The influence of graft diameter on the patency rates of axillary-axillary arteriovenous grafts in hemodialysis patients

Original Article

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ABSTRACT

Introduction: End-stage renal disease (ESRD) arises from several heterogeneous disease pathways that permanent alter renal function and structure over months or years. Hemodialysis (HD) is a lifeline treatment for cases with ESRD. A ratio of HD cases exhaust all methods for permanent vascular access (fistula or graft) in both upper limbs.

Aim: The current study aims to compare 8 and 6 mm extended polytetrafluoroethylene (PTFE) grafts according to the primary patency in cases undergoing axi-ax arteriovenous grafts.

Patients and methods: This retrospective, prospective case–control cohort study included all patients with ESRD referred to the Vascular Outpatient Clinic, Mansoura University hospitals, seeking for creation of HD access and decided for arteriovenous synthetic graft due to the lack of suitable autogenous veins in the arms patient were classified into two groups, in the first group (A) an 8 mm PTFE graft (26 patients) in the second group (B) a 6 mm PTFE graft, grafts (21 patients) were placed on the chest wall anastomosed between first part axillary artery and axillary vein.

Results: This study was conducted on 47 patients, a 6 mm graft was used on 21 patients and an 8 mm graft on 26 patients. There was a statistically significant difference between the graft 6 mm group and the graft 8 mm group regarding preoperative axillary artery diameter and preoperative vein diameter ($P < 0.001$ and 0.001, respectively) and significant difference between graft 6 mm group and graft 8 mm group regarding complications (thrombosis) ($P = 0.033$). And nonsignificant regarding infection ($P = 1.0$).

Conclusion: The current study revealed that without considering certain changes in 6 and 8 mm grafts, primary patency can be improved by placing 8 mm grafts while respecting the axillary artery and vein diameters.

INTRODUCTION

End-stage renal disease (ESRD) arises from several heterogeneous disease pathways which induce permanent alteration of renal function and structure, over months or years. It could be described as renal dysfunction revealed by glomerular filtration rate (GFR) of less than 60 ml/min per 1.73 m², or markers of kidney injury, or both, of at least 3 months duration, irrespective of underlying etiology[1].

Hemodialysis (HD) is a lifeline therapy for cases with ESRD. An essential factor in the survival of renal dialysis cases is the surgical creation of vascular access, and international strategies suggest arteriovenous fistulas (AVF) as the best approach to vascular access for HD[2]. A ratio of HD cases exhausts all options for permanent vascular access (fistula or graft) in both upper limbs. Once this happens, continued HD must choose between placing an arteriovenous grafts (AVG) in the thigh or long-term dependence on tunneled HD catheters[3].

Hemodynamic situations inside a vascular vessel produce forces at the vessel wall that could be divided into two types, namely wall shear stress (WSS) and pressure. WSS is the dragging mechanical stress acting at the interface of the vascular wall owing to blood flow, and pressure is the circumferential stress acting on the vessel wall owing to pulse pressure change. Based on various flow situations, WSS is divided into laminar shear stress and disturbed shear stress. The former is generated by the laminar flow, which has blood flow in the same direction; the latter is produced by eddy turbulence and reciprocating flow, and is also called oscillation shear stress. Laminar shear stress is essential against inflammatory stimulation and endothelial cell hyperplasia; as a result, it is very critical for normal vascular functioning. In contrast, disturbance of shear

stress has an essential role in pathophysiological processes comprised of endothelial dysfunction, comprising thrombosis and neointimal hyperplasia[4].

Autologous AVF are obviously favorable to polytetrafluoroethylene (PTFE) grafts for long-term HD with regard to patency and infection rates, and charges. The most common etiology of PTFE graft failure is intimal hyperplasia (IH) at the venous anastomoses. In contrast to arterial hyperplasia, which appears to represent an adaptation of the vessel wall to low-shear stress, limited data are available regarding venous hyperplasia[5].

