



# Assessment of Venographic Abnormalities during Replacement of Dysfunctional Tunneled Hemodialysis Catheters and Outcome of Endovascular Salvage Techniques

## 기능부전 터널식 투석용 도관의 교체 시 시행한 정맥조영술 결과의 분석과 혈관 내 치료 기술의 결과

Pae Sun Suh, MD<sup>1</sup>, Seon Young Park, MD<sup>1</sup>, Jinoo Kim, MD<sup>1</sup>, Chang Kwon Oh, MD<sup>2</sup>,  
Su Hyung Lee, MD<sup>2</sup>, Je Hwan Won, MD<sup>1\*</sup>

Departments of <sup>1</sup>Radiology, <sup>2</sup>Surgery, Ajou University School of Medicine, Ajou University Hospital, Suwon, Korea

**Purpose:** To assess the venographic findings of central venous abnormalities before exchanging dysfunctional tunneled hemodialysis catheters and the outcome of endovascular salvage techniques.

**Materials and Methods:** A total of 110 episodes of tunneled hemodialysis catheter dysfunction in 78 patients undergoing catheter-directed hemodialysis treatment from January 2011 to December 2015 were retrospectively evaluated. Venography was performed before catheter exchange, and the following procedures were conducted according to the venographic findings: balloon disruption of a fibrin sheath, angioplasty for central vein stenosis, or stent insertion. Technical success was defined as at least one successful session of hemodialysis with the exchanged catheter. Patients were followed until the study endpoints or the last hospital visit.

**Results:** Venography showed abnormalities in patients with 67 of the 110 exchanged catheters, including central vein stenosis ( $n = 27$ ), fibrin sheath formation ( $n = 17$ ), and thrombus formation ( $n = 12$ ). Technical success was confirmed in all cases. The estimated 30-day catheter patency for all assessable catheters was 61.7%. Nine catheters were removed during the follow-up period because of suspected catheter-related infections.

**Conclusion:** In approximately 60% of cases of dysfunctional tunneled hemodialysis catheter, abnormal venographic findings were observed in the patients. Following appropriate endovascular techniques could be helpful in improving catheter patency with a low risk of procedure-related complications.

### Index terms

Renal Dialysis  
Catheters  
Venography  
Endovascular Procedures

Received January 9, 2018

Revised May 10, 2018

Accepted May 16, 2018

\*Corresponding author: Je Hwan Won, MD  
Department of Radiology, Ajou University  
School of Medicine, 164 Worldcup-ro, Yongsong-gu,  
Suwon 16499, Korea.  
Tel. 82-31-219-5863 Fax. 82-31-219-5862  
E-mail: wonkwak@ajou.ac.kr

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## INTRODUCTION

Although the native arteriovenous fistula (AVF) is recommended as the first choice dialysis access for most patients with better outcomes (1-3), the usage of hemodialysis catheter is unavoidable in some patients; these include using catheter as a bridge before maturation of AVF or waiting for renal transplantation, and in elderly and diabetic patients having unsuitable vessels for AVF. The National Kidney Foundation-Kidney Dis-

ease Outcome Quality Initiative issued Clinical Practice Guidelines for Vascular Access in 2006 recommend that less than 10% of prevalent hemodialysis patients should be maintained on central catheters as their permanent dialysis access. However, catheter usage in prevalent hemodialysis was reported from 2% to 45% among 20 countries in 2013, in which most countries except Japan reported more than 10% usage of catheter as prevalent hemodialysis access (4).

There are several complications associated with tunneled he-

modialysis catheters that can reduce catheter survival, including central vein stenosis, thrombus, and fibrin sheath formation which can lead to catheter dysfunction causing inadequate dialysis, and catheter-related infection. Up to 52% of tunneled hemodialysis catheters are reported to be removed within one year due to catheter dysfunction and catheter-related infection, and some of the reports suggest catheter dysfunction as the main reason for non-elective removal (5-8). In these cases of catheter dysfunction, subsequent catheter replacement is mostly required, but prior catheter dysfunction itself is reported to be the strong predictor of hemodialysis catheter failure due to anatomical alterations in the central vein (5, 6), including prementioned central vein stenosis, thrombus, or fibrin sheath formation.

