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Clinical Analysis of Hemodialysis Vascular Access: Comparision of Autogenous Arterioveonus Fistula & Arteriovenous Prosthetic Graft

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Background: Mature autogenous arteriovenous fistulas have better long term patency and require fewer secondary interventions compared to arteriovenous prosthetic graft. Our Study evaluated vascular patency rates and incidence of interventions in autogenous arteriovenous fistulas and grafts. ***Material and Methods:*** A total of 166 vascular access operations were performed in 153 patients between December 2002 and November 2009. Thirty seven caeses were excluded due to primary access failure and loss of follow-up. One group of 92 autogenous arterioveous fistulas and the other group of 37 arteriovenous prosthetic grafts were evaluated retrospectively. Primary and secondary patency rates were estimated using the Kaplan-Meier method. ***Results:*** The primary patency rate (84%, 67%, 51% vs. 51%, 22%, 9% at 1, 3, 5 year; p=0.0000) and secondary patency rate (96%, 88%, 68% vs. 88%, 65%, 16% at 1. 3, 5 year; p=0.0009) were better in autogenous fistula group than prosthetic graft group. Interventions to maintain secondary patency were required in 23% of the autogenous fistula group (average 0.06 procedures/patient/year) and 65% of prosthetic graft group (average 0.21 procedures/patient/year). So the autogenous fistula group had fewer intervention rate than prosthetic graft group (p=0.01) The risk factor of primary patency was diabetus combined with ischemic heart disease and the secondary patency's risk factor was age. ***Conclusion:*** Autogenous arteriovenous fistulas showed better performance compared to prosthetic grafts in terms of primary & secondary patency and incidence of interventions.

Key words: 1. Fistula
2. Graft
3. Vascular patency

INTRODUCTION

Maintaining a functionally good arteriovenous fistula is very important in chronic renal failure patients for effective hemodialysis treatment. However, complications related with arteriovenous fistula are the most crucial cause to morbidity rate of patients treated with hemodialysis, which takes a large part in treatment cost. There are three types of hemodialysis access: autogenous arteriovenous fistula, arteriovenus prosthetic graft, and central venous catheter. Among these types, mature autogenous arteriovenous fistula is known to be the best hemodialysis method with promising good long-term pa-

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Table 1. Vascular access procedures

Autogenous AVF		Prosthetic AVG	
Radio-cephalic direct wrist	78	Brachial-antecubital forearm loop	44
Radio-cephalic direct cubital	6	Brachial-axillary straight	5
Brachial-cephalic upper arm direct	28		
Brachial-basilic upper arm transposition	5		
Total cases 166 (100%)	119 (71%)		49 (29%)

Primary access failure rate (7.8%): AVF 10 (8.4%), AVG 3 (6.1%). AVF=Arteriovenous fistula; AVG=Arteriovenous graft.

tency rate and low morbidity rate [1].

Autogenous arteriovenous fistula has its own weakness that it has a greater rate in failure to maturity when compared with prosthetic graft. However, when autogenous arteriovenous fistula is successfully used in hemodialysis, it shows significantly lower occurrence of revision for long-term patency than prosthetic graft. According to National Kidney Foundation-kidney disease outcomes Quality Initiative guidelines (NFK/KDOQI), using an autogenous arteriovenous fistula such as radiocephalic fistula or brachiocephalic fistula is recommended. However, when the patient is female, older, obese, diabetic, or has peripheral vascular disease, usage of autogenous arteriovenous fistula is known to be relatively low. Also, prosthetic graft can be an appropriate alternative in cases where autogenous arteriovenous fistula has failed or could not be used [1-3].

Authors of this research retrospectively observed patients gone through arteriovenous fistula operations. Authors analyzed the differences in primary and secondary patency rates of autogenous arteriovenous fistula group and arteriovenous prosthetic graft group. Risk factors affecting the patency rate along with revision method and frequency to maintain secondary patency were analyzed.

