TECHNIQUE OF CIRCULAR NARROWING WITH A POLYTETRAFLUOROETHYLENE GRAFT IN PATIENTS WITH HIGH-FLOW ARTERIOVENOUS FISTULA: MID-TERM RESULTS

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ABSTRACT

Introduction*: An arteriovenous fistula with a high-flow rate adversely affects the hemodialysis treatment of the patients. There are several methods that help to decrease the high-flow rate. This study aims to investigate the effects of circular narrowing technique on lowering the flow rate with a polytetrafluoroethylene graft for the treatment of patients with a high-flow arteriovenous fistula and to present our shortand mid-term results.*

Materials and methods*: Seven patients with a fistula flow rate of above 1200 ml/min were retrospectively analyzed. All patients were operated on under local anesthesia and underwent a circular narrowing procedure with a polytetrafluoroethylene graft. Additional aneurysmectomy was performed on the patients with aneurysms. Fistula flow rates were recorded at baseline and following the procedure.*

Results*: Postoperative thrill was observed in all patients. The mean preoperative flow rate of arteriovenous fistula was 1428±230 ml/min. At three to six months following the procedure, it was 655±98 ml/min. Two patients suffered from pain in the arm at rest preoperatively and the pain resolved postoperatively. All patients continued to receive hemodialysis through the native fistula on a regular basis in the postoperative period.*

Conclusion*: Our study results suggest that the circular narrowing technique with a polytetrafluoroethylene graft is an effective modality that can be easily used in patients with high-flow arteriovenous fistulas.*

Keywords*: High-flow rate, flow reduction, arteriovenous fistula, circular narrowing technique, polytetrafluoroethylene graft.*

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Introduction

Arteriovenous fistula (AV fistula) was first described by Cimino and Brescia in 1966 for vascular access in hemodialysis patients, and continues to be the gold standard technique[(1)]. Although arteriovenous fistula is the gold standard method, it is associated with several complications. The most common complications include stenosis, thrombosis and aneurysmatic dilations in late stage[(2)].

Aneurysmatic dilation and high-flow may coexist in certain patients[(3)]. A single treatment modality may not be adequate in the treatment of these patients. As a result, both lowering the high-flow and restoration of the fistula segment with aneurysm development at a single session are essential.

In this study, we aimed to investigate the effects of circular narrowing technique on lowering the flow rate with a polytetrafluoroethylene (PTFE)

graft for the treatment of patients with high-flow AV fistula and to present our short- and mid-term results.

Material and methods

Between 2013 and 2015, seven patients who underwent circular narrowing with a PTFE graft (Impra Carboflo, Cravley, UK) due to high-flow AV fistula at a cardiovascular surgery clinic were retrospectively evaluated.

Patients with a fistula flow of >800 mL/min and those with pain at rest or aneursym in the related extremity were operated. Target postoperative fistula flow rate was defined as 400-800 ml/min.

Demographic characteristics of the patients undergoing circular narrowing with a PTFE graft were recorded. The duration of operation, complications, and duration of postoperative follow-up were also noted. The patients were scheduled for follow-up at the outpatient clinic postoperatively. Physical examinations were performed during these visits. Fistula flow rates were measured using a Doppler US (Aplio™ 500 Ultrasound Machine, Toshiba Medical Systems, Otawara, Japan), both preoperatively and postoperatively. Postoperative fistula flow rates were measured at 0 to 3 months, 3 to 6 months, and on a regular basis thereafter. Changes from baseline to the postoperative visits were expressed in percentages (%).

Informed consent was obtained from each patient. The study protocol was approved by the local ethics committee of an university (01.16.2015 - 01-no:07). Patient records were obtained from the hospital archive and our records. During the follow-up, the patients and dialysis centers where they were receiving dialysis were contacted. Whether the patients received regular hemodialysis treatment was questioned.

Surgical Technique

All patients were operated on under local anesthesia. Standard heparin at a dose of 5000 IU was administered preoperatively. Following skin incision and subcutaneous dissection, AV fistula anastomosis line was reached (Figure 1A). The venous site was hung-up and freed from the surrounding tissues. Subsequently, a 6 mm PTFE graft was longitudinally cut (Figure 1B). The PTFE graft measuring approximately 2-3 cm was wrapped circularly around the venous site from the AV fistula anastomosis.

Then, each side of the PTFE graft was sutured using a 6-0 prolene suture with an over and over technique and venous site of the fistula was narrowed (Figure 1C). The skin incision was closed and the operation was completed. In addition, aneurysmorrhaphy was performed on the patients with an aneurysm and aneurysmatic parts were resected and fistula continuity was provided. The patients continued to receive hemodialysis treatment through the same arm following the procedure.

