Impact of Dialysis Access Fistula on Cardiac Function After Kidney Transplantation

Mohammad Javad Soleimani,[1] Hosein Shahrokh,[1]
Pejman Shadpour,[1] Majid Shirani,[2] Said Arasteh[1]

[1]Hasheminejad Clinical Research Development Center, Tehran University Medical Sciences, Tehran, Iran
[2]Department of Urology, Shahrekord University of Medical Sciences, Shahrekord, Iran

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Introduction. The cardiovascular impact of a patent arteriovenous fistula (AVF) following kidney transplantation has not been clearly described. This study aimed to evaluate the natural history of AVFs in kidney transplant recipients and the effect of spontaneous AVF closure after kidney transplantation on cardiac status.
Materials and methods. Data on vascular access for dialysis were collected from medical charts of kidney transplant recipients between July 2009 and November 2010 at a single center. Echocardiographic re-assessment of the AVF flow and cardiac status was done in selected patients with functioning and nonfunctioning AVFs.
Results. Of 180 kidney transplant recipients, 142 had AVFs before transplantation and 99 (69.7%) had a functioning fistula at the time of study after kidney transplantation. Twenty-three patients with a functioning AVF were compared with 17 with spontaneously closed AVFs. The left ventricular ejection fraction improved in both groups posttransplant. In the group with patent fistulas, there was a trend towards lower value of left ventricular end-systolic and end-diastolic diameters, but it did not reach statistical significance. The mean fistula flow was 560 ± 405 mL/min in this group. A significant reduction was observed in the interventricular septum and left ventricular posterior wall diameters in the group with closed AVFs.
Conclusions. Spontaneous AVF closure did not offer a significant cardiac beneficial effect. There are insufficient data to promote systematic closure of AVF after successful kidney transplantation.

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INTRODUCTION

One of the common treatment options of patients suffering from end-stage renal disease is hemodialysis. Hemodialysis is usually done through a vascular access route, ie, arteriovenous fistula (AVF). Arteriovenous fistula is a nonphysiologic vascular access which is imposed on cardiovascular system[1]; however, it is the best vascular access for hemodialysis and has lower risk of side effects, especially infection, in comparison with other vascular access methods.[2]

Arteriovenous fistula decreases systemic vascular resistance, causing increased stroke volume and cardiac output in order to maintain blood pressure, and this can cause left ventricular volume overload and eccentric left ventricular hypertrophy.[3] Although the chronic volume overload caused by AVF induces structural and functional changes on cardiovascular system, whether these changes increase mortality and morbidity in patients is unclear.[4] Some researchers believe that AVF has destructive effects on the cardiovascular system, such as left ventricular

hypertrophy,[3,5-7] high-output cardiac failure,[3,8,9] and other symptoms of cardiovascular diseases, such as hypertension and aortic stiffness.[1,10] Some others believe that AVF has negligible effects on cardiovascular system in long term.[6,11] Although there is agreement that AVF makes considerable structural changes in the cardiovascular system in long term, there is no consensus on functional changes at least in an AVF with normal-range flow.[1]

Successful kidney transplantation improves uremia, normalizes hemoglobin level, increases serum albumin, and improves left ventricular volume and volume status. These factors theoretically reduce left ventricular hypertrophy,[4,12,13] although some factors such as uncontrolled hypertension and anemia my interfere in creation and continuation of left ventricular hypertrophy.[4] Some studies have shown that left ventricular dimension is improved after kidney transplantation, but left ventricular hypertrophy does not completely reverse.[3,11,14] Arteriovenous fistulas may be another factor that impede improvement of left ventricular hypertrophy. They usually remain unused and are usually forgotten after successful kidney transplantation. Some of these fistulas are closed spontaneously.[2] Given the need for vascular access on one hand and the negative effects of AVF on cardiac function and morphology on the other hand, the value of keeping an AVF patent or deciding to close it is a challenging decision after a successful kidney transplantation.[4] Although closure of the AVF may be useful for the patient, it destroys a valuable vascular access, which is necessary for returning the patient to dialysis in case of graft loss.[5]

