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Case Series

Successful Removal and Replacement of a Stuck Hemodialysis Catheter via Thoracotomy: Report of Two Cases and Literature Review

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Keywords

Stuck catheter · Central venous catheter · Hemodialysis access · Fibrin sheath · Open surgery

Abstract

Introduction: Stuck tunneled central venous catheters (CVCs) have been increasingly reported. In rare cases, the impossibility of extracting the CVC from the central vein after regular traction is the result of rigid adhesions to the surrounding fibrin sheath. Forced traction during catheter removal can cause serious complications, including cardiac tamponade, hemothorax, and hemorrhagic shock. Knowledge and experience on how to properly manage the stuck catheter are still limited. ***Case Presentation:*** Here, we present two cases that highlight the successful removal of the stuck tunneled CVC via thoracotomy through the close collaboration of multidisciplinary specialists in the best possible way. Both patients underwent an unsuccessful attempt at thrombolytic therapy with urokinase, catheter traction under the guidance of digital subtraction angiography and intraluminal balloon dilation. And we reviewed the literature on stuck catheters in the hope of providing knowledge and effective approaches to attempted removal of stuck catheters. ***Conclusion:*** There is no standardized procedure for dealing with stuck catheters. Intraluminal percutaneous transluminal angioplasty should be considered as the first-line treatment, while open surgery represents a second option only in the event of failure. Care must be taken that forced extubation can cause patients life-threatening.

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Introduction

Effective hemodialysis of patients with end-stage renal disease depends on functional vascular access [1, 2]. Arteriovenous (AV) fistulas, AV grafts, and hemodialysis catheters are the three main forms of vascular access for hemodialysis. AV fistulas are proposed as the first option due to their long lifespan, low complication rates, and favorable treatment conditions [3]. However, tunneled and cuffed central venous catheter (TC-CVC) may be the only vascular access for hemodialysis patients with poor vascular condition, especially for patients with diabetes mellitus and metabolic syndrome [4, 5]. TC-CVC is now still frequently used as hemodialysis access for patients with end-stage renal disease, although long-term indwelling TC-CVC is prone to catheter dysfunction, fibrin sheath formation, infection, thrombosis, and venous stenosis [4, 6].

Recently, the failure to remove stuck hemodialysis catheter has been increasingly reported in patients with TC-CVC. The fibrin sheath, long residence time, and infection are the main risk factors that make it difficult to remove the catheter, which can cause strong adherence between the catheter and the central vessel wall. Catheter incarceration is a very difficult problem during TC-CVC replacement, and forced extubation can easily be life-threatening for patients [7]. Treatments for stuck catheters include intraluminal percutaneous transluminal angioplasty (PTA), sheath resection with or without laser, open surgery or leaving part of the catheter in situ [8, 9].

Fibrin sheaths have been reported around deep venous catheters, and animal experiments have confirmed that the incidence of fibrin sheaths reached 100% after 1 week of catheterization [10, 11]. As the TC-CVC catheterization time is prolonged, the fibrin sheath around the catheter calcifies and the tissue proliferates, and the catheter adheres to the local blood vessels, resulting in catheter incarceration [7, 12, 13]. Sealing early and regular infusion of urokinase into the catheter can effectively prevent catheter dysfunction caused by the fibrin sheath [14, 15].

Knowledge and experience of the standardized solution for entrapped catheters are still limited to date. Here, we present two cases that highlight the successful removal of an adherent dialysis catheter via thoracotomy through the close collaboration of multidisciplinary specialists. And we did a literature review to show the effective approaches to deal with stuck catheters. More attention should be paid to standardizing of the procedure to manage the stuck catheter in the best possible way.

The CARE Checklist has been completed by the authors for this case report, attached as online supplementary material (for all online suppl. material, see https://doi.org/10.1159/000537740).

