Retrieval of Entrapped Embolic Protection Device during Carotid Artery Stenting: A Case Report

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AIM: This study aims to report a rare case of an embolization protection device (EPD) entrapment during Carotid Artery Stent (CAS) and to discuss the management strategy, including open surgery and concurrent carotid endarterectomy (CEA).

CASE PRESENTATION: A 71-year-old female presented with left limb weakness and unclear speech following CAS. Imaging revealed a new cerebral infarction and right internal carotid artery stenosis. The patient underwent endovascular retrieval of the entrapped EPD, which failed, leading to an emergency open surgical procedure.

RESULTS: The surgical approach involved a longitudinal incision along the anterior border of the right sternocleidomastoid muscle, followed by carotid artery exposure and temporal artery clamps application. The entrapped EPD and stent were successfully retrieved, and the thrombus was aspirated. Subsequent endarterectomy removed the stenotic plaque, and meticulous washing cleared the carotid arteries. Post-operative indocyanine green fluorescence angiography confirmed patency of the arteries, and the patient was discharged without new neurological symptoms after 11 days of hospitalization.

CONCLUSIONS: This case underscores the challenges in managing EPD entrapment during CAS and the necessity for a swift transition to open surgical intervention when endovascular techniques fail. The concurrent performance of CEA in such cases offers a comprehensive treatment strategy, highlighting the importance of a multidisciplinary approach in complex vascular interventions.

Keywords: carotid artery stenting; embolic protection device; complications; carotid endarterectomy

Introduction

Carotid Artery Stent (CAS) is a treatment modality for carotid artery stenosis. However, this procedure carries a potential risk of plaque embolization. If plaque becomes dislodged or fragmented during the procedure, it can lead to cerebral embolism, causing symptoms ranging from local paralysis to life-threatening conditions [1,2]. The intraoperative use of embolization protection devices (EPDs) effectively prevents these complications by reducing the risk of plaque dislodgment towards cerebral vasculature, thereby decreasing the occurrence of cerebral embolism [3]. It significantly enhances surgical safety [4] and is widely used in clinical practice [5]. While EPDs have significantly reduced the risk of embolic events during CAS, they are not without potential complications. Common complications associated with EPDs include difficulty in retrieving the device and instances of retrieval failure [6,7], such as EPD entrapment within the stent, as observed in our study. EPD entrapment is a rare but serious complication, with an incidence ranging from 0.1% to 0.5% in some series [8]. This complication can lead to several issues including vessel injury, thrombosis, and the requirement for open surgical intervention to retrieve the device. The rapid advancements in interventional techniques and materials have provided more effective tools and strategies for managing challenging EPD retrievals [9]. However, there are still cases where interventional retrieval fails, demanding surgical intervention [10]. In instances of retrieval failure, surgical removal or rescue stents to secure EPDs within the stents may be required, or even conservative measures might be employed for EPDs that have drifted into the distal internal carotid artery system. Unfortunately, these measures can result in unnecessary patient discomfort and iatrogenic complications [11,12]. Open surgical retrieval of an entrapped EPD can lead to complications such as bleeding, infection, and damage to surrounding tissues. Moreover, manipulating the carotid artery during the procedure may result in thrombosis or dissection, potentially compromising blood flow to the brain. Additionally, the concurrent performance of carotid endarterectomy (CEA) adds further complexity and elevates the risk of perioperative morbidity. This study reports a patient who underwent carotid artery open surgery for EPD and stent retrieval following entrapment during CAS, accompanied by CEA, offering valuable insights for clinicians facing similar challenges.

