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Original Article

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Endovascular treatment of proximal venous outflow obstructions in patients with arteriovenous fistula: Our single-center experience

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ABSTRACT

Objectives: In this study, we present our early and mid-term results of percutaneous treatment for proximal venous outflow obstruction (PVOO).

Patients and methods: Between January 2017 and July 2019, a total of 40 patients (19 males, 21 females; mean age: 61.9±12.1 years; range, 49 to 74 years) who underwent hemodialysis from the arteriovenous fistula (AVF) were included. All patients had advanced edema due to PVOO in the extremity with AVF. All patients received endovascular treatment for PVOO.

Results: Percutaneous transluminal angioplasty (PTA) was performed to all patients. Stent implantation was performed in 20 patients who could not achieve full patency after PTA. A patient whose edema did not regress despite stent implantation underwent surgical AVF recreation. A total of six patients underwent minor/major surgical procedures. In 14 patients, edema completely regressed and the functionality of the fistula increased in the one-month follow-up after the PTA procedure. The patients who underwent percutaneous intervention were evaluated at 3, 6, 12, and 24-months of follow-up, and primary patency rates were found to be 92%, 82%, 67%, and 45%, respectively.

Conclusion: Our study results suggest that PVOO should not be overlooked in patients with AVF, edema in the extremity, and no loss of fistula functionality. Percutaneous interventions should be considered primarily in the treatment of PVOO.

Keywords: Chronic, kidney failure, percutaneous intervention, proximal outflow obstruction.

Chronic renal failure (CRF) can be defined as the inability of the kidney to adjust the fluid-solute balance at the required level as a result of the decrease in glomerular filtration rate and chronic and progressive deterioration in metabolic-endocrine functions. In addition to its medical aspect, it also affects the social, economic, and psychological conditions of the patients. According to 2010 data, approximately 2.6 million individuals around the world are living with dialysis or kidney transplant treatments.[1] This number is expected to reach 5.5 million in 2030 and the total cost of treatment is expected to exceed 2 trillion Dollars. The ultimate treatment for CRF is kidney transplantation. However, due to donor shortage, not all patients have the opportunity to have kidney transplantation, and many of them continue their lives with hemodialysis. Arteriovenous fistulas (AVFs) are the best quality method for hemodialysis in terms of both patient comfort and full and proper treatment. However, the fact that the fistula stays open for a long time in practice is still a major problem.[2]

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There are many factors that affect fistula patency. These factors are age, sex, diabetes, hypotension, arterial diameter, atherosclerosis, arterial flow, vessel diameter, venous extensibility, smoking, obesity, early hemodialysis, type of anastomosis, vascular clip, antiplatelet therapy, systemic heparin use, infrared ray use, timing of first hemodialysis, cannulation technique, and follow-up.[3] Even if fistula patency is provided, problems with fistula functionality or extremity with fistula can be seen. Proximal venous outflow obstruction (PVOO) usually presents with edema in the involved extremity after the AVF becomes functional. Edema, which develops due to venous obstruction in the arm with fistula, causes severe pain and deterioration of the function of the fistula in the following periods. Surgical treatment of PVOO is both difficult and dangerous and not always successful. Interventional therapy is less invasive, as well as presents fewer risks to physicians. It is clear that percutaneous interventional procedures would be needed more in the near future in terms of both patient and physician comfort.

In the present study, we aimed to present our early and mid-term results of percutaneous treatment for PVOO.

PATIENTS AND METHODS

This single-center, case-control, cross-sectional study was conducted at Sivas Cumhuriyet University, Faculty of Medicine, Department of Cardiovascular Surgery between January 2017 and July 2019. A total of 40 patients (19 males, 21 females; mean age: 61.9±12.1 years; range, 49 to 74 years) who underwent hemodialysis from the AVF were included. All patients were those who were admitted with swelling in the arm undergoing hemodialysis, pain, and decreased hemodialysis rates.

