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DEALING WITH STUCK HEMODIALYSIS CATHETER: STATE OF THE ART AND TIPS FOR THE NEPHROLOGIST

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ABSTRACT

The term *stuck catheter* refers to the condition in which a catheter is not removable from a central vein using standard techniques. Although it is a rare complication, in the last few years it has been reported ever more frequently in hemodialysis due to the widespread use of tunneled catheters. Poor knowledge of the correct procedures and limited experience and training of the specialist in facing this problem are the main reasons for catheter internalization. Stuck catheter is often diagnosed by the nephrologist who should be competent enough to manage this clinical complication. Among the many options for removing a stuck catheter from the fibrin sleeve, an *interventional radiology* approach, mainly with endoluminal balloon dilatation, probably provides the best solution. Vascular surgery should be reserved to selected cases in which percutaneous techniques have failed. Nephrologists must play a central role in organizing the treatment of this complication with other specialists in order to avoid making mistakes that may preclude future positive results.

Key Words: stuck catheter, retained catheter, embedded catheter, internalization of central venous catheter

INTRODUCTION

The use of tunneled catheters (tCVCs) as long term central venous access for hemodialysis has significantly increased in the last decade (1). Several factors have influenced this occurrence, ranging from aging of uremic patients who have numerous co-morbidities to organizational factors that very often negatively affect AVF creation and rescue. Despite

undeniable advantages, tCVCs continue to be at risk for medium and long term complications (2). Among them, infection still raises the main concern, despite the progress that has been made in preventive measures (3). An increasing number of reports regarding the mechanical complications of stenosis and thrombosis as the consequence of damage to the vascular wall have also been described (4). Tunneled catheter insertion is frequently a definitive indication, with the need for possible removal/exchange owing to infection or dysfunction. The right jugular internal vein is the preferred site of insertion due to the straight path of the innominate-cava trunk, followed by left internal jugular vein; the femoral vein may be considered when the neck vessels are no longer accessible, but special attention should be paid in patients who are current or future kidney transplant candidates. More recently, the stuck catheter, also known as “retained”, “embedded” or tethered” has been reported among the mechanical complications. It makes removing the catheter by standard techniques extremely difficult or even impossible because of the tight adherences between the catheter and the vessel wall in one or more points of the endovascular segment. The definition of “stuck catheter” does not include states of adherence in the subcutaneous tunnel of the CVC. The first case of a stuck hemodialysis catheter was reported in 2005, and was complicated by CVC fracture and the allocation of a segment in the vessel lumen (5).

THE STUCK CATHETER: AN ISSUE STILL TO BE FOCUSED ON

In clinical practice, the typical indications for catheter removal or exchange include infection that does not respond to antibiotic therapy, malfunction that is not otherwise resolvable, symptoms and signs of central venous obstruction and central vein thrombosis, end of use of the AVF, and a switch to different replacement treatments (PD or transplantation).

Routine surgical removal is usually done by means of a skin incision to free either the cuff from the subcutaneous fibrous tissue or the catheter from the surrounding fibrin sleeve. The procedure is quite simple and is usually performed in local anesthesia, thus allowing the intravascular catheter to easily slide out. However, when dealing with a stuck catheter, once the cuff has been dissected, the catheter cannot be unthreaded, despite strong traction. It must be pointed out that a significant force of traction may give rise to retrosternal pain with neck radiation, tachycardia, ST depression on ECG, NSTEMI (non-ST-segment elevation myocardial infarction) and vasomotor collapse, central vein or atrial wall injury with fatal outcome and possibly CVC rupture (5-6). The true incidence of catheter retention is not known: anecdotal reports and small surveys have been published, nonetheless the phenomenon is most likely under-reported. The greatest experience with stuck catheter is reported in pediatric patients with hematologic disorders resulting in a high incidence of retained lines (7-8).

We recently presented the preliminary results of a survey of 21 cases of stuck tCVC confirming the impression of an unacknowledged phenomenon (personal data). The widespread use of tCVC will likely increase the incidence of stuck catheters, and nephrologists need to be trained to correctly manage the problem.