Contrasting to autogenous fistulae, extended polytetrafluoroethylene (ePTFE) grafts are easily exposed to graft outflow tract IH which may be accompanied by graft outlet stenosis and graft thrombosis after a certain period of usage. The most common etiology of PTFE graft failure is IH at the venous anastomoses. In contrast to arterial hyperplasia, which seems to represent the vessel wall adaptation to low-shear stress, little is known as regards venous hyperplasia. To overcome venous hyperplasia, novel studies have sought to assess the effect of changing the geometry of the anastomosis. Some trials suggest increasing the diameter of PTFE could decrease the incidence of neointimal hyperplasia[4].

AIM

To compare between 8 and 6 mm ePTFE grafts anastomosed between the axillary artery and axillary vein according to the primary patency of dialysis access, and also to compare between them according to the complications occurring.

PATIENTS AND METHODS

This study was carried out under the approval of the Institutional research board (R.18.01.6.R1). This retrospective, prospective case–control cohort study included all patients with ESRD (GFR < 30) referred to the Vascular Outpatient Clinic, Mansoura University hospitals (Proposal Code: R.18.01.6.R1-2022/06/05) seeking for creation of HD access and decided for arteriovenous synthetic graft due to lack of suitable autogenous veins in the arms confirmed by the duplex report (cephalic or basilic veins are < 3 mm), or after failed brachial axillary or axillo-axillary AVG in the axilla. All cases with baseline blood pressure (below 110/70), or evidence of subclavian or innominate vein stenosis were excluded from the study.

Patients after signing informed consent, patient were classified into two groups. In the first group (A) an 8 mm PTFE graft was placed on the chest wall anastomosed between the first part axillary artery and axillary vein. In the second group (B), a 6 mm PTFE graft was placed on the chest wall anastomosed between the first part of the axillary artery and the axillary vein.

Our technique was carried out by placing the patient in the supine position and placing a bag between both scapulae to allow hyperextension of the neck, a transverse infraclavicular skin incision and splitting of the pectorals major muscle aiming to expose a 3 cm segment of the first part axillary artery and vein by gentle dissection and encircling them by vessel loops. A subcutaneous circular tunnel was created along the chest wall and PTFE synthetic graft was placed (either 6 mm or 8 mm). Anastomoses were done using prolene 6/0 or 5/0 sutures and closure of skin with drains (Figure 1a and b).
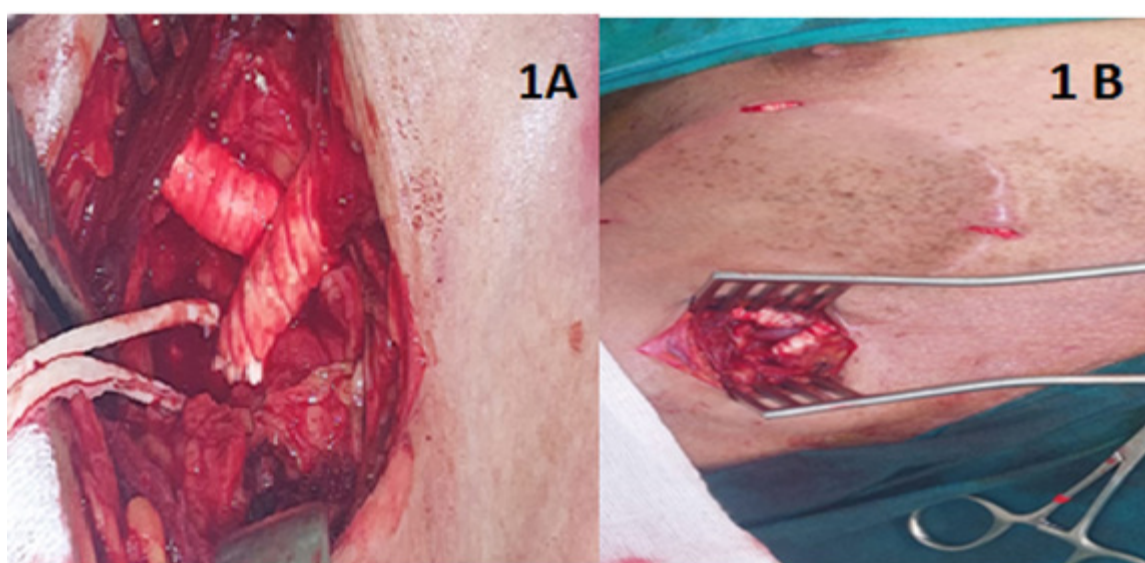