Case Reports

Case 1

A 52-year-old woman on maintenance hemodialysis was admitted to the hospital to establish a new dialysis access due to the malfunctioning of the TC-CVC in her left internal jugular. The patient underwent hemodialysis using a left AV fistula followed by a TC-CVC in the right internal jugular vein 8 years ago. She started regular dialysis via a TC-CVC in the left internal jugular vein after the aforementioned dialysis access failed 6 years ago. The chest X-ray showed that the end of the catheter was level with the upper edge of the 10th thoracic vertebra (Fig. 1a). Doppler ultrasound showed a poor vascular condition in both hands. Continuous pumping of urokinase through the end of the catheter showed poor results. On July 20, 2021, the patient underwent removal of the TC-CVC + central

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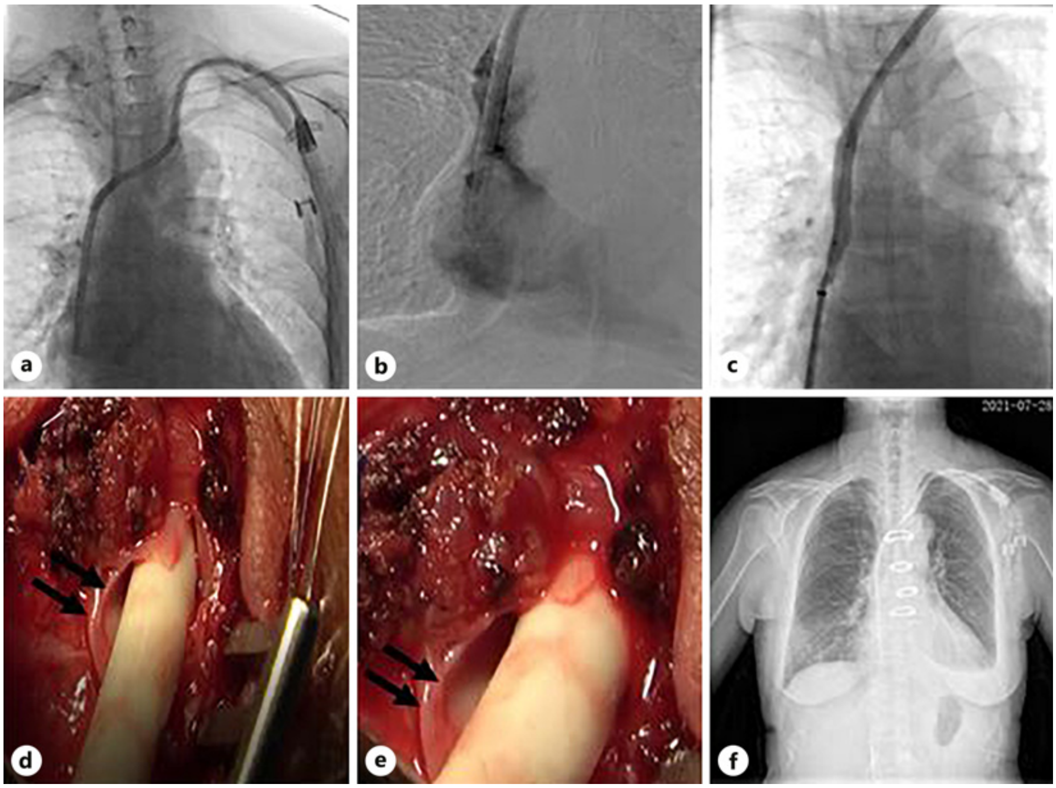

Fig. 1. Preoperative, intraoperative, and postoperative catheter status of the first patient. **a** Angiography showed the position of long-term hemodialysis catheter in the left internal jugular vein before surgery (the end of the catheter was flush with the upper border of the 10th thoracic vertebra). **b** Angiography showed that the patient's superior vena cava had no obvious stenosis. **c** Intraductal balloon dilatation was performed to assist extubation under DSA. **d**, **e** Fibrin sheath was found around the catheter during thoracotomy. **f** X-ray showed the postoperative position of long-term hemodialysis catheter in the left internal jugular vein (the end of the catheter was located in the shadow of the right atrium, which was flush with the upper border of the 11th thoracic vertebra).