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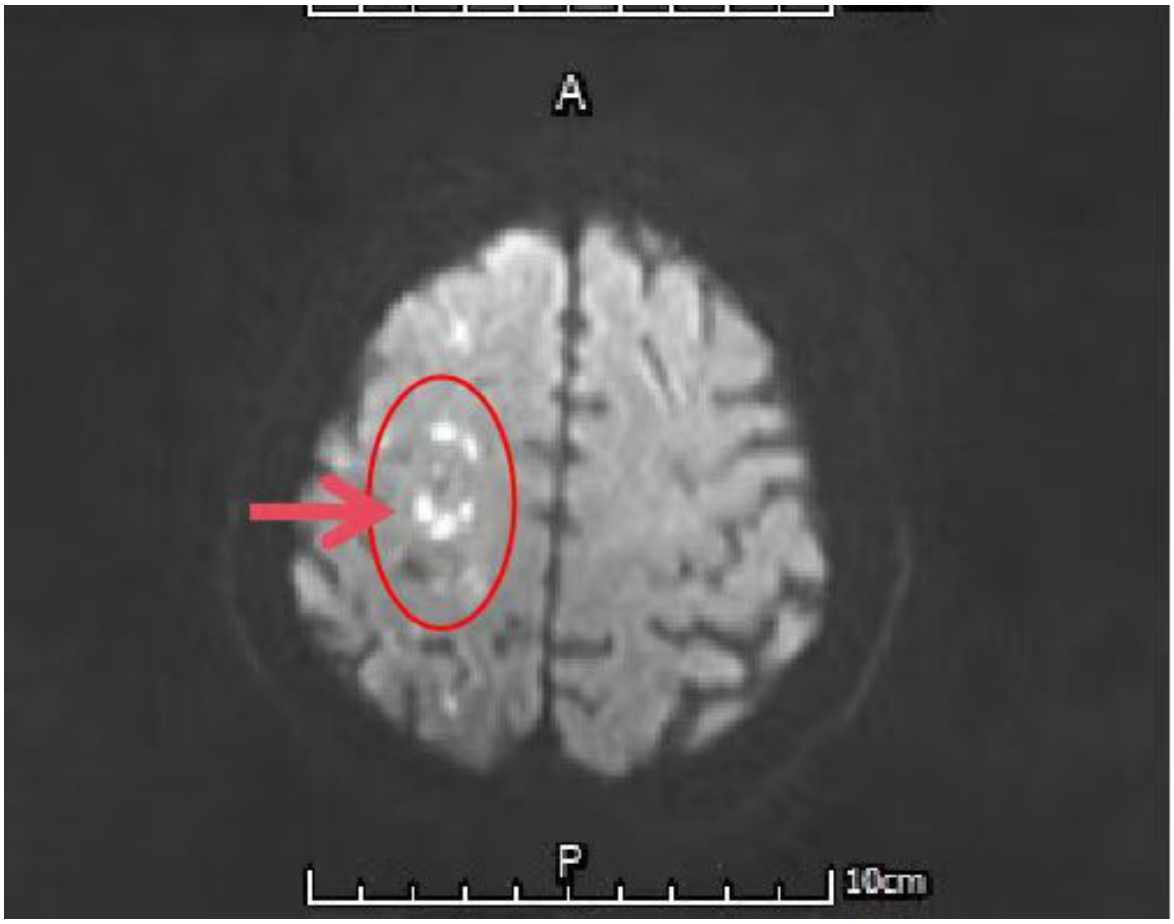

Fig. 1. The cranial Magnetic Resonance Imaging (MRI) scan revealed a newly developed cerebral infarction in the right frontal, parietal, and occipital lobes. The arrow indicates the location of the newly diagnosed cerebral infarction. Scale bar: 10 cm.

Case Report

A 71 years old female patient, admitted to the Neurosurgery Department of the First People's Hospital of Jining City, Shandong Province, on 4 December 2021, was presented with a 10-day history of left limb weakness and unclear speech, occurring 4 hours after stenting of the right internal carotid artery. A cranial Magnetic Resonance Imaging (MRI) at a local hospital revealed a new cerebral infarction in the right frontoparietal lobe (Fig. 1). Subsequently, she was diagnosed with right internal carotid artery stenosis (Fig. 2) and underwent a procedure for "right internal carotid artery balloon dilatation and stent placement". However, during the procedure, following the release of the carotid artery stent, the cerebral protection umbrella could not be smoothly retrieved (Fig. 3), prompting an emergency transfer to our hospital.

