Management of Catheter Related Fibrin Sheath by Balloon Disruption

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ABSTRACT

Background: *Catheter-based hemodialysis remains a distinct valid option in many patients with chronic kidney disease (CKD). Catheter related fibrin sheath (CRS) formation is responsible for a significant proportion of catheter dysfunction; moreover, the presence of CRS at the time of catheter exchange significantly reduces subsequent catheter function. Several strategies have been described for management of CRS. However, no consensus has been reached about the preferred technique, associated with the longest catheter patency.* ***Aim of the study:*** *We report our experience in management of tunneled hemodialysis CRS by means of balloon disruption followed by over guidewire catheter exchange.* ***Patients and methods:*** *Between November 2011 through March 2015, 26 patients (female, n=15; male, n=11) with end stage renal disease (ESRD) undergoing catheter-based hemodialysis (CBH) with age range from 25 to 77 years (mean, 50.8±13.1 years) were included in the study. The studied patients had episodes of catheter dysfunction with clinical and/or radiographic evidence consistent with the presence of a CRS on either the arterial and/or venous port. All patients were subjected to catheter directed balloon disruption of their CRS at the time of catheter exchange. Patients were followed-up prospectively for technical success, complications, catheter patency, and short-term outcome.* ***Results:*** *The technique was successful in all patients with adequate aspiration and infusion capabilities of both ports of the newly inserted catheters. No periprocedural complications were reported. Patients were followed for a minimum of six months to assess for recurrent catheter dysfunction, time to repeat catheter exchange, mean blood flow during hemodialysis treatment, and adverse events.* ***Conclusion:*** *Balloon disruption of CRS proved to be safe and effective in maintenance of vascular access with durable catheter patency. Additionally, the procedure can tackle concomitant central vein stenosis with eventual chance of future AV fistula creation.*
Key words: *Tunneled hemodialysis catheters, catheter related fibrin sheath, balloon disruption.*

INTRODUCTION

Catheter based hemodialysis (CBH) is considered in a significant proportion of ESRD patients despite of the emphasis of the (Fistula first) concept. The need for long term CBH continues to be encountered in patients requiring immediate dialysis, awaiting the creation or maturation of AV access, having exhausted safe permanent options, fragile patients with systolic hypotension & limited tolerance to arteriovenous fistula (AVF) related hemodynamic changes, and those with limited life expectancy. [1]

Since it was first described, [2] several terms have been given to describe the physiologic reaction that occurs between the catheter, vein wall, and blood elements. It has been referred to as a fibrin sleeve, a sleeve thrombus, a sleeve, and most recently, the catheter related fibrin sheath. [3-5] CRS starts to develop within the first 24 hour of insertion of central venous catheter (CVC) and can cover the entire length of a catheter within a week. Even a cannula that is inserted into a periphery vein can acquire a fibrin sheath. Moreover, the port of port-A-cath acquires the same sheath that continue to cover a variable length of its catheter, [6, 7] *picture (1).*

The incidence of CRS development ranges from 42% to 100% that may remain clinically asymptomatic. However, CRS can eventually manifest clinically into a variety of complications that include withdrawal occlusion (one-way obstruction), total catheter occlusion, vein thrombosis, medication extravasation, pulmonary embolism at catheter removal, and predisposition to infection with an overall worsening impact on repeated catheter removal and replacement up to loss of an access route. [8-13]

Several strategies have been described to deal with CRS including thrombolytic therapy, stripping of the sheath, and disruption using wires and balloons together with catheter exchange. [14-20]

We hereby report our experience in management of tunneled hemodialysis CRS by means of balloon disruption & over the guidewire catheter exchange.

PATIENTS AND METHODS

Patients

This study was conducted mainly at the faculty of medicine, Kasr Al-Aini hospital, Cairo University from November 2011 through March 2015. The study group included 26 CBH patients (15 females and 11 males). Demographics, height, weight, presence of diabetes, duration of dialysis, vascular access history, use of antiplatelets or anticoagulants, hemoglobin level, and coagulation profile were collected as baseline for each patient.

Their age range was 25-77 years (mean, 50.8±13.1). The most common co-morbidity was hypertension in 19 (73%) patients. Other co-morbidities included type I diabetes mellitus in 6 (23%) and type II diabetes in 5 (19%). Four patients (15.3%) had ischemic heart disease.