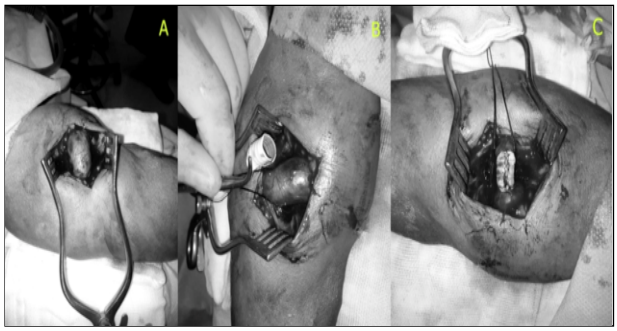

Figure 1: Photographs of the surgery in a patient.

Statistical Analysis

Statistical analysis was performed using SPSS v22.0 software (SPSS Inc., Chicago, IL, USA). Data were presented in mean ± standard deviation.

Results

Three patients were male and four were female, with a mean age of 57±17 years. The mean follow-up was 16±1 months. The mean duration of hemodialysis was 78±45 months. All patients were hypertensive, while four of them had concomitant diabetes mellitus. One patient had coronary heart disease, while three had peripheral arterial disease. An AV fistula was localized in the left brachiocephalic region in six patients and left radiocephalic region in one patient. Demographic characteristics and comorbidities are shown in (Table 1).

Five patients had aneurysmatic dilation, one had pain at rest in the distal extremity, and one had both aneurysmatic dilation and pain at rest in the distal extremity. In six patients, PTFE circular narrowing along with aneurysmorrhaphy was performed due to the presence of an aneurysm. The PTFE graft circular narrowing alone was performed in one patient who had only extremity pain at rest. The mean duration of operation time was 45 min.

The flow rate was measured preoperative and postoperatively by color Doppler ultrasonagraphy.

The mean preoperative fistula flow rate was 1428±230 ml/min. The mean postoperative fistula flow rate was 604±77 ml/min at 0 to 3 months, 655±98 ml/min at 3 to 6 months, and 660±77 mL/min thereafter. The mean postoperative decrease in the fistula flow rate was 57±5% at 0 to 3 months, 53±7% at 3 to 6 months, and 53±1 thereafter (Table 2).

Parameters	Patient (n:7)
Age (years±SD)	57±17
Gender (male, n)	3
Diabetes Mellitus (n)	4
Hypertension (n)	7
Coronary artery disease (n)	1
Peripheral artery disease (n)	3
Follow-up period (months±SD)	16±1
Duration of dialysis (months±SD)	78±45
Indications for operation: Aneurysm / Rest pain/Aneurysm with rest pain	5/1/01

Table 1: Demographic data of patients.
SD; Standard Deviation

Patients (n:7)	Before operation flow (ml/min)	Flow 0-3 months after operation (ml/min)	Flow 3-6 months after operation (ml/min)	6 months after operation (ml/min)	Percent reduction 0-3 months (%)	Percent reduction 3-6 months (%)	Percent reduction 6 months after (%)	Operation time (min)
1	1200	610	650	680	49	45	43	61
2	1200	498	640	660	58	46	45	56
3	1400	630	650	650	55	53	53	55
4	1750	750	870	820	57	50	53	52
5	1250	550	580	600	56	53	52	28
6	1500	600	600	610	60	60	60	35
7	1700	590	600	600	66	65	65	30
Total (Mean ± SD)	1428±230	604±77	655±98	660±77	57±5	53±7	53±1	45

Table 2: Patients fistula flow rates and percent flow reduction.

An aneurysmatic dilation was observed at 10 months following surgery in one of the patients in a collateral branch of the left brachiocephalic AV fistula. The aneurysmatic section was ligated and excised. The patient continued to receive hemodialysis therapy through another collateral vascular access. All patients continued to receive hemodialysis treatment on a regular basis.

Discussion

Chronic renal impairment is a disease that reguires regular hemodialysis treatment periodically in patients' whole life. Effective hemodialysis reduces the mortality and morbidity rates. A vascular access providing an adequate flow is required for an effective hemodialysis[4].

Currently, AV fistula has been widely adopted in the treatment of hemodialysis patients. However, AV fistula has some complications which are seen in high incidence, including stenosis and thrombosis, in particular[2]. Contrary to the stenosis, another important complication is the development of a high-flow AV fistula. AV fistula with a high flow may cause ischemia in the limbs and high-flow heart failure. To date, various methods have been used in the treatment of high-flow hemodialysis patients. Some of those are banding, T banding, simple narrowing, and extensive bypass procedures. These procedures have two goals: to alleviate the symptoms and to preserve the working AV fistula[5].

Furthermore, many factors play a role in the development of high-flow AV fistula in patients who are treated with hemodialysis. Repeated punctures, high-turbulent flow, primary trauma from needles, and outflow vein stenosis contribute to the development of enlargement in venous vessels and aneurysmatic dilatation in AVF. The mean fistula flow rate was 1288 ml/min in a study in which the patients with AV fistula aneurysms were analyzed[6].