venous catheterization + intraluminal balloon dilation under digital subtraction angiography (DSA). The proximal segment of the catheter could not be removed after the subcutaneous cuff was released and the peri-catheter fibrous tissue loosened. There may be an intravascular fibrin sheath. Extubation was unsuccessful, although intraductal balloon dilation was performed to help (Fig. 1c). On July 21, 2021, the patient underwent hemodialysis via a temporary right femoral venous catheter. The cardiologist and cardiac surgeon suggested that the catheter should be stuck and recommended a thoracotomy. The patient underwent TC-CVC removal + thoracotomy + exploration of the superior vena cava + central venous catheterization. The skin was dissected along the direction of the cervical catheterization, and the anterior border of the sternocleidomastoid muscle was carefully dissociated. Edema of the subcutaneous tissue and hyperplasia of the local inflammatory tissue were observed. There was no adhesion between the catheter and the surrounding tissue, but the extubation failed due to excessive resistance. To avoid damaging the superior vena cava (SVC), a middle thoracotomy was performed. After the brachiocephalic vein and the SVC are released, the cord-like sclerotic zone can be palpated in the SVC (Fig. 1d, e). After loosening the scleral strip, the catheter can be released and has been cut. The original TC-CVC was removed and a new tunneled catheter was

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inserted. After internal fixation of the sternum with steel wire and TiNi girdle bone graft, the thorax was closed layer by layer. A drainage tube was placed behind the sternum, and the incision was sutured. The chest X-ray showed that the tip of the catheter was in the shadow of the right atrium, at the level of the upper edge of the 11th thoracic cone, and the mediastinum was not widened (Fig. 1f). The patient's hemodialysis went smoothly during the follow-up period.

Case 2

A 55-year-old man was admitted to hospital to establish a new dialysis access due to dialysis catheter dysfunction. The patient started hemodialysis through a TC-CVC in the left internal jugular vein for 7 years due to occlusion of the right internal jugular vein. The patient had a history of thrombotic thrombocytopenic purpura. The chest X-ray showed that the tip of the catheter was at the level of the 7th thoracic vertebra (Fig. 2a). The Doppler ultrasound showed poor vascular condition in both hands.

Continuous pumping of urokinase through the end of the catheter showed poor results. On July 21, 2021, the patient underwent removal of the TC-CVC + central venous catheterization + intraluminal balloon dilation under DSA. Cavography of the superior vein showed no vascular stenosis (Fig. 2b). It was not possible to withdraw the line after releasing the subcutaneous cuff and dissecting the surrounding tissue. Considering that there may be an intravascular fibrin sheath. Extubation still failed, even though intraductal balloon dilation was performed (Fig. 2c). On July 22, 2021, the patient received a non-tunneled CVC (NT-CVC) in the left femoral vein to maintain dialysis. On July 27, 2021, the patient underwent removal of the TC-CVC + thoracotomy + exploration of the SVC + central venous catheterization. A mid-sternal thoracotomy was performed to expose the brachiocephalic vein and the external pericardial segment of the SVC. The dialysis tube could be reached in the left brachiocephalic vein, but the catheter could not be removed due to severe adherence. The SVC and the distal end of the left brachiocephalic vein were blocked, and the innominate vein was dissected. The catheter was removed from the fiber bundle after local release of the adhesion and a new dialysis tube was reinserted. The follow-up procedure to the surgery was the same as for the first patient above. The patient's hemodialysis went smoothly during the follow-up period.