MATERIAL AND METHODS

Patients gone through autogenous arteriovenous fistula or arteriovenous prosthetic graft operations from December, 2002 to November, 2009 were considered as the subject group. The patency rates up to March 31st, 2010 were retrospectively researched. Total number of operations in 153 subject patients was 166. 117 cases were autogenous arteriovenous fistula and 49 cases were arteriovenous prosthetic graft with polytetrafluorethylene (PTFE) material (Table 1). Among these patients, 129 cases were set as research subject excluding 37 cases with primary access failure, postoperative early death, kidney replacement, peritoneal dialysis, and loss of follow-up observation. There were frequency differences of diabetes, hypertension, and ischemic heart disease between two groups (Table 2).

Clinic's medical record was referred in patients with possible clinic follow-up observation and phone interview with the patient or dialysis clinic was done for patients gone to different clinics for hemodialysis.

Primary and secondary patency difference in autogenous arteriovenous fistula or arteriovenous prosthetic graft was observed along with factors affecting patency such as primary diseases causing chronic renal failure, age, sex, and associated diseases. In addition, revision method and frequency difference in cases where autogenous arteriovenous fistula and arteriovenous prosthetic graft failed functionally were investigated.

Primary patency was defined as the time period from formation of arteriovenous fistula to first revision due to malfunction of arteriovenous fistula such as stricture or thrombosis. Secondary or cumulative patency was defined as the time period from formation of arteriovenous fistula to complete failure to hemodialysis with the corresponding arteriovenous fistula disregarding the number of revisions. In cases where the patient deceased or the follow-up was lost before primary or secondary patency were considered as censored data. Primary access failure was defined as cases where hemodialysis could not be done properly due to early obstruction of arteriovenous fistula or immuturity. In this research, 13 cases (7.8%) had primary access failure and were excluded from patency analysis subject group.

Table 2. Patients characteristics

	AVF (92 cases)	AVG (37 cases)	p-value
Age (Y)	55.4±13.7	59.8±10.4	0.053
Men (%)	57 (62.0%)	16 (43.2%)	0.052
Primary disease (DM/non DM)			
DM	42 (45.7%)	31 (83.8%)	0.00
GN	17 (18.5%)	5 (13.5%)	0.49
PCKD	1 (1.1%)	1 (2.7%)	0.51
Other & unknown	32 (34.8%)	1 (2.7%)	0.00
Comobidity			
HTN	63 (68.5%)	16 (43.2%)	0.01
CVA	13 (14.1%)	8 (21.6%)	0.30
IHD	7 (7.6%)	8 (21.6%)	0.03
PAD	4 (4.4%)	1 (2.7%)	0.65
CHF	5 (5.4%)	2 (5.4%)	1.0

DM=Diabetes mellitus; GN=Glomerulonephritis; PCKD=Poly cystic kidney disease; HTN=Hypertensiom; CVA=Cerebrovascular accident; IHD=Ischemic heart disease; PAD=Peripheral arterial disease; CHF=Congestive heart failure; AVF=Arteriovenous fistula; AVG=Arteriovenous graft.

Table 3. Primary patency rates of hemodialysis access

	Patency rares			
Access type	1 year (%)	2 year (%)	3 year (%)	5 year (%)
Autogenous AVF	84 (CI 75~90)	72 (CI 61~81)	67 (CI 55~76)	51 (CI 38~63)
Prosthetic AVG	51 (CI 34~66)	28 (CI 15~44)	22 (CI 10~37)	9 (CI 2~23)

AVF=Arteriovenous fistula; AVG=Arteriovenous graft.

SPSS (PASW) statistics 17.0.2 was used for statistical analysis. T-test, chi-square test, and correlation analysis were used for variable comparison within two groups. Survival analysis such as Kaplan-Meier survival curve, log rank test, and Cox proportional hazard model were used for primary and secondary patency rates. Cox proportional hazard model was composed of factors that showed significant relationship with independent or result variable in univariate analysis. The factors were age, diabetes, hypertension, and ischemic heart disease. Statistically significant level was considered as $p < 0.05$.