Figure 1: (a) Left axillary artery and axillary vein anastomosis, (b) configuration of left axillary-axillary loop arteriovenous graft.

All patients were followed up by regular visits every week till the first month, then every 3 months till the first year, and then annually till 3 years follow-up. Evaluation based on clinical examination of the fistula reporting functioning palpable thrill and various possible complications (infection, swelling, hematoma, etc.). Duplex surveillance will be done regularly during the first month, third month, sixth month, and annually. Report will include dimensional measurements (anastomotic diameters) and hemodynamic measurements (peak systolic velocities across anastomoses and volume flow).

Statistical analysis:

Data analysis was conducted by SPSS (PASW statistics for Windows, version 25;SPSS Inc., Chicago, Illinois, USA). Qualitative data were described using number and percent. Quantitative data were defined by utilizing mean ± SD for normally distributed data after assessing normality by utilizing the Kolmogrov–Smirnov test. The significance of the obtained results was judged at the P value less than or equal to 0.05 level. $\chi2$, Fisher exact test was utilized to compare qualitative data between groups as appropriate. Student t test was utilized to compare two independent groups for normal distribution of data. Kaplan–Meier test was utilized to assess overall survival and disease-free survival by using log-rank $\chi2$ to determine the effects of predisposing factors affecting survival.

RESULTS

This retrospective, prospective case–control cohort study included patients with ESRD (GFR < 30) seeking to create HD access and decide on arteriovenous synthetic graft due to lack of suitable autogenous veins.

We started our study with 54 patients in which seven cases were missed in follow-up, so the total number of cases was 47. They were classified into two groups. In the first group (A) (n = 26), an 8 mm PTFE graft was placed on the chest wall anastomosed between the first part of the axillary artery and axillary vein. In the second group (B) (n = 21), a 6 mm PTFE graft was placed on the chest wall anastomosed between first part of the axillary artery and axillary vein. All cases were subjected to history taking, clinical examination, and duplex and followed up for 6 months.

Table 1: Age, dialysis duration, and medical history among studied grafts:

	Graft 6 mm (N = 21) [n (%)]	Graft 8 mm (N = 26) [n (%)]	Test of significance
Age (years) (mean ± SD)	56.71 ± 8.19	57.35 ± 6.65	t = 0.292 P = 0.772
Dialysis duration (days) (mean ± SD)	11.47 ± 2.92	11.12 ± 3.77	t = 0.360 P = 0.721
Diabetes	9 (42.9)	13 (50.0)	$\chi2$ = 0.238 P = 0.626
Hypertension	12 (57.1)	15 (57.7)	$\chi2$ = 0.001 P = 0.970
SLE	3 (14.3)	1 (3.8)	FET = 1.63 P = 0.311

$\chi2$, $\chi2$ test; FET, Fisher exact test; SLE, systemic lupus erythematosus; t, Student t test.

Table 1 shows nonstatistically significant difference between graft 6 mm group and graft 8 mm group as regards mean age, mean dialysis duration, diabetes mellitus, hypertension, and systemic lupus erythematosus (P = 0.772, 0.721, 0.626, 0.97 and 0.311, respectively).