Discussion

Establishing reliable vascular access is the premise for the long-term survival of patients with end-stage renal disease who depend on hemodialysis. AV fistulas, AV grafts, and hemodialysis catheters are the three main forms of vascular access for hemodialysis. The 2019 KDOQI guideline recommends selecting vascular access based on the principle of "patient priority" [2]. CVCs seem the only access for patients with exhausted vessel resources. However, Murakami et al. [16] recently reported that there were four types of vascular access: AVF, AVG, arterial superficialization, and TC-CVC in Japan. They found that AVF usage may have the lowest risk of all-cause mortality. Their study also suggested that the usage of arterial superficialization may be associated with better survival rates compared to those of TC-CVC in patients who are not suitable for AVF or AVG. Due to poor heart function and vascular condition, 2 patients described above were unable to use the AV fistula as dialysis access. The second patient was unable to undergo peritoneal dialysis due to thrombotic thrombocytopenic purpura. Therefore, the CVC was the salvation for the 2 patients to maintain dialysis. Lawson et al. [3] pointed out that 10% of uremic patients in China use CVCs as dialysis access.

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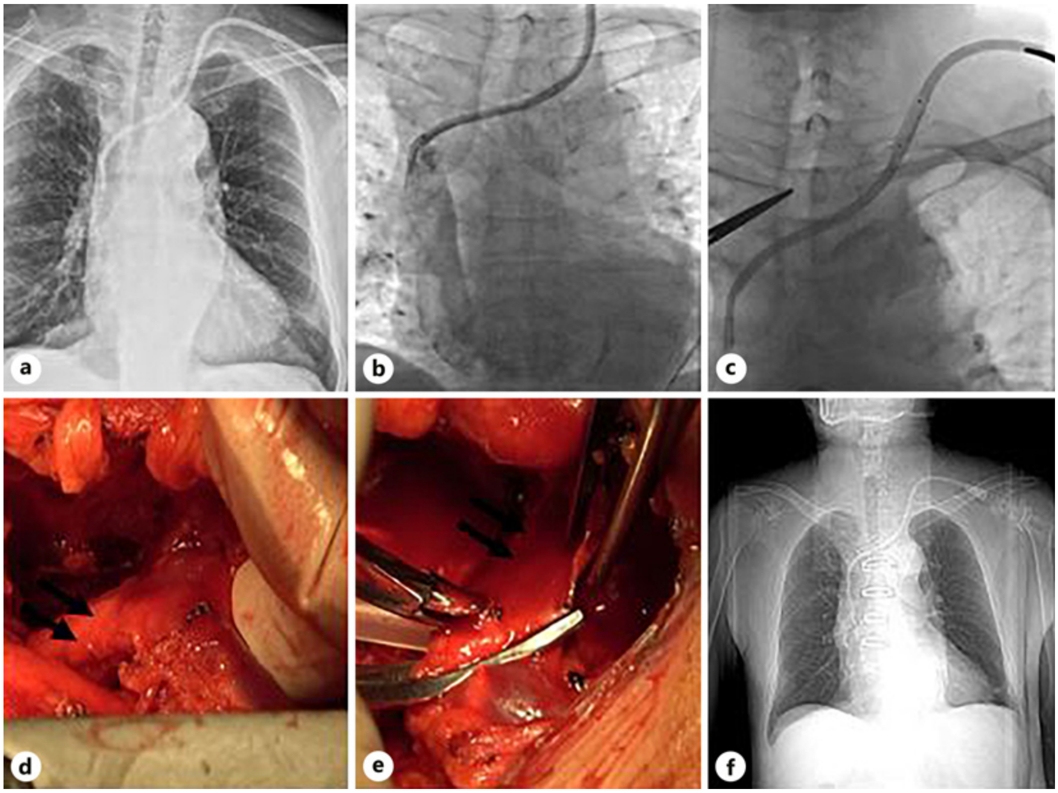

Fig. 2. Preoperative, intraoperative, and postoperative catheter status of the second patient. **a** Angiography showed the position of long-term hemodialysis catheter in the left internal jugular vein before surgery (the end of the catheter was flush with the level of the 7th thoracic vertebra). **b** Angiography showed that the patient's superior vena cava had no obvious stenosis. **c** Intraductal balloon dilatation was performed to assist extubation under DSA. **d**, **e** Fibrin sheath was found around the catheter during thoracotomy. **f** X-ray showed the postoperative position of long-term hemodialysis catheter in the left internal jugular vein (the end of the catheter was located in the shadow of the right atrium, which was flush with the upper border of the 10th thoracic vertebra).