Therefore, the purpose of this study was to assess the venography findings of central venous abnormalities before exchanging dysfunctional tunneled hemodialysis catheters and also to assess the outcome of endovascular salvage techniques.

## MATERIALS AND METHODS

### Patients

From January 2011 to December 2015, a total of 78 consecutive patients undergoing catheter-directed hemodialysis treatment for 110 episodes of tunneled hemodialysis catheter dysfunction were evaluated retrospectively. This retrospective study was approved by our Institutional Review Board (AJIRB-MED-MDB-15-508) and the requirement for informed patient consent was waived.

Tunneled hemodialysis catheter dysfunction was defined as inadequate dialysis session due to decreased blood flow rates ( $< 300$  mL/minute) and frequent arterial and venous pressure alarms. The patient population included 33 men and 45 women, with a mean age of 67 years (median, 7 years; range, 25–86 years). Five patients were temporarily undergoing catheter-directed hemodialysis treatment in the setting of acute kidney injury; remaining seventy-three patients were using central catheter as their permanent dialysis access, mostly in the setting of established end-stage renal disease except in one patient who underwent bilateral nephrectomy due to emphysematous pyelonephritis. All of the patients previously underwent hemodialysis catheter insertion using tunneled single catheter with two dis-

tinct lumens: Hemo-Flow hemodialysis catheter (14.5 Fr, Medcomp, PA, USA), and Palindrome hemodialysis catheter (14.5 Fr, Covidien, Ireland).

### Techniques

The patients were placed on the angiography table, and blunt dissection was performed under local anesthesia with 1% lidocaine hydrochloride at the site of the indwelling catheter to free the cuff from the surrounding tissue at the exit site. Under fluoroscopic guidance, a 0.035-inch guide wire (Terumo Corp., Tokyo, Japan) was inserted through the one of double lumen of the hemodialysis catheter, with a wire tip placed in the inferior vena cava. After partially withdrawing and positioning the catheter tip at brachiocephalic vein level, 10 mL non-ionic contrast material (Bonorex Iohexol 350; CMS, Seoul, Korea) mixed with 5 mL saline were injected manually at another lumen, and serial digital subtraction angiography was performed. All images were assessed by the performing radiologist and categorized as normal or abnormal venography. Focal or segmental luminal narrowing of brachiocephalic vein or superior vena cava was considered as central vein stenosis, thin contrast tracking along the catheter was considered diagnostic of fibrin sheath formation, and filling defects around the catheter or elsewhere inside the central vein were considered diagnostic of thrombus formation. The following interventional procedures were performed according to the venographic findings; catheter exchange with or without tip position adjustment, balloon disruption of a fibrin sheath, or angioplasty for central vein stenosis or occlusion. A new tunneled hemodialysis catheter was advanced over the wire under fluoroscopic guidance, with the tip placed in the appropriate position after one session of venography in normal cases. Although the venography showed abnormality, simple catheter change was performed in case of non-significant luminal narrowing less than 50% caused by central vein stenosis or thrombus. Catheter tip was repositioned deeply in case of the luminal narrowing or fibrin sheath formation above the level of superior vena cava-right atrium junction. Interventional procedure was performed regardless of the degree of venographic abnormality in the patients with recurrent catheter dysfunction after catheter exchange with or without tip position adjustment. An endovascular stent was indicated in cases of recurrent or remaining venous stenosis after several sessions of balloon angio-

plasty. Immediate evaluation of catheter function was performed manually in the intervention room using a 20-cc syringe, ensuring adequate aspiration and forward flow on completion of the catheter exchange.

### Follow-Up

Technical success was defined as at least one successful session of hemodialysis with the exchanged catheter. Catheters were removed if complication was encountered (mechanical problem, suspected catheter-related infection) and in these cases subsequent catheter exchange were performed into tunneled or non-tunneled catheters according to patient status. Catheters were also removed in cases when they were no longer needed (AVF maturation, recovery of native kidney function, renal transplantation, patient death), or the patient refuses to keep catheters. They were followed up to one of these end-points or to the point of last hospital visit. The reason for catheter removal, the duration of catheter up to the point of removal or to the last hospital visit were recorded. Complications were classified as major and minor according to society of interventional radiology classifications, with catheter-related infection included as major (9).