No distinctive criteria have been proposed to decide how to manage a functioning AVF after successful kidney transplantation.[1,2,4] Few studies of the natural history of these fistulas have been published. More information is necessary to specify which patient benefits from closure of the AVF. The aim of this study was to evaluate the outcome of preserving AVF after kidney transplantation and to compare echocardiographic parameters before and after transplantation in patients with functioning AVF with those who have closed AVF.

MATERIALS AND METHODS

Patients

This study included all patients who had kidney transplantation from July 2009 to November 2010 at Hasheminejad Kidney Center. Data on the patients including demographic specifications, associated disorders, dialysis modality before kidney transplantation, allograft function, and AVF outcome were collected and analyzed. In a second phase of the study, transplant recipients who met the following criteria were enrolled: successful kidney transplantation, having a functioning AVF before transplantation, having undergone complete standard echocardiographic study before transplantation, and absence of major cardiac disorders on cardiac assessments before transplantation. This cohort was divided into 2 groups of those with functioning and nonfunctioning AVF. Fistula flow in the functioning AVF group was measured and then echocardiography was performed in both groups, 6 to 18 months after transplantation, and cardiac parameters were assessed for comparison with pretransplant echocardiography results.

Fistula Flow

Fistula flow was assessed using the Siemens-Acuson X500 ultrasonography device (Siemens, Erlangen, Germany) with a linear multifrequency probe operating at 5 MHz to 10 MHz. Arterial flow was measured immediately proximal and distal to the fistula and the flow was calculated. Flow volume obtained using the algorithm available on the system in the D-Flow method based on the mean flow.

Echocardiography

Two-dimensional echocardiography was performed using the Vivid S5 (GE Healthcare, New York, USA). The following parameters were assessed: ejection fraction, left ventricular end-diastolic diameter, left ventricular end-systolic diameter, interventricular septum diameter, posterior wall diameter, and left atrial diameter.

Statistical Analyses

Data analysis was done using the SPSS software (Statistical Package for the Social Sciences, version 18.0, SPSS Inc, Chicago, Ill, USA). Continous variables were described as mean ± standard deviation. Changes in echocardiographic parameters before and after transplantation were analyzed by the paired *t* test. A *P* value less than .05 was considered significant.

RESULTS

From July 2009 to November 2010, a total of 212 patients undewent kidney transplantation at our center. Clinical records of 180 patients were available for this study (117 men and 63 women with a mean age of 41.7 ± 13.2 years). The mean follow-up time from kidney transplantation was 13.9 ± 4.8 months, and the mean duration of hemodialysis before kidney transplantation was 29.6 ± 17.3 months. Sixteen of the 180 patients (8.9%) had preemptive kidney transplantation, and 6 patients (3.3%) had been on peritoneal dialysis before transplantation. Of the remaining 158 patients (86.8%) who had been on hemodialysis, 142 (78.9%) had an AVF and 16 (8.9%) had a catheter or artificial vessel for vascular access.

Five patients died during the follow-up period and 6 patients lost their graft function and strarted on dialysis again, all through their previous AVF. Among the patients who had functioning AVFs before transplantation, 99 (69.7%) had a functioning fistula at the time of study after kidney transplantation. In 34 patients, the fistula was spontaneosly closed and 4 patients had their fistula surgically closed.

