wagging' or 'Bumping' technique:** Microcatheters or guidewires can be employed to manipulate and change the location of the device in situations where the FD is kinked or misaligned. If the proximal end of the FD fails to open after complete deployment, both the delivery wire and microcatheter can be gently pushed back and forth to assist with device expansion. Additionally, bumping the microcatheter against the proximal end of the FD and advancing the microwire with a J-tip across the kink can help induce complete expansion of the device [5]. The intermediate catheter can then be used to "bump" the device along the outer curvatures for better device opening and wall apposition [8]. This method can generate enough radial force to realign the FD and allow it to open entirely. It is particularly useful when repositioning alone is insufficient to resolve the deployment issue.

b) **Intra-catheter deployment:** This technique, described by Lin LM et al., is utilised in situations where the FD fails to progressively open or becomes stretched due to a jammed delivery wire or coil tip in tortuous vessels [9]. A DIC is advanced to the unopened portion of the FD, where the FD device is fully unsheathed inside the DIC, effectively releasing it from the delivery wire. Similar to the waggling technique, the DIC and microcatheter (Marksman) are intermittently waggled back and forth to assist with wall apposition.

c) **Balloon angioplasty:** This approach is employed only when the first two manoeuvres fail. A compliant or semi-compliant balloon is navigated across the kink and then inflated to stretch the FD, bringing it closer to the wall of the vessel and thereby improving the blood flow dynamics necessary for effective treatment of the aneurysm. It is prudent to keep the balloon entirely inside the stent rather than placing it in the proximal portion, as the latter carries an increased risk of arterial injury [10-12]. In cases where anterograde access via the ICA through the kinked FD is not possible, retrograde access via the contralateral anterior communicating artery has been shown to be feasible by Navarro R et al. [13].

d) **Additional stent placement (Telescoping technique):** If the FD does not fully expand or sufficiently cover the neck of the aneurysm, another stent can be inserted inside the previous device. By placing a second stent or FD, this "telescoping" approach ensures correct apposition to the vessel wall, guaranteeing that the aneurysm is completely covered, which increases the overall efficacy of the procedure [8].

e) **Flow Diverter (FD) retrieval and repositioning:** The FD may be retrieved and repositioned in the early phases of deployment if it is still linked to the delivery system. The catheter and delivery system may be withdrawn as a whole if the distal end of the device fails to expand because a flow diverting device is typically deployed from the distal to proximal direction. However, it becomes challenging to remove if the device is completely unsheathed and the proximal end fails to expand [5,8-10].

Utilising these auxiliary manoeuvres is associated with additional risks, and care must be taken to avoid inadvertent vessel injury and device foreshortening or migration. Even if the FD opens sufficiently after rescue strategies, it is critical to perform post-deployment angiography and imaging (such as DSA or 3D imaging) to confirm proper apposition, flow diversion, and aneurysm exclusion.

CONCLUSION(S)

This case report emphasises that the successful use of FD stents in treating complex aneurysms requires a deep understanding of potential complications and the swift application of rescue techniques. Failure of FDs may result in serious challenges in managing an aneurysm; however, several endovascular rescue techniques, including angioplasty, placement of an additional stent, and mechanical adjustment, can be undertaken to ensure proper deployment. These techniques require a high level of operator skill and are often selected based on the cause of the deployment failure. Postprocedural imaging plays a crucial role in ensuring the success of the intervention.

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