Digital subtraction angiography (DSA) performed to the patients on clinical suspicion revealed outlet stenosis in the proximal venous outflow proximal extremity with AVF. Angiography of the cases included in the study was performed using Philips Xper Allura FD-10 Model C Arm Detector System Angiography Device (Philips Medical Systems International B.V. Best, Netherlands). Angiographies of the patients were performed over the venous fistula line in the extremity with AVF. After venous puncture, first a fistulogram and, then, the entire venous line was visualized with a 6-Fr sheath. The patients had total occlusion in the subclavian vein on the right and the innominate vein on the left. Diffuse collaterals and continuation of venous drainage were detected. Before the interventional procedure, 5,000 IU heparin was administered intravenously to the patients. All interventional procedures were performed transfemorally to avoid unnecessary trauma to peripheral arm veins. Extremely tight stenoses were pre-dilated to allow passage of stent equipment in treated patients. The lesions were crossed with a 0.035-inch guidewire. A balloon size of 10% larger than the non-stenotic vein of interest was typically selected, and the balloon diameter varied from 8 to 16 mm. Non-compliant balloons were used, and inflation pressures ranged from 10 to 25 ATM. Self-expanding stents, including Wallstents (Boston Scientific/Scimed, Natick, MA, USA) and Smart stents (Cordis, Johnson & Johnson, Warren, NJ, USA), were used in all cases. Their diameters ranged from 5 to 10 mm, and their lengths varied from 90 to 130 mm. After stent implantation, all stents were post-dilated with high-pressure balloons to ensure full opening in fibrotic venous stenosis. Following stent implantation, the patients were given a continuous heparin infusion for three days and the activated partial thromboplastin time (aPTT) was maintained between 60 and 90 sec. The patients, for whom predilatation could not be performed to the stenosis area were referred to the surgical procedure. The patients were given maintenance treatment with 100 mg of acetylsalicylic acid daily throughout the study period.

All patients were evaluated regularly for two years, first at one month and, then, at three-month intervals, with clinical examination and, if necessary, with color Duplex sonography. The presence of recurrent swelling or signs and symptoms of symptomatic restenosis were followed.

The age, sex, and comorbidities of the patients participating in the study were evaluated. Inclusion criteria were determined as patients undergoing hemodialysis due to CRF and the presence of PVOO in the extremity with AVF was proven. Patients younger than 18 years of age were not included. The primary endpoint was stent restenosis or restenosis in the follow-up of the patients after angiographic intervention.

Statistical analysis

Statistical analysis was performed using the IBM SPSS version 24.0 software (IBM Corp., Armonk, NY, USA). Continuous variables were expressed in mean ± standard deviation (SD) or median (min-max), while categorical variables were expressed in number and

Table 1. Demographic and clinical characteristics of patients

Variables	n	%	Mean±SD
Age (year)			61.9±12.1
Sex			
Female	21	52.5	
Diabetes mellitus	36	90	
Hypertension	38	95	
Chronic kidney disease (year)			7.3±3.4
Number of catheters			6.2±2.3
Interventions			
PTA	40		
Stent	20		
Surgery	6		

SD: Standard deviation; CKD: Chronic kidney disease; PTA: Percutaneous transluminal angioplasty.

Table 2. Number of stents-grafts and sizes by target vein

Implantation site	13×5	12×6	10×10	10×6	9×10
Right subclavian	3	2	2	2	3
Left innominate	2	3	1	1	1

Graft stent diameters and lengths (mm × cm).

frequency. The survival analysis was performed using the Kaplan-Meier curves to demonstrate event-free outcomes of primary patency. A p value of <0.05 was considered statistically significant.

RESULTS

The main characteristics, age, sex, comorbidities, PVOO location, and interventions of the patients included in the study were noted. All patients were followed for two years. Additional risk factors were diabetes mellitus (DM) in 36 (90%) and hypertension in 38 (95%) patients (Table 1). The mean duration of chronic kidney disease of the patients was 7.3±3.4 years, and hemodialysis catheters were changed approximately six times (mean: 6.2±2.3).