STUCK CATHETER: PATHOGENESIS AND CONTRIBUTING FACTORS

Cumulative indwelling time is by far the most important factor in the pathogenesis (9), but this complication may occur even shortly after insertion (personal data). Both site and side of cannulation undoubtedly play an important role, presenting greater risks in the left jugular and brachiocephalic veins where three curves and friction points between catheter and vessel are found. Among other factors, female gender, small vessel caliber, past episodes of infection (favoring a prothrombotic state), repeated catheterizations in the same vessel (9) and damage to the CVC wall (7) should also be considered. Type of CVC material (Pu/Silicon) does not seem to influence the phenomenon (9). The presence of pacemaker wires, ICDs and stents may favor vascular injury and adherence formation (10). Finally, other possible contributing factors include an existing functioning AVF ipsilateral to the catheter leading to intimal damage and wall thickening (11) or calcification inside the fibrin sleeve.

In the literature, the diameter of the CVC has not been taken into consideration as a potential risk factor for line retention. According to Poiseuille's law, increasing the caliber of HD catheter is essential in order to achieve high blood flow but it may favor blood stasis and possibly even catheter-associated central vein thrombosis. The tendency to insert large-bore HD catheters is actually somehow in contrast with the recommendation by *Twardowsky* "to adapt the catheter to the vein" (12). Nevertheless, it should be emphasized that catheter retention is well documented with different types of small caliber lines including pacemaker leads. Therefore, even if a high ratio of catheter/vein caliber may not be excluded as a risk factor for stuck catheter, the previously reported elements should be taken into account first (Table 1).

At the tissue level, the "stuck" phenomenon is determined by the presence of a fibrin sleeve or *fibrin sheath* that develops shortly after catheter insertion. It progressively wraps itself around the catheter, rising from the entry point towards the tip as occurs in the subcutaneous segment(13). Post-mortem animal studies carried out <14 days after catheter insertion showed *foci* of local intimal injury, endothelial denudation and adherent thrombus. Smooth muscle cell proliferation takes place in long-term catheters, thus leading to vein wall thickening and focal areas of catheter attachment to the vein wall, with thrombi in different stages of organization. Collagen and endothelial cells can also be detected. Indeed, in addition to fibrin, we may observe collagen and smooth muscle cells that from the damaged vessel wall to the thrombus adherent to the catheter and covered by endothelium (14). This encapsulating sleeve may firmly adhere to the vessel wall. Proliferating fibro cellular tissue or thrombi at the distal side holes of the catheter may lead to adhesion to the atrial wall.

Why these factors promote envelopment of the catheter in some, but not in all patients remains unclear.

STUCK CATHETER: REMOVAL TECHNIQUES

Being a rare and unpredictable event, stuck catheter is commonly diagnosed when removal/exchange is scheduled, taking operators unawares. Sites of adhesion may be located in different points of the endovascular part, from the entry site up to the atrium when dealing with a jugular catheter.

Various diagnostic imaging techniques may be used: ipsilateral upper arm phlebography to identify obstruction and collateral circles, MRI (magnetic resonance) in order to detect organized thrombi and fibrous tissue in the sites of adherence (9), and CT (computed tomography) to gain complete imaging of the mediastinal vasculature. Lu et al also described a calcified fibrin sheath revealed by TEE or CT that was masquerading a retained catheter (15).

Several approaches for freeing a stuck catheter, especially in pediatric and oncologic patients, have been described. Lack of knowledge about the effectiveness of these techniques and misleading indications have led to a number of intervention failures and tCVC internalization, i.e., *buried catheter*. It must be emphasized that the procedure for removing an embedded catheter has to be performed by expert operators due to the potentially life-threatening complications that may arise, regardless of the technique that is used (16).

Interventional radiology and cardiovascular surgery have both contributed to overcoming these difficulties. Percutaneous techniques currently confine surgical options to selected cases and are no longer the first treatment choice.

The surgical approach consists in skin and subcutaneous dissection in order to expose the catheter at the vein entry site and remove the peri-catheter fibrous tissue. The success rate is not high because adhesences may occur in several points along the intravascular segment. Furthermore, this maneuver may result in CVC and vessel rupture in case of traction (5,6,17).

Although successfully reported (18-19), thoracotomy carries a high surgical risk in feeble patients and should be adopted when other techniques fail and catheter removal is mandatory. In these situations, it is foremost to weigh the risks between a surgically aggressive approach and line internalization.

In recent years, interventional radiology has benefited from technological improvements and provides a great deal of opportunities for stuck catheters.