Upon admission, the patient was conscious and responsive, with normal facial expressions, slight shallowing of the left nasolabial fold, and midline tongue protrusion. The right lower limb was immobilized, with the sheath retained at the right femoral artery puncture site, undergoing continuous compression and flushing. The remaining limbs exhibited voluntary movement as instructed. Muscle strength [13] was graded as V-, with normal muscle tone, and the bilateral Babinski sign [14] was negative. The NIHSS score [15] was 8 points. The patient had previously undergone right carotid artery stenting (Protégé RX) at a local facility, during which the cerebral protection umbrella (SpiderFX) was entrapped within the carotid artery stent. This posed an imminent risk of internal carotid artery occlusion, which could lead to extensive cerebral infarction or even death. Consequently, an emergency right internal carotid artery endarterectomy was performed, during which the stenotic plaque was removed, and the carotid artery stent and the entrapped cerebral protection umbrella (device) were extracted, restoring normal blood flow.

The surgical approach involved a longitudinal incision along the anterior border of the right sternocleidomastoid muscle. The skin and subcutaneous tissue were sequentially dissected to expose the carotid artery sheath, revealing the common carotid artery, internal carotid artery, and external carotid artery. Temporal artery clamps were applied to occlude the internal carotid artery, external carotid artery, and superior thyroid artery. A rubber loop was used to occlude the common carotid artery, and the systolic blood pressure was raised to approximately 150 mmHg. The common carotid artery was then opened, revealing the carotid artery stent and the tip of a guide catheter. The internal

Fig. 2. Cerebrovascular angiography revealed severe stenosis of the right internal carotid artery. The red arrows indicate intravascular plaques and stenosis sites. Scale bar: 2 cm (left), 0.5 cm (right).

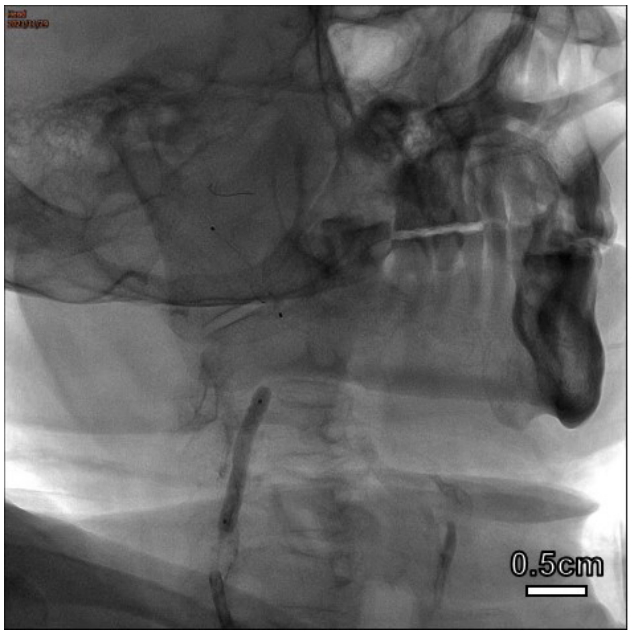

Fig. 3. The embolization protection device (EPD) is lodged within the stent, resulting in the retention of contrast media. Scale bar: 0.5 cm.

carotid artery was further dissected upwards to fully expose the stent, where the protection umbrella was found to be entrapped (Fig. 4). Thrombus formation was observed within the stent and the internal carotid artery. The carotid artery stent and the embolic protection device were extracted, and the thrombus was aspirated (Fig. 5). The thickened and hardened plaque, approximately 2 cm in length, was excised from the common carotid, internal, and external carotid arteries, comprising calcified plaque causing severe stenosis at the beginning of the internal carotid artery. The plaque was completely removed, and meticulous washing was performed to clear any plaque debris from the intima of the common, internal, and external carotid arteries (Fig. 6). The arterial incisions were carefully sutured, and hemostatic gauze was applied to the sutured area. Blood pressure control was strictly controlled, maintaining the systolic pressure at 110 mmHg. Indocyanine green fluorescence angiography indicated the patency of the common, internal, and external carotid arteries. The carotid artery sheath was then sutured, and the surgery was completed. After the surgery, a carotid Computed Tomography Angiography (CTA) examination revealed that the blood vessels were unobstructed (Fig. 7). The patient was discharged after 11 days of hospitalization with no new neurological symptoms at the time of discharge. A flow chart of the treatment process for this case report is depicted in Fig. 8.