All patients had 15.5-French dual lumen catheters, 21 (81%) patients had a low lying tunneled, cuffed internal jugular vein (IJV) catheters and 5 (19%) patients had a tunneled, cuffed subclavian catheter in place. Twenty two (84.6%) patients had right-sided catheters and 4 (15.4%) had left-sided catheters with an average catheter insertion period of 23.9±11.1 (range 10 to 51) weeks. At least one criterion of catheter dysfunction was detected in each patient with withdrawal occlusion as the most common dysfunction criterion detected in 15 (57.6%) patients.

The potential benefits and risks of the endovascular treatment were explained to each patient, and written informed consent was obtained. Each patient was also informed for a possible need of angioplasty ± stenting of central vein. The procedure and the prospective study were conducted in accordance with the local ethics committee rules.

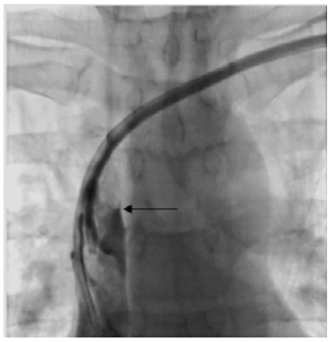
Technique:

All procedures were carried out in the Cath. Lab. Patients were positioned supine on the operating table. After applying antiseptic and draping, the procedure began with injection of contrast medium into the catheter connection (if either is patent), *picture (2),* at a rate of 2-5 ml/sec.

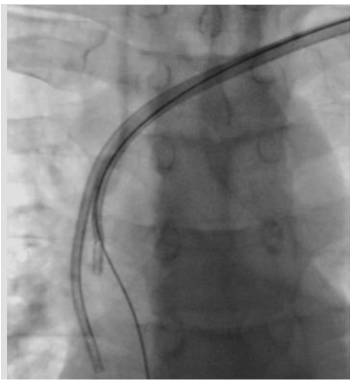
Lignocaine 2% is injected in the subcutaneous tissue at the vein puncture site (through which the catheter had initially been inserted into the vein). Skin was incised for a length of 1.5 to 2 cm and catheter was dissected free and hooked by a suitable hemostat. Another injection of lignocaine was carried out in the subcutaneous tissue around the Teflon cuff. The latter was dissected free from the surroundings after making 1 cm skin incision. Catheter was clamped at the vein puncture site and chopped off peripheral to the clamp. The part of catheter peripheral to where it had been cut is pulled out of the tunnel and discarded.

The stump of the catheter was cannulated by a 0.035” wire through one of its lumens into the superior vena cava, *picture (3).* The remaining part of the catheter was pulled out and discarded while the wire was maintaining the access. A 10 F sheath was then advanced over the 0.035” wire into the vein. Another injection of contrast medium was carried out through the sheath, picture *(4).* CRS site, length and extent were identified. A balloon in length and diameter (from 8 to 12 mm X 40 to 80 mm) suitable to vein being treated was advanced over the wire through the access sheath, *picture (5) & (6)*, and inflated. Check angiogram was obtained following each balloon deflation, picture *(7).* Balloon disruption was repeated whenever necessary and might be with larger balloon according to the operator’s discretion. A new 15.5 F dual lumen cuffed CVS (in a suitable length) was inserted down to the upper part of the right atrium after being tunneled, *picture (8).*

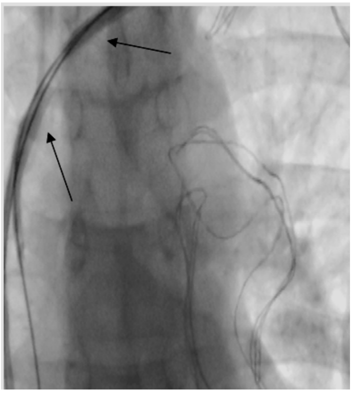
Picture (1): Extirpated port showing complete envelop of the fibrin sheath.



Picture (2): Contrast injection through malfunctioned (CVC). Fibrin sheath being formed around its tip, mainly at its arterial channel, arrowed.

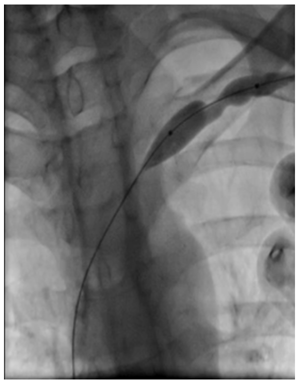


Picture (3): A 0.035" guidewire was advanced into the SVC through the stump of the catheter.