The fistula localizations of the patients were determined as 12 right distal radiocephalic, 10 right proximal radiocephalic, and eight left brachiocephalic. In all of the patients, percutaneous transluminal angioplasty (PTA) and stent procedures were performed to the subclavian vein on the right and the innominate vein on the left. The PTA was performed in all patients with tight stenosis that prevented stent advancement. Stent implantation was performed in 20 patients whose 70% stenosis persisted after balloon angioplasty (Table 1). As the stenosis of 14 patients was less than 70%, they were followed medically. Since pre-dilatation could not be performed in six patients and the stent could not be advanced during the follow-up of these patients, fistula closure was performed in four of these patients and fistula tract narrowing was performed in two of these patients (Table 1).

Diameter, length, and implantation site of the implanted stents are shown in Table 2. Patients who underwent percutaneous intervention were evaluated at 3, 6, 12, and 24-month follow-ups, and primary patency rates were found to be 92%, 82%, 67%, and 45%, respectively. Recreation of AVF was performed surgically in a patient whose edema did not regress, despite stent implantation and whose complaints continued. During follow-ups of the patients who underwent PTA, the fistula functionality continued

Figure 1. **(a)** Pre-interventional procedure, **(b)** post-interventional procedure.

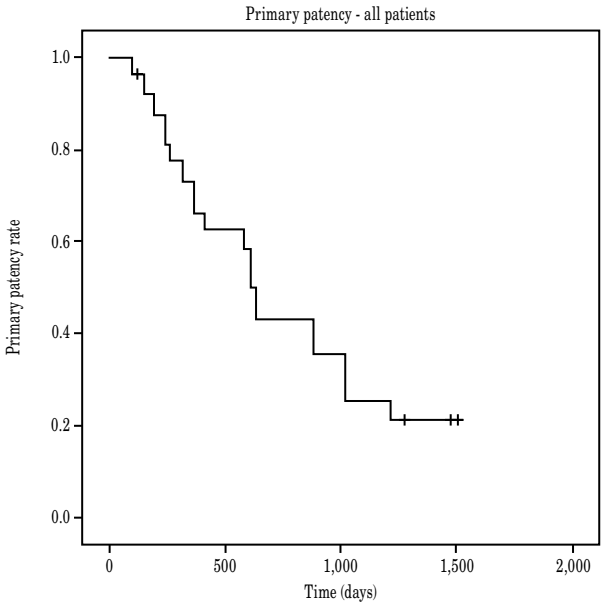

Figure 2. Primary patency rate after interventional procedure of the original 34 PTCA stent patients.

PTCA: Perkütan translüminal coroner anjiyoplasti.

Table 3. Primary patency ratios

Follow-up period (month)	Number of patients (n)	Primary patency ratio (%)
3	31	92
6	27	82
12	22	67
24	15	45

and the edema regressed. In our study, the stent implantation of the patient with residual stenosis after PTA is shown in Figure 1.

In our study, the patients who underwent percutaneous intervention were evaluated at 3, 6, 12, and 24-month follow-ups, and primary patency rates were found to be 92%, 82%, 67%, and 45%, respectively (Figure 2). The patency rates and event-free survival analysis are shown in Table 3.

DISCUSSION

Arteriovenous fistula, which is required for hemodialysis due to CRF, is used as the first choice until kidney transplantation.[4] One of the most common causes of shunt dysfunction in chronic hemodialysis patients is PVOO. In most cases, this problem occurs as a chronic complication of subclavian dialysis catheters used for temporary hemodialysis access.[5,6] Proximal venous outflow obstructions can result in decreased vascular access flow, increased venous pressure, and subsequent graft thrombosis. Most patients present with long-term symptoms, namely ipsilateral arm swelling, pain, and inadequate hemodialysis, confirming the chronic nature of their stenosis and occlusion.[7,8] Therefore, thrombectomy, thromboaspiration, or thrombolysis alone are unlikely to adequately restore venous patency. In these patients, surgical or angiographic interventional procedures are performed to treat the condition. In this study, we evaluated the patients who underwent percutaneous intervention with angiography for the treatment of PVOO.