Schematically, two typologies of sets for procedures of debridement of retained lines from the host vessel are presently available: the first works *inside the vessel* but outside the catheter, while the other operates *inside the catheter*.

Among the devices in the former group, a wide range of technical characteristics, efficacy, safety, and costs are available.

With regard to the *external* approach, Hong suggested using an introducer sheath. A subcutaneous segment proximally to the cuff is extracted by dissection at the vein entry site, and is firmly anchored by a long heavy thread. A guidewire is inserted through the lumen

into the superior vena cava. Thread and guidewire are then inserted into the distal part of a matching size introducer for the catheter and the latter is advanced under fluoroscopy over the catheter along the jugular vein. The cutting edge of the introducer works by *de facto* breaking the external adherences around the line while this is gently pulled until it is released (20). This procedure implies some limits: if tight fibrosis is felt at the vein entry site, the introducer may encounter resistance upon insertion. Moreover, in case of the left side, friction points make advancing the sheath introducer a hazardous maneuver with sequelae of phlebitis. These difficulties and the risks associated with a peel-away insertion make it preferable to avoid introducers in the left side, where using a catheter with stylet is recommended.

Another technique involves cutting the adherences and releasing an extravascular portion of the catheter by dissecting it at its entry point and then introducing a stiff guidewire through the line and forming a snare using a second wire. A second snare is inserted into the femoral vein to steady the catheter tip. The wire that is placed around the catheter by a to and fro motion cuts the line free from the sidewall of the vein. Despite the relative speed of the procedure (15'), Foley et al report incomplete removal of the catheter with a residual fragment left in situ (21). Although no consequences are reported regarding this case, there is still the possibility of long term and potentially life-threatening complications (22).

Using a similar approach, McIntyre inserts a hydrophilic wire into the superior vena cava over the tethered portion of catheter (10). The wire is captured with a Gooseneck snare and recovered externally through the femoral vein sheath. Using a sawing motion, the two ends of the wire are used to cut through the adhesions, allowing the catheter to be removed through the femoral sheath.

Two other similar systems are available: a sophisticated device employed by cardiologists in order to extract retained PMs or ICDs. The Evolution[®] Mechanical Dilator Sheath Set acts like a drill around the catheter. Once a brief segment of the subcutaneous part of the line has been isolated, the device is advanced in the vascular lumen disengaging cicatricial and calcified tissue (23). Use with hemodialysis catheters has not been reported, but the maximum internal diameter that is available (13F) might be compatible with some types of tCVC.

A promising use in hemodialysis has been described using laser technology (24) (Spectranetics Inc) in three patients with stuck catheter and previous surgical cut-down failure. The procedure demands heavy sedation, is poorly accessible and extremely expensive; a laser sheath maximum internal diameter of 12.5F limits its application to small-bore CVCs.

The second type of interventional approach involves exerting high endoluminal pressure inside the catheter, which thus expands the lumen and stretches the wall, thereby breaking the adherences between the catheter and the adherent vein (Photo 1). The dilatation of the catheter wall also expands the vein presenting stenosis or fibrosis and as a consequence the procedure requires moderate sedation to control pain during balloon inflation. Since 2011, a high success rate for endoluminal balloon dilatation has been reported in the literature.

Hong et al. reported positive results in a patient with a large-bore bilumen catheter who had a history of unsuccessful surgery (25). Hong's technique involves inserting a guidewire into the catheter lumen up to the atrium, while the line is held in place by a clamp. A PTA balloon (5 mm x 4 cm) is then inserted over the wire, inflated and deflated step by step along the catheter from the entry site toward the tip

Other authors later reported the successful use of this technique without complications (26,27).

Quaretti et al. (28) recently modified Hong's technique to make it safer. This refinement involves the use of a valved introducer to avoid air embolism and thrombosis and a stiff wire insertion into the catheter lumen in the inferior vena cava. By doing so, atrial damage is prevented; the stiff guidewire makes it easier to advance the low profile balloon of greater diameter and length and perform dilatation of the vessel if necessary. Once the PTA balloon has been set free from the adhesion, mild inflation may offer an extra grip during extraction thus avoiding ruptures at high friction points. A 100 per cent complication-free success rate has been reported (28). Hong's modified technique is easy and safe in expert hands; however, it requires perfect knowledge of the physical and mechanical specifics of implanted catheters that are usually resistant to high endoluminal pressure, but potentially weak at specific sites. This was the case with our patient in whom CVC wall rupture occurred after high pressure inflation and the balloon was temporarily stuck in the stuck catheter. The interventional radiologist was eventually able to remove both by sliding the other line of the dual Tesio catheter and creating enough space to work with the remaining line (Photo 2).