High flow accelerates the degeneration of AV fistula and, thereby, the development of aneurysms. Sigala et al. reported high flow rate in 29% of patients with aneurysm development[7]. In the literature, patients with an AV fistula flow rate of >800 ml/min are defined as high-flow patients[8]. In the present study, the mean fistula flow rate was 1428±230 ml/min at baseline. An aneurysmatic dilation co-existed in six patients. PTFE circular narrowing was applied to those patients to decrease the high flow rate. In addition, aneurysmorrhaphy was performed in patients with aneurysmatic vascu-

lar structures and fistula flow was restored. All patients benefited from surgery and continue to receive hemodialysis treatment through the native AV fistula.

Recently, two important surgical techniques were developed to decrease the flow rate while preserving the high flow AV fistula, namely the Minimally Invasive Limited Ligation Endoluminal-Assisted Revision (MILLER) and Revision Using Distal Inflow (RUDI) techniques. The RUDI technique is complex and includes ligation and re-anastomosis, and the expected success rate of the method is low(9). The other widely-used technique is the MILLER technique, developed by Goel et al.[10].

However, an angiography laboratory is required to perform the MILLER technique. Although the method is minimally invasive, it should be considered a hybrid procedure that required an angiography and the surgery theater. Considering the cost of angiography, the availability of this method in undeveloped countries should be evaluated. An additional procedure such as angiography is unnecessary in the circular narrowing procedure with a PTFE graft, which we used in the present study. It can be performed in a standard operating room. Decreasing the flow rate is important in patients with high flow AV fistula; however, a much more important issue in those cases is the patency rate of the fistula to maintain regular dialysis treatment.

Zanow et al.[11] applied a continuous narrowing suture and PTFE graft narrowing technique in their patients with high flow AV fistulas to lower the flow rate. The cumulative patency rate for all accesses was 85±4% at 12 months[11]. On the other hand, in a study performed by Schneider et al, the T banding technique was used in patients with high-flow AV fistulas. The primary patency rate of this method and the mean duration of surgery were reported to be 90% and 96±23 min, respectively. In addition, the mean reduction in the flow rate was 50%. However, the fistula flow rates were measured at 1 to 3 months after surgery[5]. The mean duration of surgery our patients was 45 min, which is relatively shorter compared to similar studies.

The other important complications of the AV fistula procedure in dialysis patients is ischemic steal syndrome in the extremity in which the operation is undertaken. In general, the cause of steal syndrome in the arm is arterial disease or inadequate collateral system of the hand.

In the treatment of this syndrome in patients with high flow, methods for flow reduction such as fistula banding, Distal Revascularization and Interval Ligation (DRIL), Revision Using Distal Inflow (RUDI) and Proximal Arterial Inflow Graft (PAI) have been used[12]. All of those methods are among the major alternative techniques. However, new bypass procedures should be performed in all complex operations other than banding. The banding technique, which seems to be a simpler method compared to the others, could be considered in the treatment of those cases with high success[13]. Two patients in our study had extremity pain at rest. Those patients were operated on using the PTFE graft circular narrowing technique. Extremity pain at rest was relieved (radial artery pulse by hand) during follow-up.

Seven patients who underwent PTFE graft circular narrowing were followed for 16±1 months. The patients continued to receive the hemodialysis treatment through the same fistula during the follow-up period. The fistula flow rates were measured on a regular basis during the follow-up. Preoperative mean fistula flow was 1428±230 ml/min, while the mean flow rate was 604±77ml/min, 655±98 ml/min, and 660±77 at 0 to 3 months, 3 to 6 months, and thereafter, respectively. The mean percentage of flow reduction was 57±5%, 53±7%, and 53±1% at 0 to 3 months, 3 to 6 months, and thereafter, respectively. When the percentage of reduction of the flow rate and flow rates during the follow-up were evaluated together, the results were consistent with the target values of the study, which is approximately 400-800 ml/min.

One of the major complications of fistula narrowing procedures is the development of thrombosis among the patients with a high-flow AV fistula. It has been also reported in many studies[5,11]. However, in the present study, none of the patients developed thrombosis. This can be attributed to the short duration and simplified nature of the technique. The rate of flow reduction is often similar to previous studies published in the literature.

On the other hand, there are some limitations to this study. A total of 203 patients underwent fistula operation during the study period. However, we performed this procedure on only seven of them. Therefore, we suggest that the patient group on whom we operated is extremely rare. However, the strengths of our technique are high patency rate, short surgery duration, and the absence of thrombosis.

Conclusion

In general, flow rates were stable in patients in whom flow reduction was provided after the procedure. The rate of flow reduction was observed to be 53% even at postoperative 6 months. All patients received regular hemodialysis treatment through the same fistula after the procedure. We may consider that the method used meets the study aims, despite the small sample size. In conclusion, our study results suggest that the circular narrowing technique with a PTFE graft is an effective modality that can be easily used in patients with a high-flow AV fistulas.

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