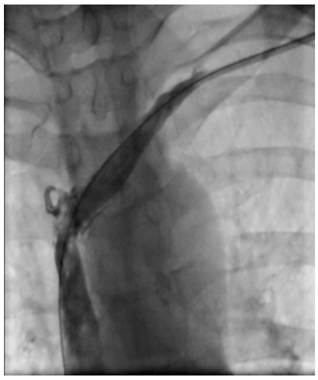


Picture (4): Contrast injection through the access sheath, upper arrow. Fibrin sheath, appeared as if the CVC had not been removed, lower arrow.

Picture (5): Balloon disruption applied to the lower part of CRS.



Picture (6): Balloon disruption applies to the upper part of CRS.



Picture (7): Completion angiogram after disruption of CRS.

Picture (8): A new CVC was inserted into the upper part of the right atrium.

At the first dialysis treatment after the exchange, patients were reassessed about the presence of cough, shortness of breath, chest pain, fever, and local symptoms at the exit site (pain, bleeding, redness, and/or swelling) experienced between the exchange procedure and the dialysis treatment. Patients were followed prospectively at each hemodialysis treatment for a minimum of 6 months. Parameters of catheter function included total volume of blood processed, need for lumen reversal, and blood flow rate (250-350 ml/min).

RESULTS

The procedure was performed in 26 cases that were diagnosed as having dysfunctional hemodialysis catheter over a 40-months study period. Patient's demographics and base line characteristics are shown in table 1.

Table 1: Patients demographics and baseline characteristics

Variable	***Value***
No. of patients	26
Age in years (Mean ± SD)	50.8 ±13.1
Catheter insertion period (Mean ± SD) days	361±57
Female (*n* [%])	15 (57.6)
Male (*n* [%])	11 (42.3)
Hypertension (*n* [%])	19 (73)
Diabetes (*n* [%])	11 (42.3)
Ischemic heart disease (*n* [%])	4 (15.3)
Height (cm; median)	167
Weight (kg; median)	67.5
Body mass index (kg/m^2)	21.5
Catheter use (Mean ± SD) weeks	23.9±11.1
Right-sided catheter (*n* [%])	22 (84.6)
Left-sided catheter (*n* [%])	4 (15.4)
Dysfunctional IJV catheters (*n* [%])	21 (81)
Dysfunctional subclavian catheters (*n* [%])	5 (19)
Previous catheters (median)	2.0
Previous AV fistula(s) (*n* [%])	21 (80.7)
Previous AV graft(s) (*n* [%])	3 (11.5)
Antiplatelets (*n* [%])	5 (19.2)
Anticoagulants (*n* [%])	4 (15.3)
Hemoglobin (mean)	9.5
INR (mean)	1.2

Initial clinical success in our series was achieved in all patients (26/26) as evidenced by restoration of target flow rates on subsequent hemodialysis. The median procedure time was 32.6±5.8 minutes. No reports of post-procedure bleeding, shortness of breath, cardiac arrhythmias, hospital admission, or pulmonary embolism were reported. Patient complaints were limited to pain experienced during the balloon inflation. There were no mortalities.

DISCUSSION

Long decades of clinical experience have concluded very strong evidence of superiority of an AVF when compared to a hemodialysis catheter in terms of longer patency rates, less likelihood of thrombosis and higher resistance to infection in the context of long-term hemodialysis. However, CBH still maintains its role in certain situations. [24, 25]

Possible explanations of CRS formation are provided, however, none is certain. From the histological point of view, CRS is described as cellular-collagen tissue covered by an endothelial layer. Fibrin was described as a component of an early physiologic response to the catheter that consists of pericatheter thrombus, but the CRS itself is not composed of fibrin. [27] Further studies concluded the concept that CRSs are more likely representing a spectrum of thrombosis and thrombus organization. [28, 29]

CRS is believed to develop within the first 24 hours of catheter insertion and can cover the entire length of catheter within a week. Interestingly, similar sheaths develop around cannulas when they are inserted into a periphery vein. Inflected trauma and incited microthrombosis occurring during catheter insertion could have a role in the genesis of CRS. Vein trauma is not limited to the insertion of the CVC. Being fixed at its tunnel by the Teflon cuff while its distal end is free in a large central vein, CVC continue to chafe the venous wall upon bending of the upper trunk and movement of patient's neck. [30] Moreover, trauma may stand behind the higher propensity of the CRS to develop around the arterial than the venous limb. Shear and pressure drop (representing trauma) are more around the arterial than the venous limb during dialysis, therefore, explaining such propensity. [32]

Currently, a number of strategies have been postulated for management of CRS. These include thrombolysis infusion, percutaneous fibrin sheath stripping, and catheter exchange. However, most of these measures have shown limited technical success. In addition, the enthusiasm of using thrombolysis in managing CRS, although supported by good initial results, is criticized by low patency of catheters beyond 1 month; hence, they represent a poor long-term solution.