DISCUSSION

The occurrence of retained tCVC is relatively rare in hemodialysis but the nephrologist needs to know, in advance, how to manage the situation properly (9,17,29).

The high incidence of "stuck" catheters that is observed in the pediatric population with malignancy (7,8) may not be comparable to the incidence of stuck HD catheters in adults. In these series, the authors hypothesized the possible role of small alterations on the surface of polyurethane and the use of chemotherapeutic agents that may contribute to the process of catheter fixation. Furthermore, hydrophilic low-friction coatings that are sometimes applied on polyurethane catheters to prevent intimal injuries and thrombus formation have not been used (8Wilson).

The unforeseen occurrence of an internalized CVC is worse if the catheter has been cut and a segment of line is not available to attempt a delayed interventional procedure (Photo 3).

A buried catheter theoretically represents an infective and thrombotic risk, and, in dialyzed patients, it could imply the definitive loss of a future vascular access.

Removing a stuck catheter does not preclude the possibility of inserting a new tCVC in the same vessel (27), and in any case it maintains or restores drainage from the ipsilateral side.

The transplant waiting list should be taken into account, as should the infectious risk associated with a foreign body in patients on immunosuppressive therapy (9). The possibility that a retained catheter may become a hotbed for infective or thrombosis events has been reported in non-uremic patients (30). Nevertheless, it has to be considered that no long term complications have been noted in our study except for one patient requiring stent implant due to partial obstruction of drainage from the ipsilateral AVF (personal data).

In case of prothrombotic events, some authors adopted anticoagulant and platelet inhibitor therapy (9), but official recommendations for antibiotic or antithrombotic prophylaxis in patients with buried lines have not been published.

Inserting a new tCVC in the contralateral side of a stuck catheter, as some colleagues did because of the high risk of superior vena cava syndrome should be carefully evaluated (6,28). In one of these cases, the stuck catheter was successively removed by the modified Hong's technique (28) (Photos 4-5).

Currently, the stuck catheter problem may be faced in a sensible and less invasive way; when a stuck catheter will not slide out on the first attempt, it is possible to postpone its removal by leaving a short portion (a few centimeters long) "sheltered" under the skin, that would be suitable for interventional procedures. Therefore, except for rare situations of severe sepsis requiring urgent removal, the stuck catheter never actually represents a real emergency. Accordingly, immediate internalization of the CVC is no longer acceptable.

Some authors recently recommended replacing the CVC every two years to prevent the stuck catheter phenomenon (31). Considering how rare this event is as related to the extensive use of tCVC, and above all the non-negligible risks of catheter guidewire exchange, the justifiability of this solution is questionable. This certainly would lead to an increase in costs and eventually in the number of complications.

The above mentioned suggestion is probably unfeasible. In our opinion considering the increasing risk of complications related to the development of the fibrin sleeve and the loss of mechanical properties of the catheter over time (as manufacturers declare as well), it should be safer to plan a replacement of a catheter that has been *in situ* for several months in a well-equipped operating context, supported by expert specialists. The high success rate in case of stuck catheter together with the low costs related to the correct endovascular procedure widely anticipates the innate risk of a routine guidewire exchange of a tCVC.

CONCLUSIONS

Stuck catheter is a rare complication in hemodialysis and its frequency will very likely increase in the future. The endovascular option, specifically the endoluminal balloon dilatation, is the first line treatment but more importantly, the nephrologist must correctly manage the pre-procedure phase, avoid the definitive CVC internalization and only sending the patient to an interventional radiologist with expertise in handling this type of complication.