Discussion

CEA, combined with drug therapy, was once considered as the standard treatment option for carotid artery stenosis. Large-scale, multicenter randomized controlled trials have confirmed the effectiveness and safety of CEA, establishing it as the "gold standard" for treating carotid artery stenosis [16]. With advancements in materials science, particularly the advent of cerebral protection devices and self-expanding stents, endovascular stenting for extracranial carotid artery stenosis has emerged as a recent research hotspot and has shown promising outcomes. In

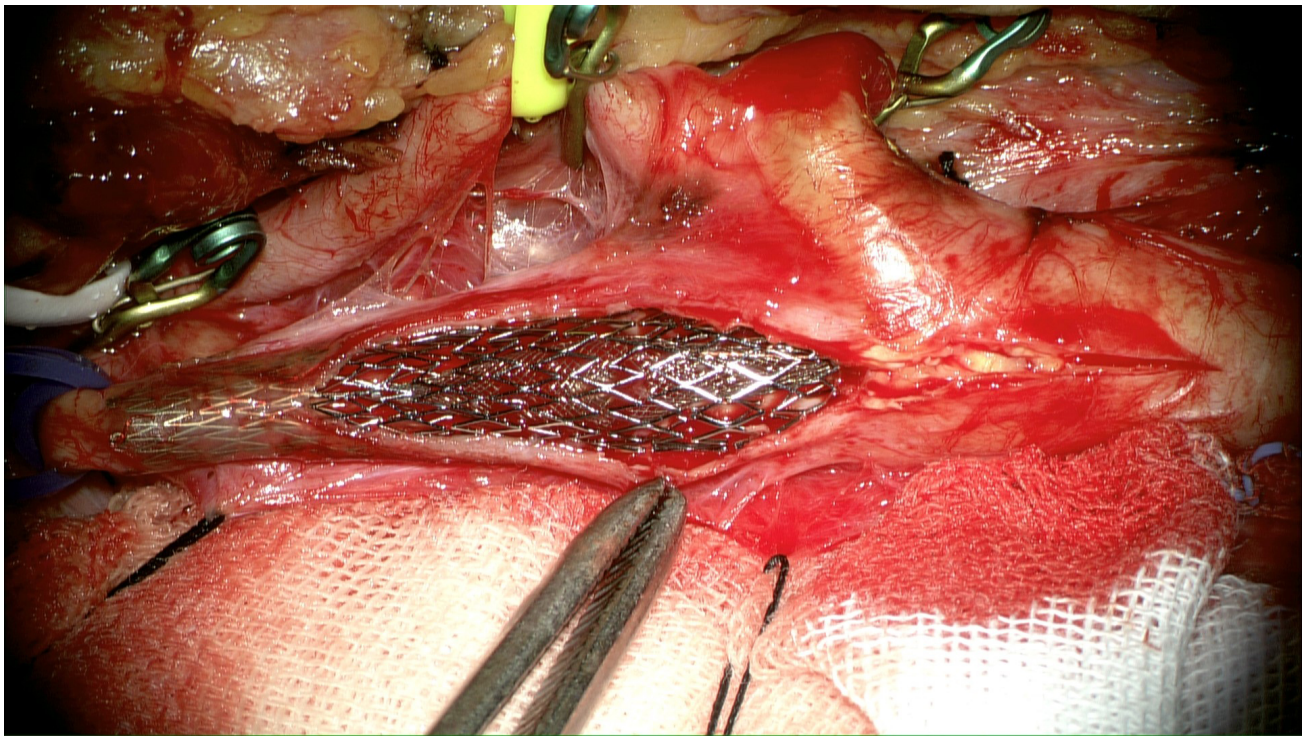

Fig. 4. Entrapment of the EPD within the stent.