Table 2: Comparison of preoperative evaluation of axillary artery diameter and vein diameter between studied groups:

Preoperative evaluation	Graft 6 mm (N = 21)	Graft 8 mm (N = 26)	Test of significance
Axillary artery diameter (mm)	7.90 ± 1.14	9.77 ± 1.14	t = 5.58, P < 0.001*
Vein diameter (mm)	7.81 ± 0.93	10.15 ± 1.22	t = 7.25, P < 0.001*

t, Student t test.
*Statistically significant.

Table 2 shows a statistically significant difference between graft 6 mm group and graft 8 mm group as regards preoperative axillary artery diameter and preoperative vein diameter (P < 0.001 and 0.001, respectively).

Table 3: Comparison of complications between studied groups:

	Graft 6 mm (N = 21) [n (%)]	Graft 8 mm (N = 26) [n (%)]	Test of significance
Infection	1 (4.8)	1 (3.8)	FET = 0.024 P = 1.0
Thrombosis	9 (42.9)	4 (15.4)	$\chi2$ = 4.38 P = 0.036*

$\chi2$, $\chi2$ test; FET, Fisher exact test.
*Statistically significant.

Table 3 shows the statistically significant difference between graft 6 mm group and graft 8 mm group as regards complication (thrombosis) ($P = 0.036$).

There is a nonstatistically significant difference between graft 6 mm group and graft 8 mm group as regards complication (infection) ($P = 1.0$).

Table 4: Incidence of primary patency and secondary patency among studied groups:

	Graft 6 mm (N = 21) [n (%)]	Graft 8 mm (N = 26) [n (%)]	Test of significance
Primary patency at 3 months	19 (90.5)	26 (100)	FET = 2.58 $P = 0.194$
Primary patency at 6 months	17 (81.0)	25 (96.2)	FET = 2.82 $P = 0.115$
Primary patency at 9 months	14 (66.7)	24 (92.3)	FET = 0.531 $P = 0.032*$
Primary patency at 12 months	12 (57.1)	22 (84.6)	FET = 0.531 $P = 0.039*$
Time to secondary patency (months) (mean ± SD)	6.0 ± 2.76	8.0 ± 2.0	t = 1.12 $P = 0.297$

FET, Fisher exact test; t, Student t test. *Statistically significant.

Table 4 shows a nonstatistically significant difference between graft 6 mm group and graft 8 mm group as regards incidence of primary patency (at 3 and 6 months), while a statistically significant difference between the graft 6 mm group and graft 8 mm group as regard incidence of primary patency at 9 and 12 months and mean time to secondary patency ($P = 0.194, 0.009, 0.644$ and 0.297, respectively; Figures 2 – 4) (Table 5).
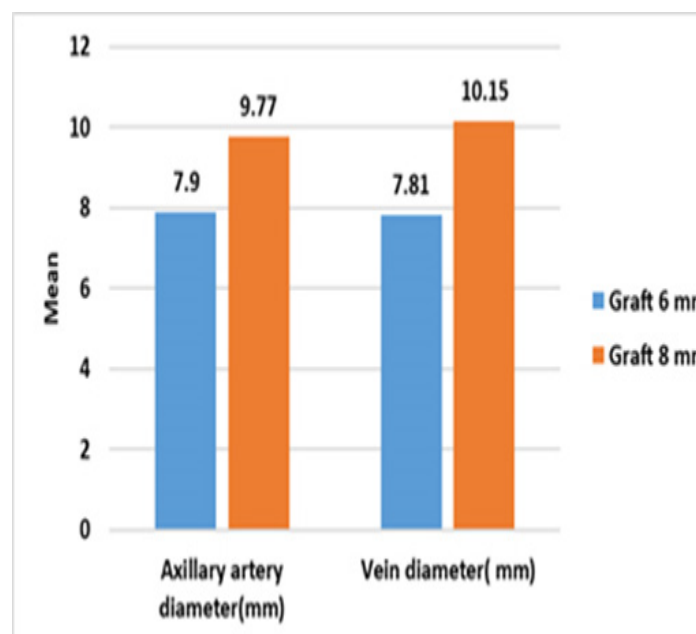

Figure 3: Incidence of primary patency among the studied groups:

Figure 2: Comparison of preoperative evaluation of axillary artery diameter, vein diameter between studied groups.