## RESULTS

Venography findings were considered abnormal in 67 out of 110 exchanged catheters (60.9%); central vein stenosis in 27 (40.3%, out of 67 abnormal venography), fibrin sheath formation in 17 (25.4%), thrombus formation in 12 (17.9%), complex findings of more than two abnormalities in 9 (13.4%), and two

cases of in-stent restenosis where central venous stenting was done previously (Table 1). Additionally, simple fluoroscopic images taken before withdrawal of dysfunctional catheter revealed inappropriate positioning or wedging of the catheter in 4 cases among 43 catheters showing normal venography findings (Fig. 1).

Among 67 abnormal venography cases, 34 catheters were exchanged with or without catheter tip position adjustment. Balloon disruption of fibrin sheath was performed in 9 cases and balloon angioplasty of central vein stenosis or occlusion was performed in 20 cases. Balloon was used for both fibrin sheath disruption and central venous angioplasty in one complex case showing combination of fibrin sheath formation and central vein stenosis. Endovascular stent was placed in 3 cases according to the indication, which were all complex cases (Figs. 2–5). All of the catheters showing normal venography findings were simply exchanged with or without catheter tip position adjustment. Manually assessed immediate catheter function was good

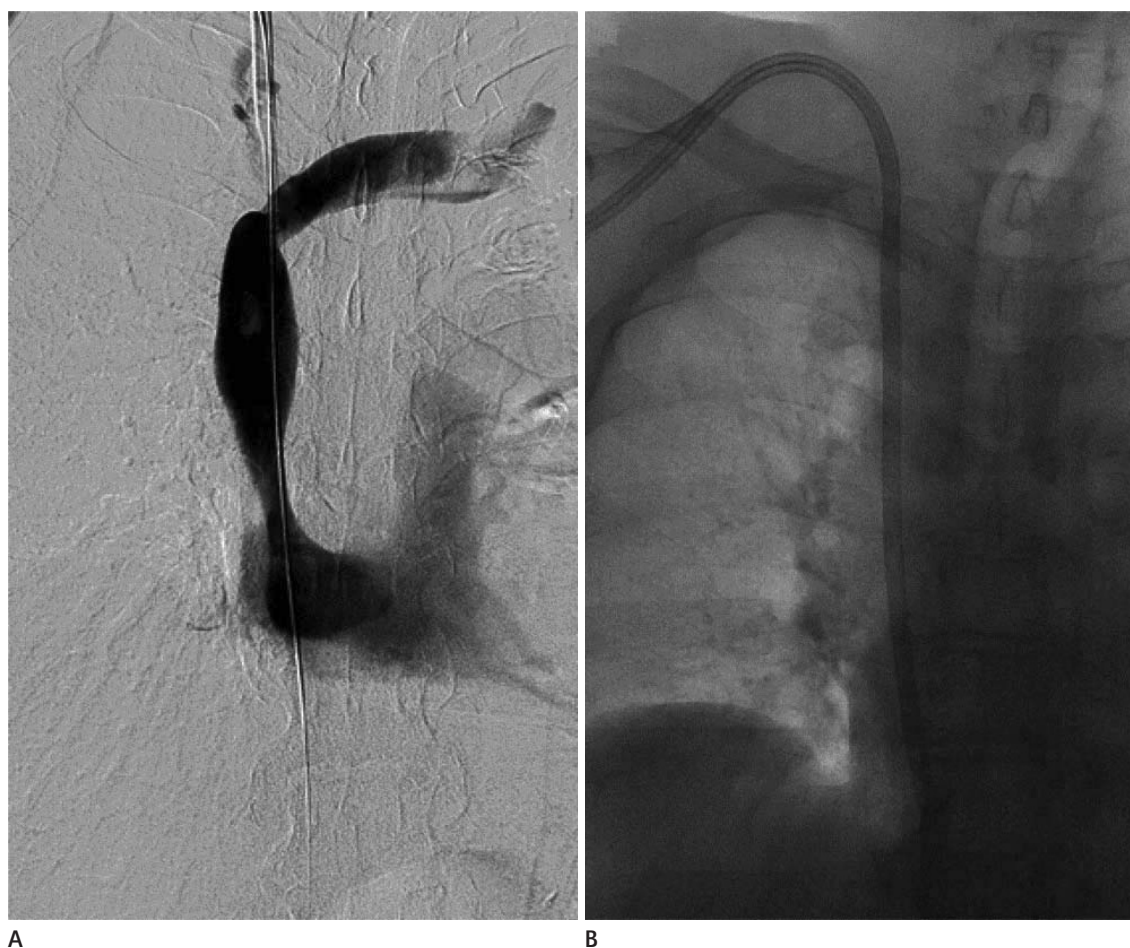


**Fig. 1.** Normal venography findings in 75-year-old male. The patient was managed with simple catheter exchange over the wire without additional intervention.

**Table 1. Venography Findings**

Venography findings	<i>n</i> ( <i>n</i> = 110)	%
Abnormal	67	60.9
Central vein stenosis	27	40.3
Fibrin sheath formation	17	25.4
Thrombus formation	12	17.9
Complex*	9	13.4
In-stent restenosis	2	3
Normal	43	39.1
With mechanical problem	4	9.3
Without mechanical problem	39	90.7

\*Two or more combined findings of central vein stenosis, fibrin sheath formation, thrombus formation.



**Fig. 2.** A 68-year-old female.

**A.** Venography reveals central vein stenosis at junction of superior vena cava-right atrium.

**B.** The patient was managed with catheter exchange over the wire with adjustment of catheter tip position, avoiding the site of central vein stenosis.

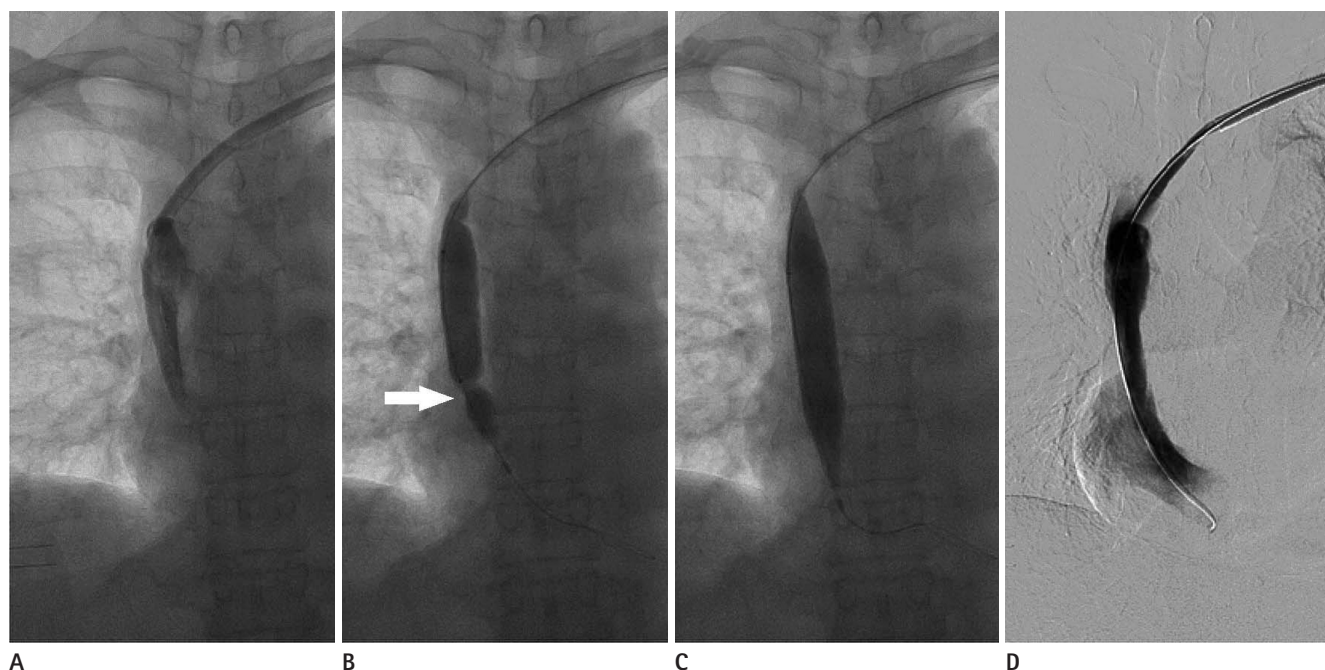
in all cases and technical success rate was 100%.