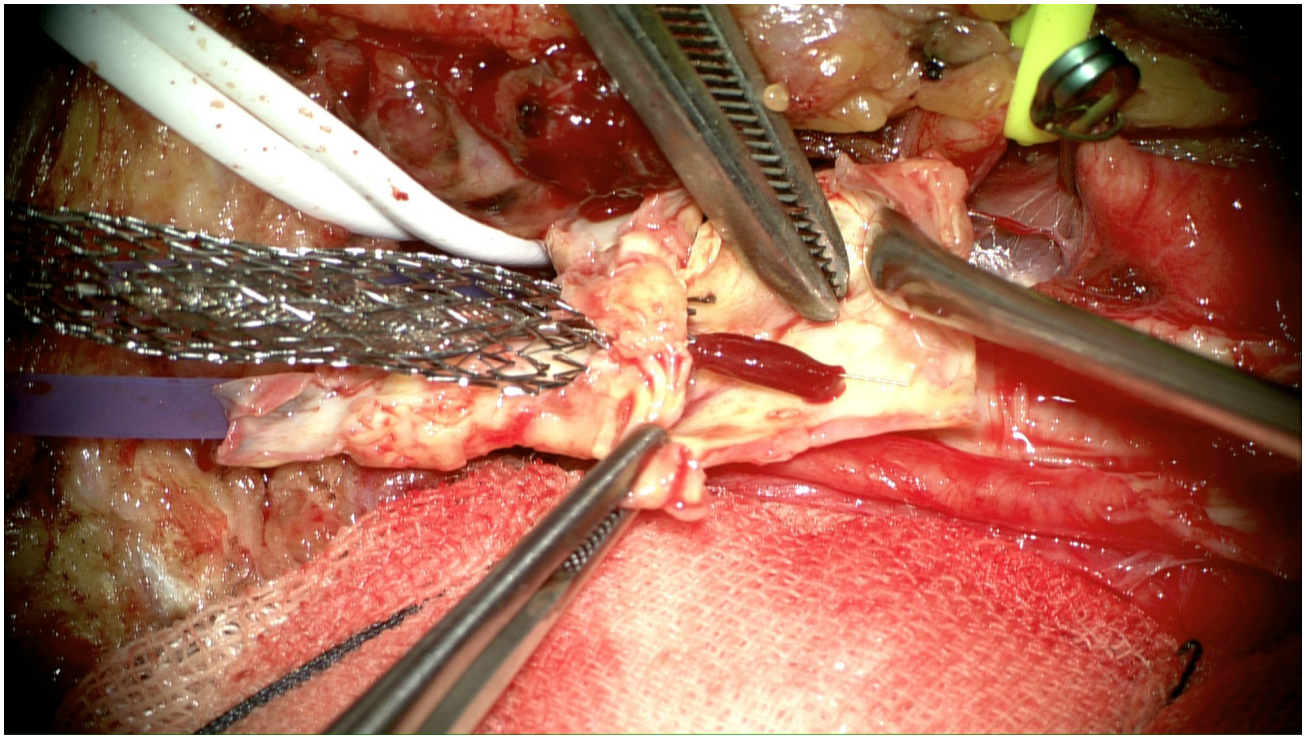

Fig. 5. Retrieval of Carotid Artery Stent (CAS) and EPD once thrombus is aspirated.

the 1990s, Diethrich *et al*. [17] successfully performed the first CAS. However, due to relatively primitive interventional instruments and limited technical expertise at that time, the incidence of intraoperative embolism during CAS was higher than that in carotid endarterectomy. As interventional technology and expertise have advanced, the advantages of CAS have gradually been recognized, leading to its widespread use in clinical practice.