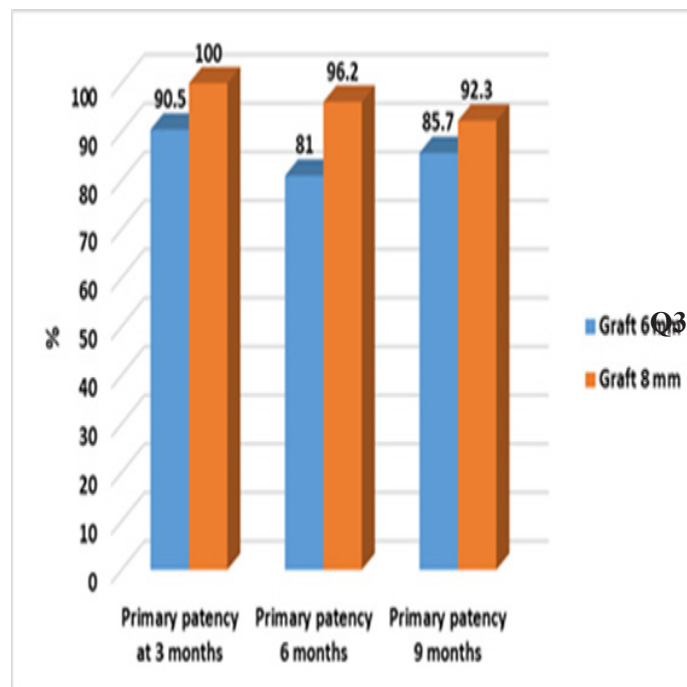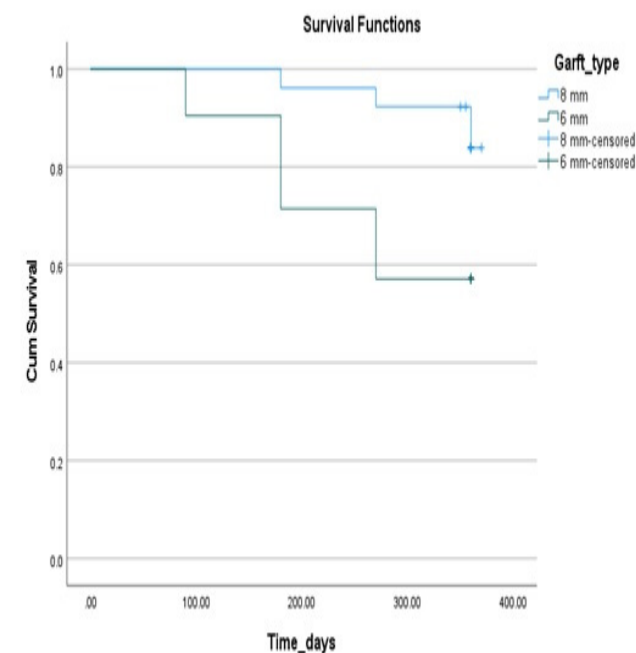**Figure 4:** Kaplan–Meier curve showing primary patency at 1 year among studied groups:

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Table 5: Significant differences regarding primary patency among the studied groups:

	χ^2	DF	Significance
Log-rank (Mantel–Cox)	4.562	1	0.033

Test of equality of survival distributions for the different levels of Garft_type.

DISCUSSION

Current National Kidney Foundation strategies suggest an AVF as the first access for HD[6]. On the other hand, primary failure rates for AVF remain high (> 20 %) and for several cases, AVF is not a viable modality owing to vascular anatomy or different factors[7]. An AVG is suggested for vascular access in the upper extremity in such cases. One of the most broadly utilized graft materials is ePTFE[8].