Among exchanged 110 catheters, 29 catheters were lost to follow-up returning to referring hospital after the procedure, and remaining 81 catheters were followed up to the point of removal or to the point of their last hospital visit. The estimated 30-day catheter patency was 61.7% for all of the assessable catheters, and among them, 63% for catheters showing abnormal venography findings and 59.3% for catheters showing normal venography. Among assessable catheters showing abnormal venography findings, estimated 30-day catheter patency for each interventional procedures are as follows; 60.7% for catheter exchange with or without catheter tip position adjustment, 75% for balloon disruption of fibrin sheath, and 70% for balloon angioplasty of central vein stenosis or occlusion. The mean follow-up duration per catheter was 74.8 days (range, 3–389 days) with 67 catheters (82.7%) removed and 14 catheters (17.3%) pre-

served function at the end of the study with mean duration of 96 days (range, 25–321 days). The reasons for catheter removal are listed in Table 2. The most common reason for catheter removal was catheter dysfunction, in 31 out of 67 removed catheters (46.3%). Other reasons for catheter removal included maturation of AVF in 11 (16.4%), suspected catheter-related infection in 9 (13.4%), mechanical catheter problems such as catheter dislodgement and injury in 7 (10.4%), patient death in 5 (7.5%), patient refusal in 2 (3%) and each one cases of renal transplantation and recovery of native kidney function. The removed 9 catheters due to suspected catheter-related infection were equivalent to 1.1 episodes/1000 catheter days.

During the follow-up period, 32 re-intervention episodes were required in 26 catheters (38.8%, out of 67 removed catheters) due to recurrent catheter dysfunction, involving 13 patients with a 30-day catheter patency of 53.8%. The most common