There were 40 patients with successful kidney transplantation who had been on hemodialysis through AVF and had undergone complete standard echocardiographic study before kidney transplantation with the results indicative of no major cardiac disorder. They were divided into 2 groups with functioning and nonfunctioning AVFs. Clinical characteristics of these two groups are summarized in Table 1. Echocardiography parameters in both groups were similar before kidney transplantation. Echocardiographic re-assessment after kidney transplantation showed improvement in the ejection fraction in both groups with functioning and nonfunctioning AVFs (Table 2). Reduction in the interventricular septum and posterior wall diameters in the group with nonfunctioning AVFs was significant, while in the group with functioning AVFs, only changes in the interventricular septum diameter were statistically arginally significant (P = .06). There was also a significant increase in the left atrial diameter posttransplantation in the patent AVF group.

DISCUSSION

The strategy for AVF management after successful kidney transplantation is debatable. Keeping the AVF may be useful in case the transplanted kidney fails and the patients requires dialysis. On the other hand, a functioning AVF remained unused after

Table 1. Clinical Characteristics*

Characteristic	Kidney Transplant Recipients		*P*
	Functioning AVF	Nonfunctioning AVF	
Number	23	17	
Age, y	49.1 ± 11.8	39.2 ± 12.4	.05
Gender			
Male	16	12	
Female	7	5	.94
Reassesment Time after transplantation, mo	11.1 ± 3.5 (6 to 18)	12.0 ± 3.5 (7 to 17)	.43
Time between fistula creation and transplantation, mo	29.9 ± 15.8 (10 to 71)	31.9 ± 16.7 (10 to 72)	.70
AVF flow, mL/min	560.9 ± 405.8 (105 to 1591)	…	…

*AVF indicates arteriovenous fistula.

Table 2. Echocardiographic Parameters Before and After Kidney Transplantation*

Parameter	Patients with active AVF			Patients with inactive AVF		
	Before Transplantation	After Transplantation	*P*	Before Transplantation	After Transplantation	*P*
EF, %	52.82 ± 3.90	54.34 ± 2.30	.02	52.05 ± 3.10	54.11 ± 2.00	.03
LVEDD, cm	4.84 ± 0.48	4.74 ± 0.46	> .05	4.87 ± 0.38	4.85 ± 0.47	> .05
LVESD, cm	3.15 ± 0.54	3.12 ± 0.61	> .05	3.39 ± 0.47	3.42 ± 0.58	> .05
IVSD, cm	1.22 ± 0.18	1.24 ± 0.19	.06	1.16 ± 0.11	1.10 ± 0.11	.002
PWD, cm	1.23 ± 0.19	1.24 ± 0.19	> .05	1.17 ± 0.11	1.10 ± 0.11	.001
LAD, cm	3.50 ± 0.38	3.70 ± 0.44	.006	3.48 ± 0.55	3.50 ± 0.58	> .05

*EF indicates ejection fraction; LVED, left ventricular end-diastolic diameter; LVESD, left ventricular end-systolic diameter; IVSD, interventricular septum diameter; PWD, posterior wall diameter; and LAD, left atrial diameter.

kidney transplantation may lead to complications of the fistula itself or cardiovascular disorders. Complications of AVF are not rare and include steal syndrome, arm edema, thrombosis, and rarely, traumatic bleeding. Moreover, the presence of a dilatated and pulsatile fistula is a cosmetic issue for some patients.[4]

Some fistulas close spontaneously after kidney transplantation. Manca and colleagues showed in a retrospective study on 365 patients with successful kidney transplantation that AVF was spontaneously closed in 125 patients (34%).[2] In our study, 34 out of 142 patients experienced spontaneous closure of AVF after kidney transplantation (24%). This relatively lower rate can be due to shorter follow-up time in our study.