Moreover, medical management with antiplatelet agents and vitamin K antagonists such as Warfarin are associated with an increased rate of bleeding complications without added benefit. [26]

The use of thrombolytic therapy in the treatment of hemodialysis catheter malfunction due to thrombosis is an initial, effective conservative approach to restore patency. The situation is different when thrombolytic therapy is applied to treat CRS.

The effectiveness of this modality in the treatment of CRS is limited owing to the significant cellular component of the fibrin sheath. In other words, the efficacy of thrombolytics in the treatment of CRS is parallel to its ability to interact with the thrombotic elements of the fibrin sheath, which are actually spares.[33]

Mechanical removal of CRS by percutaneous loop snare to prolong the function of these catheters has been reported in several reports with good early results. [23] However, the evidence of procedure success predictors in the literature are limited. More important, although uncommonly recorded, there is a theoretical risk of inevitable pulmonary embolism by CRS fragments. In another study that was performed to assess the efficacy of transvenous snare removal of CRS, it was concluded that the procedure did not provide durable benefit, in terms of longer patency periods, when treated tunneled hemodialysis catheters malfunction.[34] *Merport et al* concluded that treatment of dysfunctional catheters by over the guide wire catheter exchange for a new one, was significantly more likely to provide longer patency for the new catheter than did the percutaneous CRS stripping. Accordingly, it was suggested that the latter should not be performed as a routine therapy for catheter malfunction. [21]

In another report comparing the median patency periods after treatment of malfunctioning tunneled hemodialysis catheters by one of three techniques: over-the-wire catheter exchange (CE), fibrin sheath stripping (FSS) from a femoral vein approach, and over-the-wire catheter removal with balloon disruption of fibrin sheath (DFS) followed by catheter replacement with use of the same tract. All three therapies were equivalent in terms of immediate technical success, complication rates, and durability of catheter function during follow-up. Therefore, when one technique is to be chosen over another, factors other than the period of secondary patency should be considered, such as costs, patient's convenience and physician's preference.[22]

Several reports have concluded inferior outcome of catheter removal or exchange in patients with concomitant CRS and central venous stenosis (with an incidence of recurrence of catheter malfunction mounting to 100%) when compared with those with only CRS.[35] Consequently, wiring an established catheter track and balloon disruption is considered superior to other modalities of CRS management as it carries the potential advantage of dealing with possible underlying venous stenotic lesions. In the same context, the value of bringing an access central vein back to work would be maximized particularly in patients with limited access options. In addition, reviving central venous access is valuable not only for maintaining CBH, but also it restores the possibility of an ipsilateral future arteriovenous (AV) fistula creation when a subclavian vein is brought back to function.

Hemodialysis catheter exchange with or without CRS balloon disruption has been well described with comparable or even superior outcome compared to FSS. [36]

Given that, catheter exchange works in case of CRS through overtaking the fibrin sheath into a pristine segment of the vein in which the new catheter tip lies. In gist, catheter exchange does not do anything to the CRS. Moreover, it is not valid when the fibrin sheath forms in a configuration that no additional room of the vein is available for the new catheter to occupy transcending the fibrin sheath. This probability happens when the CRS develops around a low-lying (in the vein) catheter.

On the other hand, balloon disruption is not affected by the position of the old catheter and therefore by the length of the CRS. After the balloon disrupts the CRS the vein becomes ready to receive the catheter and provides the adequate flow of blood for the catheter to work properly.

In all patients, our results declared feasibility and safety of the balloon disruption technique with adequate function of the newly inserted CBH together with no significant procedure related morbidities. In other words, CRS balloon disruption can repave the way for another catheter to be inserted in the same access site.

CONCLUSION

Balloon disruption of CRS is proved to be safe and effective in maintenance of vascular access with durable catheter patency. Additionally, the procedure has the potential to tackle concomitant central vein stenosis with eventual chance of future AV fistula creation.

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