In terms of the high charge of these grafts, it is essential to know more about their optimum features. The optimum graft diameter for HD is yet to be detected. It is suggested to implant no more than 4 mm graft size at the arterial side to evade cardiovascular adverse events. However several surgeons implant 6 mm grafts in various anatomic areas[9]. Implantation of 8 mm grafts tapered to 4 – 5 mm at the arterial side is suggested in the context of upper arm dialysis grafts[10].

According to large-bore graft benefits comprising easy needling and lower occurrence of midgraft stenosis owing to IH[10], we preferred to implant 6 and nontapered 8 mm grafts, in particular in the upper arm position, owing to improper veins and situations in the forearm as suggested.

We performed arteriovenous synthetic graft (ePTFE) between the axillary artery and axillary vein in 47 patients with ESRD referred to a vascular outpatient clinic seeking to create HD access due to lack of suitable autogenous veins. The patients were divided into two groups; group A (graft 8 mm) (N = 26) and group B (graft 6 mm) (N = 21). Among the total 47 cases, the difference between the two groups was insignificant in mean age, mean dialysis duration, diabetes mellitus, hypertension, and systemic lupus erythematosus (P = 0.772, 0.721, 0.626, 0.97 and 0.311, respectively), showing that neither age nor dialysis duration contribute to successful outcomes.

Compared to other studies, the primary patency rate at 12 months in the current study was 57.1 versus 84.6 % and the mean time to secondary patency was 6.0 versus 8.0 months with a statistically significant difference between the two grafts. This finding was not consistent with the study done by Afshar et al.[11], that found the primary patency rates at 1 year were 42.2 and 36.5 % for 6 and 8 mm grafts, respectively, with no significant difference (P > 0.05).

Additionally, we found a statistically significant difference between the graft 6 mm group and graft 8 mm group as regards complication (thrombosis) (P = 0.036) with more thrombosis occurrence in 6 mm grafts (42.9 vs. 15 %). However, there was a nonstatistically significant difference as regards complication (infection) (P = 1.0). Afshar et al.[11], found that there was a significant difference as regards the complication rate between cases with and without underlying disorders (P < 0.05). Although there was a significant increase in the incidence of thrombosis among cases with 8 mm grafts (34 vs. 18 %), the overall complication rates in the two grafts did not differ significantly (P > 0.05). On the other hand, García-Pajares et al.[12], did not detect any significant difference in complication and patency rates between the two grafts. On the other hand, Polo et al.[13], concluded that if the axillary vein is more than 6 mm in diameter, an 8 mm upper arm PTFE graft tapered to 6 mm at the arterial side could offer long-term use, provided that the adverse events throughout their use for HD are discovered early and managed promptly. The main benefits of such large-bore grafts for HD are easy punction by the nurses and avoidance of late midgraft stenosis owing to IH at the puncture areas.

The discrepancies among studies could be owing to the next causes: using grafts with comparable diameter throughout the length, without tapering at the arterial side that reduces adverse events; unfamiliarity of HD unit staff and cases with appropriate care of vascular grafts and late referral of complicated cases for interference.

Despite the promising outcomes of the current study, its retrospective nonrandomized nature has been considered the main limitation that led to selection bias in the form of unequal distribution as regard axillary vein and artery diameters between both groups, and that may affected the outcomes of primary patency between both groups. Particular parameters such as depth of vessels from the skin surface, clinical manifestations, and laboratory investigations were not comprised, and as a result, their role could not be detected. Additional studies that considered the aforementioned factors may be more informative in guiding the choice of AVG creation and detecting the effect of graft diameter on the patency rates. In addition, conducting a study with many cases and randomization will be more representative of the general population.

CONCLUSION

The current study revealed that without considering certain changes in 6 and 8 mm grafts, primary patency can be improved by placing 8 mm grafts while respecting the axillary artery and vein diameters.

CONFLICT OF INTEREST

There are no conflicts of interests.

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