More catheter removal failures have been reported due to a stuck catheter. The main risk factors for a stuck catheter include a long-term catheter placement, a history of central venous stenosis, infections, and repeated catheterization [17]. Patients with hypercoagulation, obesity, and disturbed calcium and phosphorus metabolism disorders are more likely to have catheter incarceration [18]. It is difficult to remove a stuck catheter using the normal technique. Forced removal can cause catheter rupture and avulsion of the vessel wall, which can lead to cardiac tamponade, hemothorax, and hemorrhagic shock [7, 12]. There is no standardized solution for dealing with stuck catheters. Currently, the Hong's technique and intraluminal PTA with blunt dissection are suggested as effective and safe methods for stuck catheters [19]. Open surgery, laser and non-laser resection of the sheath, and maintenance of the residual part in situ are alternative treatments for stuck catheters. As in the 2 patients described in our article, thoracotomy was considered when the catheter could not be successfully removed after several attempts. Forced extubation should be avoided to prevent serious complications.

The dysfunction of long-term indwelling catheters is usually related to the fibrin sheaths around the catheters [3, 4, 6]. Fibrin sheath formation is an important cause of catheter dysfunction, central venous stenosis, and also affects the blood flow of newly inserted catheters. The long residence time can promote calcification of the fibrin sheath

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and hyperplasia of the tissue around the catheter. Thus, the catheter adhered to the blood vessel and became stuck catheter [12, 13]. The thrombus associated with the catheter is the basis for the formation of the fibrin sheath [20, 21]. Currently, there are four methods for solving the peri-catheter fibrin sheath problem: transcatheter thrombolytic infusion technique, percutaneous fibrin sheath stripping, intrapipeline trapping technique and interventional catheter replacement technique [21, 22]. The K/DOQI guideline suggests that the method of catheter replacement method combined with balloon angioplasty is more reasonable [22].

Transcatheter venography is a widely accepted imaging method today [23]. Fibrin sheath formation can be detected by venography during catheter replacement in patients with poor catheter function, but this method usually requires extubation. Color Doppler ultrasound is a noninvasive, inexpensive, and convenient method for detecting and diagnosing the fibrin sheath. However, for patients with a thick fat layer and blood vessels occluded by body bones, the results of ultrasound observation are not ideal [23]. Regular and early sealing of the catheter and infusion of urokinase are considered to be effective in preventing and treating fibrin sheath formation, thus improving the quality of life of hemodialysis patients [14, 15]. Periodic angiography of the SVC and replacement of hemodialysis catheters can prevent catheter incarceration. Recent studies have reported that printing a newly designed micropattern on the catheter can reduce the formation of fibrin sheath formation [24].

Knowledge and experience of the standardized solution for stuck catheters are still insufficient; to date, there is no standardized procedure for dealing with stuck catheters. Intraluminal PTA should be considered as the first-line treatment, while open surgery represents a second option only in the event of failure. Care must be taken that forced extubation can cause patients life-threatening. Close cooperation with multidisciplinary experts can enrich our relevant knowledge to provide better guidance on how to deal with the stuck catheter in the best way.

Statement of Ethics

The study was approved by the Ethics Committee of the Renmin Hospital of Wuhan University (WDRY2021-KS036), and the study procedures complied with the ethical standards of the committee responsible for human experimentation. Written informed consent was obtained from the patient (cases 1 and 2) for the publication of the details of their medical case and any accompanying images for clinical research.

Conflict of Interest Statement

All authors have declared no conflict of interest.

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Author Contributions

This study was conceptualized by Hongyan Liu. Yanqin Fan and Dejiao He reviewed the literature and wrote the manuscript. Jing Cheng and Zhenzhong Wu collected data. Yiqun Hao was responsible for data sorting. Hongyan Liu directed and revised manuscripts. The article has been read and approved by all authors.

Data Availability Statement

All data generated or analyzed during this study are included in this paper. Further inquiries can be directed to the corresponding author.

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