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FOLLOW – UP RESULTS OF SYNTHETIC VASCULAR GRAFTS IN CHILDREN UNDERGOING HEMODIALYSIS*

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SUMMARY: Nayır A, Sönmez Y, Şirin A, Emre S, Aydoğan Ü (Nephrology Unit, Department of Pediatrics, İstanbul University Faculty of Medicine, İstanbul, Turkey). Follow-up results of synthetic vascular grafts in children undergoing hemodialysis. Turk J Pediatr 1995; 37: 223-228.

Polytetrafluoroethylene (PTFE) grafts were inserted in the thigh of 14 children (7 boys and 7 girls, age 12 ± 1.8 years) who were undergoing chronic hemodialysis for end-stage renal disease. Removal of grafts was necessary in three patients within three months of implantation. In a fourth case it was indicated in the fifteenth month. In two cases thrombectomy was necessary. Echocardiography was performed in 10 patients before and three and 12 months after surgery. Cardiac performance followed by echocardiography did not change after one year. After two years the survival of grafts was 71%. It appears that synthetic grafts offer advantages for pediatric hemodialysis petients with arteriovenous fistula failure. On the other hand, this technique entails serious risks. *Key words: hemodialysis, children, polytetrafluoroethylene grafts, echocardiography.*

The increasing number of surviving hemodialysis patients and the demand for vascular access requires different shunting procedures in patients with arteriovenous fistula failure[1]. Synthetic or biological vascular grafts interposed subcutaneously between artery and vein provide a very important second choice for these patients[2,3]. However, while there are advantages, there are also disadvantages[4]. The most common complications of synthetic grafts are thrombosis, infection, false aneurysms and a "vascular steal" phenomenon. Patients with a vascular graft may also develop symptoms of excessive cardiac output. The aim of this paper is to present kinds of material, sites of implantation and complications of grafts used for some of our pediatric patients and to determine the long-term effects of polytetrafluoroethylene (PTFE) grafts on cardiac performance using echocardiography.

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Material and Methods

During the period from May 1989 to June 1990, 86 surgeries to create vascular accesses were performed on 48 children undergoing chronic hemodialysis (mean: 1.8 arteriovenous fistulas/patient). Twenty-six of the patients were female and 22 were male, with an age range of six to 16 years. Fourteen patients, seven boys and seven girls aged eight to 15 years (mean ± SD: 12 ± 1.8 years), with failed arteriovenous fistulas received access grafts. They had been on dialysis for an average of 12 months (range 1-32 months) (Table I). The location and type of access were PTFE grafts in the shape of a loop between the superficial femoral artery and the saphenofemoral junction. Vascular anastomoses were made using CV 7 Gore-tex sutures in running fashion. All PTFE grafts of 6 mm diameter were thin-walled and full-ringed. All patients received a prophylactic antibiotic (ceftazidime) preoperatively and postoperatively for five days. Anticoagulants were not used.

Table I: Clinical Data of Patients Who Received PTFE Grafts

Case No.	Age (years)	Sex	Underlying Renal Disease	Duration of Hemodialysis (months)	Weight (kg)	Serum Albumin (g/dl)	Removal of the Graft
1	8	F	CGN	8	28	3.2	no
2	11	F	LMM	2	2.5	3.6	no
3	13	F	PCKD	12	36	4.6	no
4	12	F	RH	12	34	4	no
5	14	F	VUR	18	52	3.9	no
6	13	M	Amyloidosis	22	28	2.3	no
7	11	F	Urolithiasis	12	32	3.6	no
8	10	M	OU	1	32	3.4	no
9	14	M	CGN +NS	32	30	2.2	3rd month (hemorrhage)
10	12	M	Alport's syndrome	20	28	3.4	2nd month (pericarditis)
11	15	M	OU	6	34	4.1	15th month (hemorrhage)
12	14	M	CGN + NS	1	30	2	1st month (hemorrhage)
13	13	F	LMM	6	46	3.4	no
14	12	M	CGN	10	36	3.6	no
mean ± SD range	12 ± 1.8 (8-15)	7 F 7 M		12 ± 9 (1-32)	33.6 ± 7.3 (25-52)	3.37 ± 0.74 (2-4.6)	

CGN : Chronic glomerulonephritis.
PCKD: Polycystic kidney disease.
VUR : Vesicoureteral reflux.
OU : Obstructive uropathy.
LMM : Lumbar myelocele.
RH : Renal hypoplasia.
NS : Nephrotic syndrome.