Distal embolization caused by plaque dislodgement is a known perioperative complication of CAS. As a mechanical device placed within the carotid artery, EPDs can effectively reduce the entry of emboli into distal vessels during

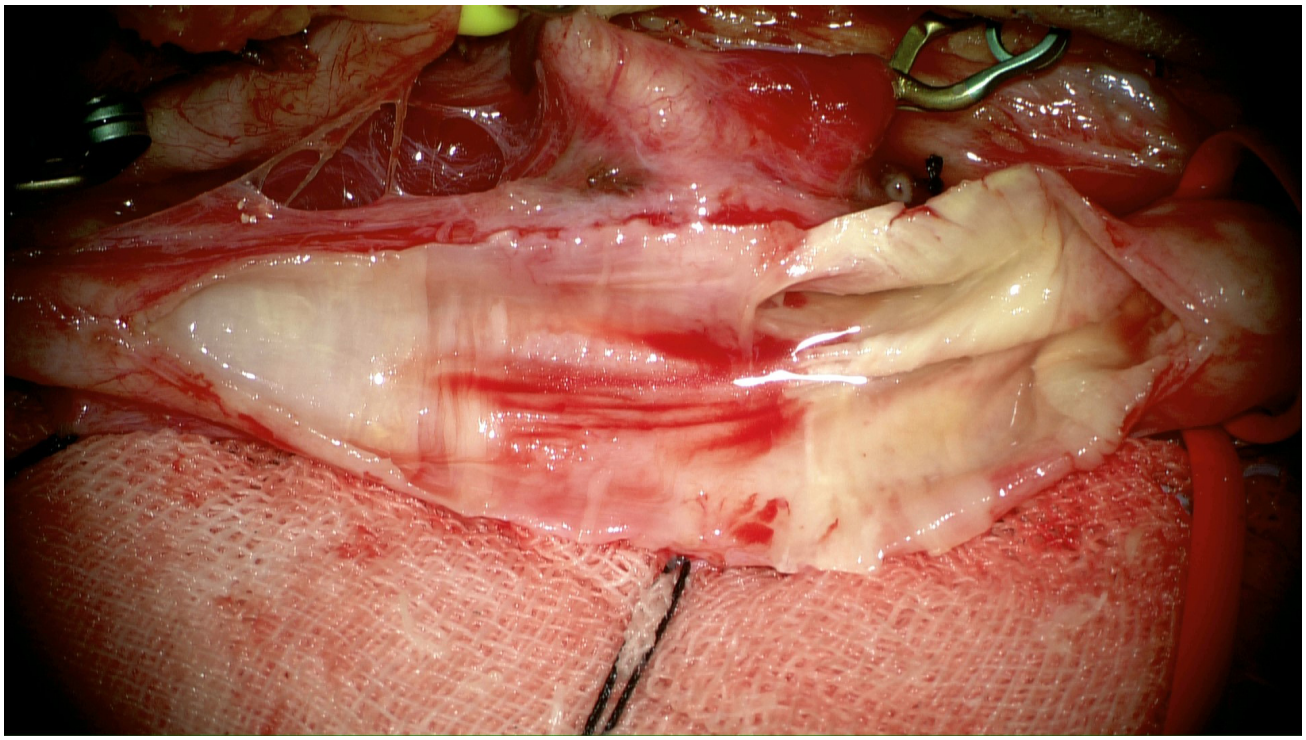

Fig. 6. After endarterectomy, the vessel is smooth.