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Table 1 Potential risk factors associated with the stuck catheter phenomenon

Cumulative catheter dwell time
Laterality of insertion site (left)
Intermittent catheter infection
Intimal injury of the vein
Gender (female)
Ipsilateral AVF
Material composition or damage of catheter
Previous catheterization in the same vessel
Presence of a stent or PM
Calcification

Fig. 1 Endoluminal balloon inflation of the catheter

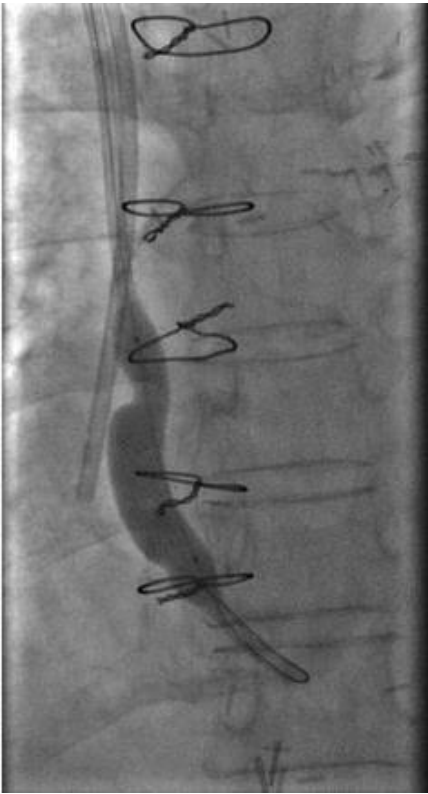


Fig. 2 Broken catheter after balloon inflation



Fig. 3 Stuck catheter cut at the vein entry site

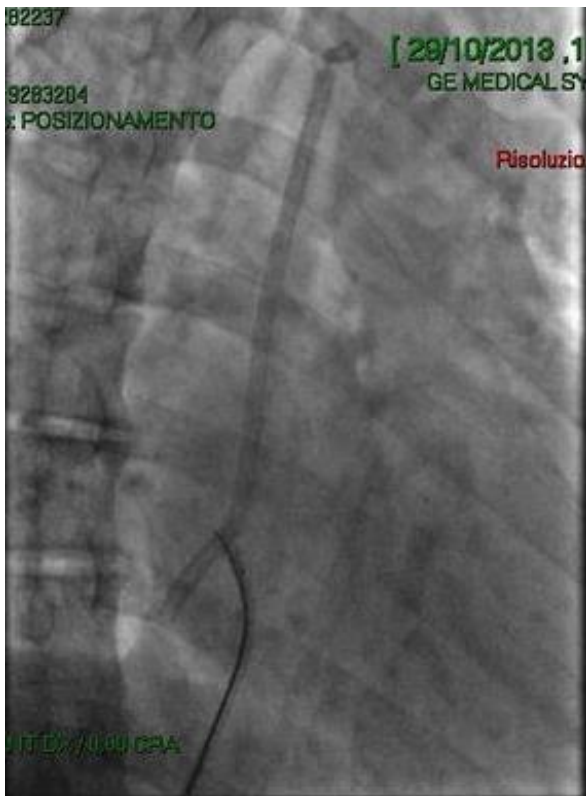


Fig. 4 Stuck CVC (left Tesio catheter) with subsequent implantation of right tCVC

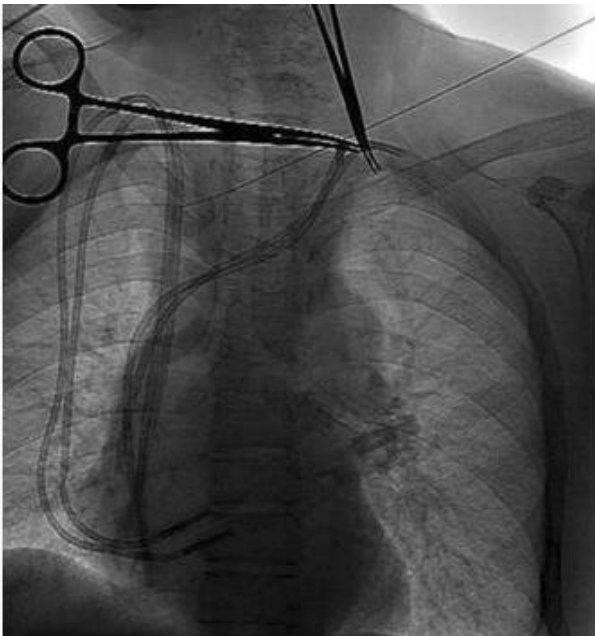


Fig. 5 Final image after left stuck CVC removal with Hong's modified technique