Patients on chronic hemodialysis treatment for more than several years are likely to have more than one surgical correction. Although open surgical treatment provides acceptable success, it is often associated with significant morbidity in dialysis patients with multiple comorbidities.[9] Interventional procedures with angiography can help to preserve most of these fistulas and reduce the length of hospital stay and the number of corrections in this group of previously operated patients. Since 1980s, endovascular methods have been developed for the treatment of venous occlusive disease.[10] Angioplasty can be considered a reasonable option for the treatment of proximal venous outflow strictures. Currently, percutaneous treatment options include high-pressure balloon angioplasty and intravascular stent placement. For percutaneous interventions, some researchers advocate initial stent placement in the treatment,[11,12] while some researchers advocate stent implantation after recurrent stenosis or unsuccessful balloon angioplasty.[13,14] In some patients, stent implantation is also performed due to the long lesion or the need for repetitive balloon angioplasty.[11,15,16] In particular, in damaged or dissected intravascular tissues, stent implantation may have beneficial effects in proximal venous outflow stenosis as well as in intracoronary lesions. We first applied balloon angioplasty to all of our patients and, then, performed stent implantation, if the stenosis persisted above 70%. In a study conducted by Oderich et al.,[12] 49 central vein occlusions and 14 peripheral vein occlusions were treated with stent implantation. In this study, 50 stents were implanted in 49 patients with central vein occlusion and 15 stents were implanted in patients with 14 peripheral vein occlusions. The authors found a one-year primary patency rate of 27% and a one-year assisted patency rate of 71% at a 16-month follow-up.

In another study, Haage et al.[11] performed stent implantation in 50 patients for the treatment and follow-up of central vein occlusion, and they found a one-year primary patency rate of 56% and a one-year assisted patency rate of 97%. In the aforementioned study, the 24-month primary patency rate was found to be 28%. In a prospective, randomized study conducted by Quinn et al.,[13] PTA and stent implantation were compared. In this study, one-year primary patency rate was 12% and one-year assisted patency rate of 100% in patients who underwent PTA alone, and 12% and 78%, respectively, in patients who underwent PTA with stent placed. As a result of this study, no statistically significant difference was found between PTA and patients who underwent stent implantation after PTA. In other studies in the literature, self-expandable[17,18] and balloon-expandable stent[19] have recently been reported to have primary one-year (two-year) patency rates of 60 to 71%. These results indicate that the results are almost similar to the results after surgical correction of central venous stenoses.[17,20] Considering these studies as an example, we offered our patients the chance for intervention with angiography. In our study, stent implantation was performed in patients with PTA and residual lesions after PTA, and the one-year primary patency rate was found to be 67%, and patency rates were similar to other studies. Therefore, we reduced duration of hospital stay of our patients and protected them from the risks of surgical intervention.

The relatively small number of patients in the study and the fact that the study was conducted in a single center are the main limitations. In addition, this study should be supported with larger patient groups. One-year assisted patency rate was not evaluated in the study.

In conclusion, endovascular stent implantation, or PTA, is a valuable way of treating proximal outflow strictures and reduces the need for surgery and hospital stay of patients. Therefore, endovascular interventional procedures should be considered before the surgical option in patients with in patients with arteriovenous fistula of PVOO.

Ethics Committee Approval: The study protocol was approved by the Sivas Cumhuriyet University, Faculty of Medicine Ethics Committee (Date: 15.01.2020, No: 2020-01/03). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Patient Consent for Publication: A written informed consent was obtained from each patient.

Data Sharing Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

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