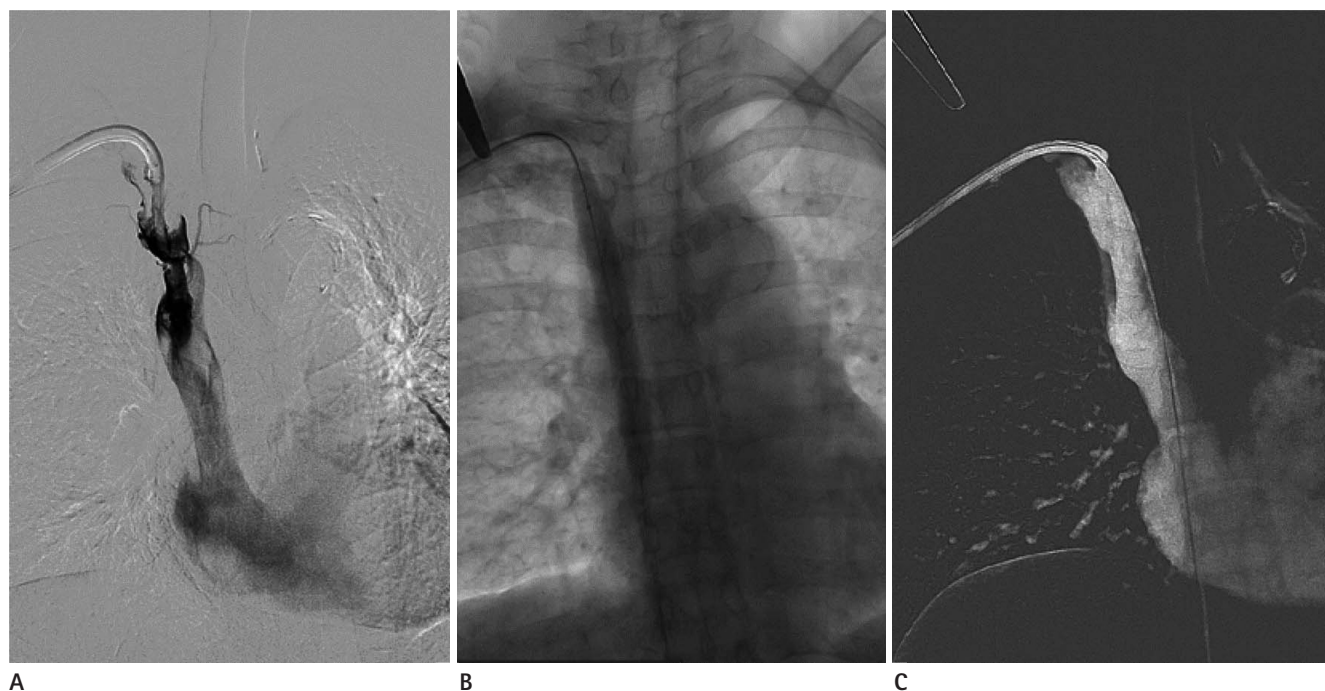


**Fig. 3.** A 51-year-old female.

**A.** Venography reveals fibrin sheath limiting contrast flow along the catheter insertion pathway.

**B, C.** Balloon angioplasty was performed to rupture the fibrin sheath using a 14 mm × 4 cm Atlas percutaneous transluminal angioplasty dilatation catheter (Bard peripheral Vascular). Note the waist formation at the balloon during partial inflation (arrow).

**D.** Repeated venography after the intervention no longer visualizes contrast flow limitation.



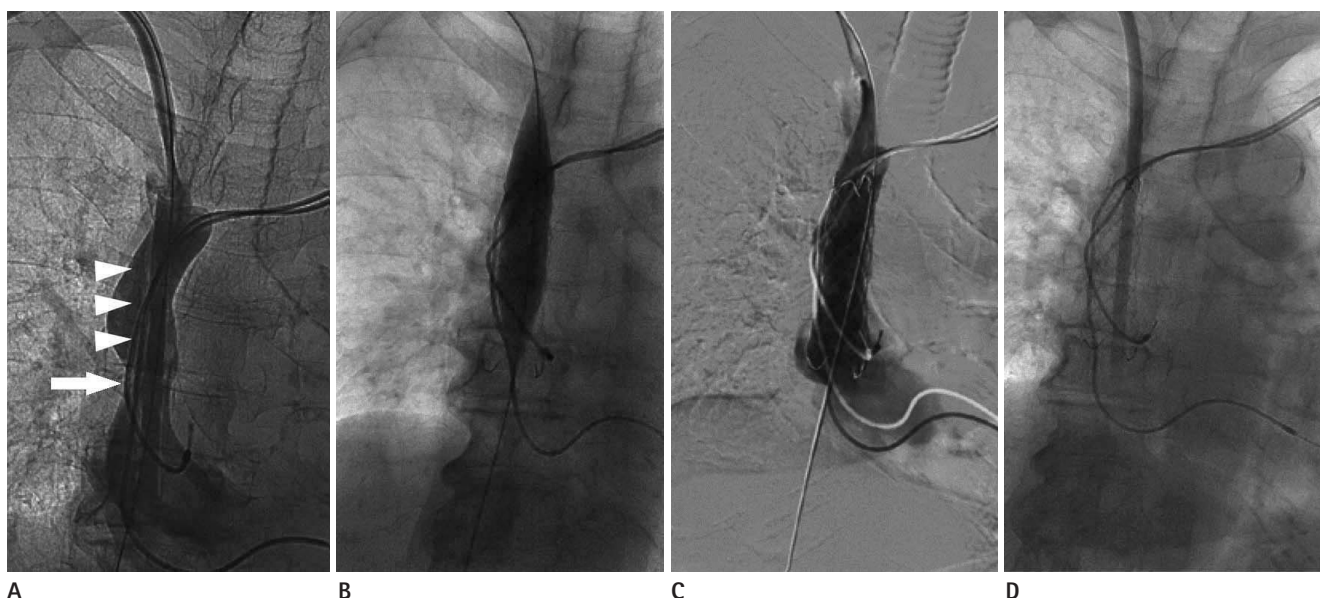
**Fig. 4.** A 45-year-old female.