Four operations were performed under ketamine anesthesia, while topical anesthesia was used for the remainder. The PTFE grafts were used for hemodialysis two weeks after implantation for the first time. Immediately prior to, three months and one year after surgery, blood samples were obtained before a hemodialysis session for hematocrit, blood urea, serum creatinine and albumin measurements.

On these days an M-mode echocardiographic tracing of the left atrium and left ventricle was obtained on ten children two hours after the hemodialysis session on a Hitachi EUB-40 ultrasonography apparatus on long-axis view. Left ventricular wall thickness, chamber size, left atrial and aortic diameters were measured by the standard technique from the m-mode echocardiogram[5]. Ventricular volume measurements were calculated using the Teichholz method[5].

Standard laboratory methods were used for blood urea, plasma creatinine, albumin and hematocrit measurements. All data were presented as mean and standard deviation. Wilcoxon signed rank test for paired data was used for statistical analysis.

Results

Removal of grafts was necessary in three patients within three months of implantation. In one patient a serious hemorrhage at the arterial anastomosis site occurred in the first month. A subclavian catheter was inserted and remained for a month; the patient was then switched to Continuous Ambulatory Peritoneal Dialysis (CAPD). In another patient, secondary infection after pericarditis was observed in the second month. He continued hemodialysis with the aid of a subclavian catheter, and a fistula was created. In a third patient, infection of the hematoma occurred in the third month at the puncture site. A Tenchoff catheter was implanted and the patient was switched to CAPD. In the first and third cases (cases 9 and 12), the primary disease was nephrotic syndrome. In the second, infection resulted in graft removal. In a fourth case, removal was required at 15 months due to hemorrhage at the anastomosis site. The patient continued hemodialysis for three months with a Permcath subclavian catheter, and a kidney transplant from her mother was then performed. In the remaining ten patients neither false aneurysm nor infectious complications were encountered. Two PTFE grafts thrombosed and required reoperation at 15 and 18 months. In two cases, moderate swelling of the leg resolved after two weeks of conservative therapy. One child developed ipsilateral limb hypertrophy with no gait abnormality.

Blood urea, serum creatinine, serum albumin and hematocrit values did not change significantly during the study (Table II). Heart rates increased slightly, but the increase was not statistically significant. Systolic and diastolic blood pressure values remained at the same levels. M-mode and two-dimensional echocardiographic measurements of left ventricular size did not change significantly between: 1. the initial and third months; 2. the initial and twelfth months; and 3. the third and twelfth months ($p > 0.05$, Table III). None of the patients showed evidence of high-output cardiac failure. Ten of the 14 grafts were still functioning after two years.

Table II: Patient Characteristics During Follow-up

	Before Surgery	3 Months Later	1 Year Later
Weight (kg)	33.6 ± 7.3		34.07 ± 7.09
Hematocrit (%)	25.07 ± 3.7	24.2 ± 3.2	25 ± 2.9
Blood urea (mg/dl)	215.3 ± 28	220 ± 25	214 ± 22.7
Serum creatinine (mg/dl)	5.7 ± 0.56	5.8 ± 0.8	5.68 ± 0.6
Serum albumin (g/dl)	3.37 ± 0.74	3.26 ± 0.81	3.41 ± 0.7
Systolic blood pressure (mm Hg)	115 ± 24	117 ± 25	107 ± 24
Diastolic blood pressure (mm Hg)	69 ± 21	75 ± 18	70 ± 22

Table III: M-mode and Two-dimensional Echocardiographic Measures Before and After PTFE Graft Implantation

	Before	3rd Month	12th Month
EDD (mm)	43.9 ± 7.5	43.8 ± 4.9	44.2 ± 8.2
ESD (mm)	29 ± 6.28	31 ± 4.28	32 ± 8.5
PWDT (mm)	10.2 ± 2.97	9.8 ± 2.6	9.6 ± 2.75
PWST (mm)	15.5 ± 3.5	13.7 ± 3.4	13.7 ± 3.2
IVSDT (mm)	9.4 ± 1.83	8.9 ± 1.3	9.5 ± 1.35
IVSST (mm)	12.6 ± 2.8	11.2 ± 2.34	12.1 ± 2.28
HR (beats/min)	87.1 ± 22.07	99.7 ± 12	104.4 ± 15.7
LVDV (ml)	107.4 ± 44.7	102 ± 25.7	108 ± 48
LVSV (ml)	35.4 ± 17.3	33.3 ± 10.4	34.4 ± 9
SV (ml)	66.8 ± 27.4	66.1 ± 18.3	69.1 ± 20.6
EF (%)	66.6 ± 8.48	63.9 ± 6.33	65.4 ± 4.9
CO (l/min)	6.46 ± 1.64	6.43 ± 1.78	6.6 ± 1.65
SF (%)	33.16 ± 7.03	29.17 ± 5.27	29.65 ± 5.39
AOD/LAD ratio	0.83 ± 0.07	0.8 ± 0.1	0.83 ± 0.09