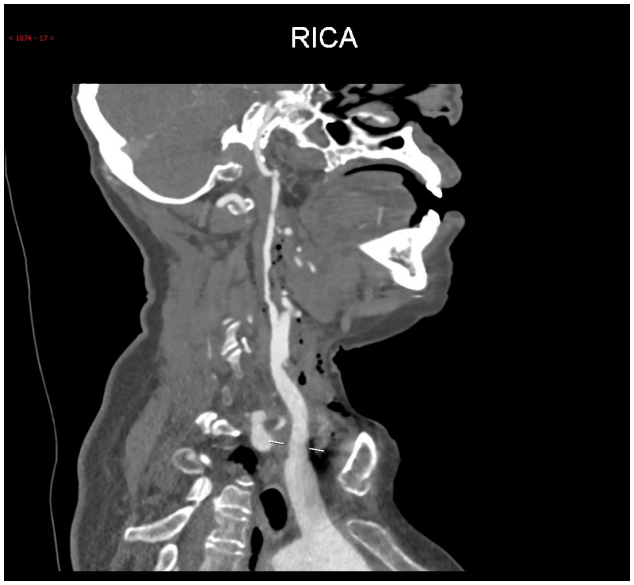

Fig. 7. After the surgery, a carotid Computed Tomography Angiography (CTA) examination showed unobstructed blood vessels. RICA, retropharyngeal internal carotid artery.

surgery [18]. Theron *et al*. [15] first applied EPDs in CAS in 1990, initially verifying their safety. However, the use of EPDs also carries potential risks, primarily vascular spasms and difficulties in their retrieval, with an occurrence rate of 7.7% (12/156) [10]. Reports suggest that the incidence of difficulty in EPD retrieval ranges from 6.5% to 15.4%, with a failure rate of retrieval between 0.1% and 0.5% [8,19]. EPD retrieval difficulties typically occur within the stent, with risk factors including calcification at the stenosis site, vascular tortuosity, vascular spasm, incomplete stent expansion, and stent fractures [20]. Another case by Nii *et al*. [10] reported the use of manual carotid compression to facilitate EPD retrieval. While this method is less invasive than surgery, it may not be effective when the EPD is deeply embedded within the stent, as was the situation with our patient. This study reports a rare case of EPD entrapment within the stent, requiring open carotid artery surgery for retrieval and endarterectomy. However, there are limited documented cases of such complications. In our case, the decision to proceed with carotid endarterectomy (CEA) was influenced by the imminent risk of internal carotid artery occlusion and the potential for extensive cerebral infarction or death. Although this approach is more invasive, it allowed for the complete removal of the stenotic plaque and the entrapped EPD, thereby restoring normal blood flow and preventing further complications. In this case, the patient experienced EPD entrapment during the neck internal artery stenting procedure at an external facility. To maintain blood flow, continuous flushing was conducted, and the patient was urgently transferred to our hospital. Emergency carotid artery open surgery was performed to retrieve the entrapped EPD, with carotid endarterectomy conducted concurrently. Intraoperative observations confirmed that the EPD was entangled with the stent.

Existing solutions for difficult EPD retrieval include applying pressure to the patient's carotid artery, turning the patient's head to the opposite side, instructing the patient to swallow, inserting the guide catheter near the stent or