The effect of an active AVF after kidney transplantation on cardiovascular parameters remains a matter of debate. In our study, it was shown that in comparison with the results of echocardiography before kidney transplantation, ejection fraction in both groups with functioning and nonfunctioning AVF had improvement due to correction of uremia, normalization of hemoglobin level, and improved volume status after successful kidney transplantation. In this study, some decreases in dimensions and volume of the left ventricle occurred in both groups. Although these changes were more evident in the group with functioning AVF, the difference was not statistically significant. In the nonfunctioning AVF group, changes in the posterior wall diameter of the left ventricle and interventricular septum diameter were more prominent. Peteiro and coworkers, in a prospective study on 30 patients after kidney transplantation, showed that left ventricular mass index and left ventricular end-diastolic volume were reduced. However, this reduction was not different between the two groups with functioning and closed AVF and depended more on blood pressure control.[11] De Lima and coleagues retrospectively studied on 61 patients receiving kidney transplantation (39 patients with functioning AVF and 22 with closed AVF) and found that there was no difference between the two groups in the left ventricular mass, cardiac index, ejection fraction, and left ventricular hypertrophy.[6] Van Duijnhoven and coworkers studied the effect of closing AVF after successful kidney transplantation on 20 patients in a prospective study. They found a reduction in end-diastolic diameter (51.5 ± 5.8 mm versus 49.3 ± 5.4, $P < .01$) and left ventricular mass index (135.0 ± 34.1 mm versus 119.8 ± 23.2, $P < .01$).[3] Unger and colleagues found in a case-control prospective study on 17 patients that surgical AVF closure reduced left ventricular mass index from 139 ± 44 g/m^2 to 127 ± 45 g/m^2 ($P = .001$).[15]

Sheashaa and colleagues compared 17 patients receiving kidney transplantation whose AVF closed spontaneously within 1 month after transplantation with a control group including 34 patients with functioning AVF. Although the end-systolic and end-diastolic volumes and diameters of the left ventricle were lower in the first group, this difference was not significant; however, cardiac index and cardiac output were higher in the first group.[16] Cridlig and coworkers studied on 76 patients receiving successful kidney transplantation (38 patients with functioning AVF and 38 patients with nonfunctioning AVF) and showed that a patent AVF in these patients caused a more prominent increase in the left ventricular mass index relative to patients with nonfunctioning AVF (112.4 ± 28.0 g/m^2 versus 135.1 ± 30.3 g/m^2, $P < .001$).[17] Valek and colleagues studied on 15 patients with AVF flows above 1300 mL/min and 40 patients with fistula flows of 200 mL/min to 1400 mL/min. They found that AVFs with normal flow had less effect on cardiovascular parameters, but higher flows, especially above 1400 mL/min, caused an increasein the left ventricular load and could be accompanied by high-output cardiac failure.[1]

The fact that functioning AVF after kidney transplantation causes deterioration of cardiovascular system and increase of morbidity and mortality is doubtful. The published studies do not support clearly beneficial effects of closing AVF on cardiovascular parameters at least in normal-range fistula flow and patients lacking other risk factors such as uncontrolled hypertension. Thus, more large-scale studies are necessary to clarify this issue. At present, we do not recommend routine closure of AVFs after successful kidney transplantation. However, it could be an option in case of stable graft function and absence of any rejection episode, especially in patients with cardiac disorders. Obviously, we should consider the peripheral vascular status as an influential factor on making the decision.

The major limitation of our study is its

retrospective nature and the short follow-up time. It is difficult to design any prospective study to show the effect of spontaneous obliteration of AVFs.

CONCLUSIONS

Morbidity and mortality of cardiac disease in patients receiving kidney transplantation are higher than those of the general population. Surgical or spontaneous closure of AVF after successful kidney transplantation can improve some cardiac parameters, but the assumption that this leads to reduction of cardiac morbidity and mortality has not been proven and prospective and randomized studies are required to prove it. At present, we may not recommend routine closure of AVF after kidney transplantation, but we believe in considering graft function, age, and cardiovascular status of the patients, as well as ease and feasibility of creating a new AVF if needed, when proposing the option for selected patients.

CONFLICT OF INTEREST

None declared.

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Correspondence to:
Majid Shirani, MD
Department of Urology, Shahrekord University of Medical Sciences, Shahrekord, Iran
E-mail: majd_uro@yahoo.com

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