EDD : Left ventricular dimension in diastole.
ESD : Left ventricular dimension in systole.
PWDT : Left ventricular posterior wall thickness in diastole.
PWST : Left ventricular posterior wall thickness in systole.
IVSDT : Interventricular septum diastolic thickness.
IVSST : Interventricular septum systolic thickness.
HR : Heart rate.
LVDV : Left ventricular diastolic volume.
LVSV : Left ventricular systolic volume.
SV : Stroke volume.
EF : Ejection fraction.
CO : Cardiac output.
SF : Shortening fraction.
AOD/LAD ratio : Aortic diameter/left atrial diameter ratio.

Discussion

The difficulty in maintaining vascular access in patients on long-term hemodialysis is a serious problem[6]. This problem is exacerbated in children because of the diameter of the vasculature[1]. Improvements in synthetic materials have made the use of PTFE an attractive alternative for hemodialysis access when the autogenous vessels are of inadequate size[2].

Guzzetta et al.[7] observed in their series that femoral artery to femoral vein PTFE grafts led to either limb hypertrophy or excessive flow through the fistula, and they did not recommend this technique for children. Some references consider forearm grafts more suitable than thigh grafts because of cardiac overload[1]. The PTFE grafts cause a circuit of low vascular resistance resulting in a decrease in circulation transmit time and an increase in venous return, stroke volume and heart rate. Echocardiography, which provides a direct means for noninvasive visualization of cardiac structure and function, is a good tool for follow-up. The results of this study using echocardiography show that thigh grafts have no clinically important side effects. Cardiac functions stroke volume, cardiac output, ejection fraction and fractional shortening), cardiac dimensions (left atrium/aorta ratio, left ventricular systolic and end-diastolic dimensions) and muscular mass are not impaired after thigh graft implantation. These findings show that a circulatory shunt through a 6 mm thigh graft does not affect cardiac functions, with the exception of a slight increase in heart rate which is statistically insignificant. On the other hand, in younger patients weighing less than the study group (less than 25 kg), the ratio of shunting to total blood volume may be significant.

In children, thigh grafts are preferable to forearm grafts because the larger vessels are more suitable for surgery and blood flow is greater in this region. Long-term follow-up of patients with these grafts is imperative since these children may develop cardiac problems due to a chronic output state.

It appears that synthetic grafts offer great advantages for pediatric hemodialysis patients, especially if the waiting time for transplantation is prolonged[8]. On the other hand, this technique entails serious risks[9]. Acute thrombosis of PTFE grafts can occur at any time after insertion. Sudden occlusion of large-caliber, PTFE thigh grafts in children, through which a large percentage of total cardiac output may be diverted, may result in hypertensive encephalopathy[10]. Early graft thrombosis (within the first postoperative month) may be due to transient hypotension, an imperfectly chosen or performed operative procedure or unusually elevated resistance in the outflow bed[11]. Late graft thrombosis (more than one month postoperatively) may be due to intimal hyperplasia or progression of atherosclerosis, although some grafts can thrombose with no apparent explanation[12, 13]. In our series thrombectomy was indicated in two cases.

An infection of a prosthetic vascular graft placed electively under sterile conditions is a rare event. However, if graft infection does occur, there are limb- and life-threatening consequences[14, 15]. During systemic infections, secondary graft colonization may also arise, as seen in our follow-up.

For patients with hypoproteinemia, PTFE grafts involve even greater risks due to delayed wound healing, increased incidence of thrombosis and infection. In two of our patients with nephrotic syndrome and hypoproteinemia, graft failure occurred. In hemodialysis patients with hypoproteinemia, insertion of synthetic grafts should be avoided when possible.

Even when a technically perfect anastomosis has been performed, significant bleeding can still result[16]. Hemorrhage may be life-threatening and can occur in both the early and late phases. After hemodialysis, perigraft hematoma at the site of puncture can cause serious complications. These complications can be remedied simply by applying pressure at the puncture site.

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