**A.** Venography reveals central vein stenosis at SVC level.

**B.** Balloon angioplasty was performed at the level of stenotic central vein using a 12 mm × 8 cm Mustang balloon (Boston Scientific Corporation).

**C.** Repeated venography after the intervention reveals improved stenosis at SVC level.

SVC = superior vena cava



**Fig. 5.** A 81-year-old female.

**A.** Venography reveals complex findings of central vein stenosis at SVC level (arrow) with fibrin sheath along catheter insertion pathway (arrow-heads).

**B.** Stenosis of SVC remained after several sessions of balloon angioplasty (not seen), and a 20 mm x 6 cm Palmaz Genesis peripheral stent (Cordis) was placed in the SVC despite the fact the patient had cardiac pacemaker installed.

**C.** Repeated venography after the intervention reveals improved stenosis and disappearance of fibrin sheath.

**D.** New catheter was inserted over the wire and lasted for 47 days.

SVC = superior vena cava

**Table 2. Reason for Catheter Removal**

Reason for removal	n (n = 67)	%
Dysfunction	31	46.3
Arteriovenous fistula maturation	11	16.4
Infection	9	13.4
Mechanical problem*	7	10.4
Patient death	5	7.5
Others <sup>†</sup>	4	6.0

\*Catheter dislodgement, injury, and leakage.

<sup>†</sup>Patient refusal, renal transplantation, and recovery of native kidney function.

reason for recurrent catheter dysfunction was central vein stenosis, followed by complex cases of more than one abnormal venography findings. More than one re-intervention was required in 8 patients (five required two, one required three, and two required more than three re-interventions). The maximum number of re-intervention was eight in one patient over the span of 11 months.

## DISCUSSION

Hemodialysis catheter dysfunction is reported to be one of the main reasons for non-elective removal of hemodialysis cath-

eter, with requirement of subsequent catheter exchange. This creates disadvantages for the patients with increased cost and increased morbidity (5-8, 10). In current study, mechanical problems such as catheter malposition or wedging was much less common than other well established causes of catheter dysfunctions such as central venous stenosis, fibrin sheath formation, and thrombus formation, which is consistent with previous studies (11).

There have been variety of techniques described for the management of dysfunctional hemodialysis catheter resulting from causes other than mechanical problems in past years, including conservative method using thrombolytic agents to dissolve fibrin clots and thrombus, which has been described for almost 30 years (12). However, with the emerging issues of thrombolytic therapy becoming refractory with recurrent flow problems in cases of persistent thrombus and fibrin sheath (13), fibrin sheath stripping was discovered as an alternative endovascular technique, followed by other techniques such as catheter exchange over the wire and balloon disruption of fibrin sheath. The reported success rates of these techniques vary with each study, and controversy remains regarding their outcomes. Our 30-day catheter patency rates for abnormal and normal venog-

raphy cases (59.3–63%) are in the range of those previous reports regarding various techniques for the management of dysfunctional hemodialysis catheter (43.9–76.1%) (14–20).

Venography was also performed in most of the previous reports for assessment of underlying cause of catheter dysfunction, through indwelling catheter either in the original place or pulled back. The difference between prior studies and current study is that venography was optional in prior studies with some portion of study population not receiving venography due to suspected infection or other miscellaneous reasons, while venography was performed in all cases of dysfunctional catheter exchange in current study. The rate of abnormal venography findings was 60.1% in current study, which is within range of 47–79% reported in previous studies (10, 11, 16, 19–22).