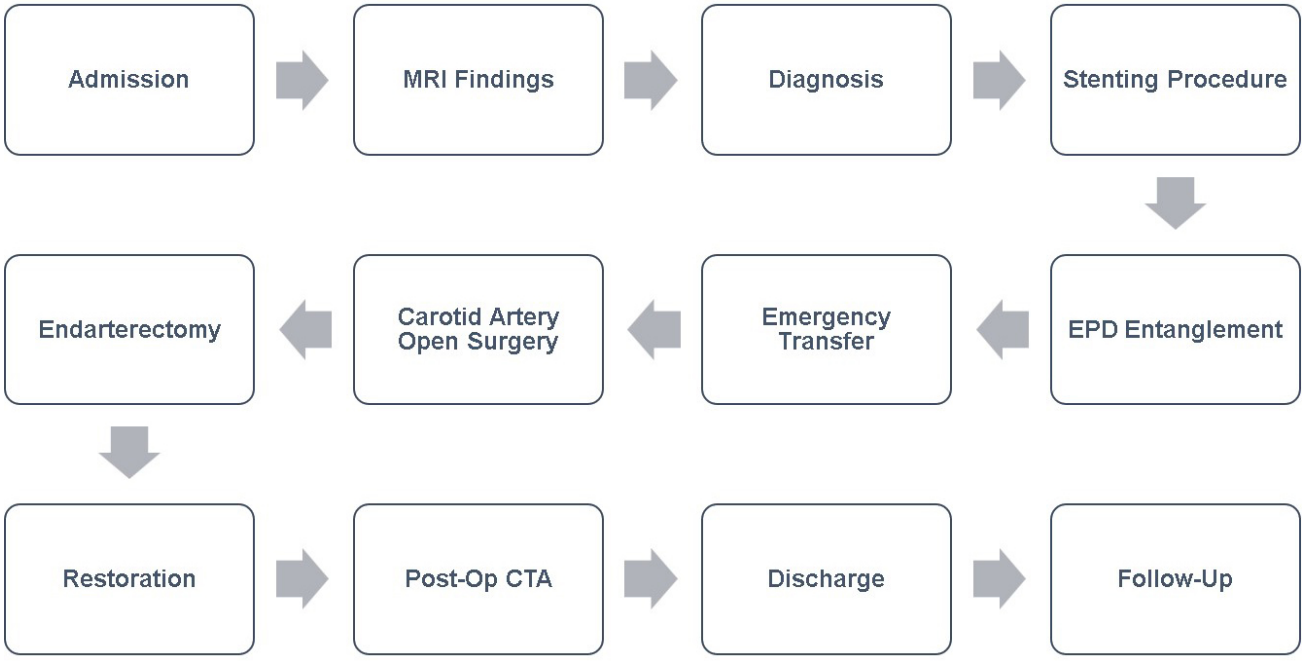

Fig. 8. A flow chart of the treatment of the case.

into the stent, and using a guide catheter with a bent tip [9]. However, in cases where EPD retrieval fails, open surgery may be needed to remove EPD and residual parts along with the stent through carotid artery endarterectomy [21]. Leaving the EPD permanently retained in the body may increase the risk of complications such as vascular spasm, thrombosis, or embolism, emphasizing the significance of preventing such occurrences [12,22].

In summary, CAS has become crucial for treating carotid artery stenosis. The routine application of EPDs in CAS has enhanced its safety. However, clinicians need to be aware of potential risks associated with EPDs to improve CAS treatment outcomes. Combined surgical approaches integrate traditional surgery with interventional treatment, providing a platform for patients to undergo surgical, interventional, and imaging examinations simultaneously, thereby opening new avenues for the treatment of ischemic cerebrovascular disease.

Conclusions

This case underscores the complexities and challenges of managing an entrapped embolic protection device during carotid artery stenting. Although these complications are rare, the successful outcome post-emergency open surgery highlights the efficacy of a careful surgical approach. This case emphasizes the need for clinicians to be prepared for unexpected complications during routine procedures and the significance of a swift transition to open surgical intervention when endovascular retrieval fails. The uneventful recovery and discharge of the patient underscore the importance of a comprehensive and well-executed treatment plan in ensuring positive outcomes.

Availability of Data and Materials

The datasets used or analyzed during the current study are available from the corresponding author upon reasonable request.

Author Contributions

All authors have contributed significantly to this work. GYF and WWG were responsible for the manuscript writing, conception and design of the study, data acquisition, analysis, and interpretation. CHS contributed to conducting experiments, drafting the manuscript and revising it critically for important intellectual content. LF and WYM were involved in the surgical procedures and provided critical revisions of the manuscript. All authors give final approval of the version to be published. All authors have participated sufficiently in the work to take public responsibility for appropriate portions of the content and agreed to be accountable for all aspects of the work in ensuring that questions related to its accuracy or integrity.

Ethics Approval and Consent to Participate

This study was conducted in accordance with the Declaration of Helsinki and was approved by the Ethics Committee of The First People's Hospital of Jining, with the reference number [2023083]. Informed consent was obtained from the patient involved in the study.

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Conflict of Interest

The authors declare no conflicts of interest.

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