The estimated 1.1 catheter-related infection episodes/1000 catheter days in current study is lower than previously reported catheter-related infection rates, which were 1.42–5.2 episodes/1000 catheter days (23–25). Five patients expired and had catheter removed during the follow-up period. Simple catheter exchange over the wire was performed in four patients and one patient received balloon angioplasty at central vein due to thrombus formation. Most of the deaths happened after more than one week of catheter exchange, suggesting low possibility of procedure-related morbidity. One patient who expired after three days from catheter exchange was in the setting of acute kidney injury due to sepsis and the death was thought to be attributed to septic shock. There was no other evidence of morbidity or mortality, suggesting that performing venography and subsequent intervention with catheter exchange over the wire is safe and has low risk of catheter-related infection or other complications.

Our study has limitations. First, it was a retrospective study with relatively small patient population. Also, patients were allowed to enroll more than once, since all dysfunctional hemodialysis catheter exchange cases were included in the study regardless of the presence of previous experience of catheter dysfunction. The outcome of the exchanged catheter was considered to be independent of the previous catheter, and the proportion of cases having repeated catheter dysfunction leading to repeated re-interventions was not low. As reported in previous study, the presence of previous experience of hemodialysis catheter insertion and/or dysfunction may play as the most powerful predictor of hemodialysis catheter dysfunction (5), and it

may have affected the catheter patency rate presented in current study. Lastly, due to the fact that our institution is a tertiary referral center, some portion of study cases were lost to follow-up after the procedure, and substantial portion of study cases had to be assumed for successful session of hemodialysis by having no more referrals issuing catheter dysfunction.

In conclusion, approximately 60% of dysfunctional tunneled hemodialysis catheter showed abnormal venography findings, with central venous stenosis being the most common abnormality followed by fibrin sheath formation. Appropriate endovascular techniques were performed according to the venography findings and the catheter patency was comparable with previous reports regarding various techniques for the management of dysfunctional hemodialysis catheter. Also, the rate of complications such as catheter-related infections was low. These findings implicate that performing venography before exchange of dysfunctional tunneled hemodialysis catheter with subsequent appropriate act could be helpful in improving catheter patency with low risk of procedure-related complications.

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## 기능부전 터널식 투석용 도관의 교체 시 시행한 정맥조영술 결과의 분석과 혈관 내 치료 기술의 결과

서배선<sup>1</sup> · 박선영<sup>1</sup> · 김진우<sup>1</sup> · 오창권<sup>2</sup> · 이수형<sup>2</sup> · 원제환<sup>1\*</sup>

**목적:** 기능부전 터널식 투석용 도관의 교체 전에 시행한 정맥조영술 소견을 분석하고 이에 따른 혈관 내 중재시술의 결과에 대해 분석하였다.

**대상과 방법:** 2011년 1월에서 2015년 12월 사이에 터널식 투석용 도관을 통하여 투석을 받는 환자 중 도관의 기능부전으로 교체를 시행 받은 78명(110예)을 대상으로 후향적으로 연구하였다. 도관의 교체 전 정맥조영술의 결과에 따라 적절한 중재시술을 시행하였다. 기술적 성공은 도관 교체 후 적어도 한 번 이상의 성공적인 투석의 진행으로 정의하였다. 환자들은 도관 제거일 또는 마지막 병원 방문일까지 추적 관찰하였다.

**결과:** 67개의 도관의 교체 전 정맥조영술에서 중심 정맥 협착, 섬유소집, 혈전 형성 등의 비정상적인 소견이 관찰되었다. 모든 증례에서 기술적 성공이 확인되었으며, 30일 도관 생존율은 61.7%였다. 추적 기간 동안 도관감염이 의심되는 9개의 도관을 제거하였다.

**결론:** 기능 부전 터널식 투석용 도관의 교체 시 약 60%에서 비정상적인 정맥조영술 소견이 관찰되었다. 이에 따른 적절한 혈관 내 중재술을 시행한 결과 도관 생존율은 이전의 다른 연구들과 비견할 만하였으며 시술과 관련된 합병증의 위험도는 낮았다.

아주대학교 의과대학 아주대학교병원 <sup>1</sup>영상의학과, <sup>2</sup>외과