RESULTS

1) Primary patency rate, patency period, and related factors

Primary patency rates in 1, 2, 3, and 5-year period were 84%, 72%, 67%, and 51% with autogenous arteriovenous fistula and 51%, 28%, 22%, and 9% with prosthetic arteriovenous graft (Table 3). This shows that autogenous arteriovenous fistula reveals better primary patency rate than that of prosthetic arteriovenous graft with statistically significant results (p=0.0000) (Fig. 1). Average primary patency periods were 936.7±663.9 days for autogenous arteriovenous fistula and 500.9±453.1 days for prosthetic graft (p=0.0000). It also shows statistically significant results.

Risk factors related with patency rate such as diabetes, hypertension, and ischemic heart disease that showed difference in two groups were analyzed with Cox proportional Hazard model. Diabetes occurred more frequently in prosthetic arteriovenous graft, but did not affect patency rate. However, considering ischemic heart disease directly related with diabetes, diabetes followed by ischemic heart disease acted as a risk factor by affecting primary patency rate (p=0.040).

Table 4. Secondary patency rates of hemodialysis access

Access type	Patency rares			
	1 year (%)	2 year (%)	3 year (%)	5 year (%)
Autogenous AVF	96 (CI 89~99)	91 (CI 82~95)	88 (CI 78~93)	68 (CI 53~80)
Prosthetic AVG	88 (CI 72~95)	73 (CI 54~85)	65 (CI 45~79)	16 (CI 1~47)

AVF=Arteriovenous fistula; AVG=Arteriovenous graft.

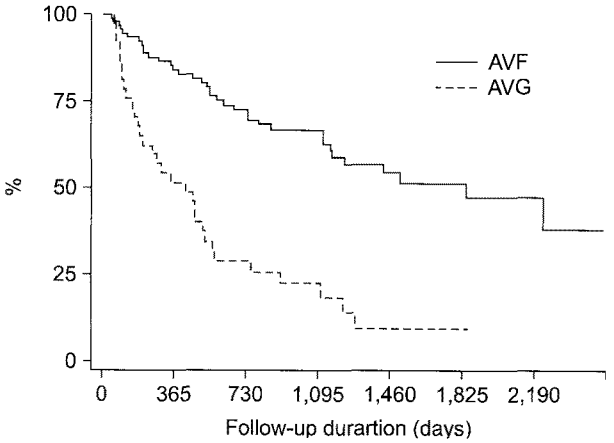

Fig. 1. Primary patency rates of AVF & AVG: Kaplan-Meier survival estimates. AVF=Arteriovenous fistula; AVG=Arteriovenous graft.

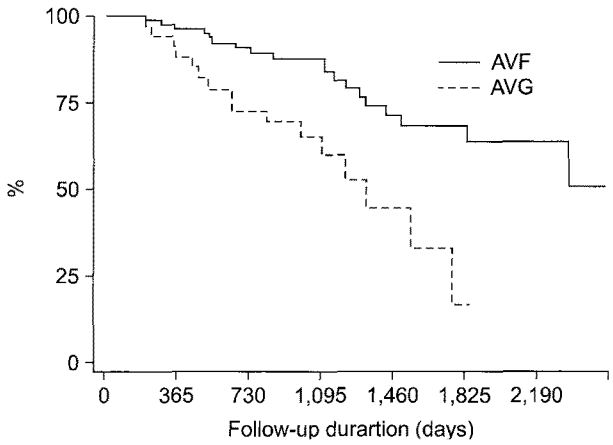

Fig. 2. Secondary patency rates of AVF & AVG: Kaplan-Meier survival estimates. AVF=Arteriovenous fistula; AVG=Arteriovenous graft.

2) Secondary patency rate, patency period, and related factors

Secondary patency rates in 1, 2, 3, and 5-year period were 96%, 91%, 88%, and 68% with autogenous arteriovenous fistula and 88%, 73%, 65%, and 16% with prosthetic arteriovenous graft (Table 4). This implies that autogenous arteriovenous fistula shows statistically better secondary patency rate (p=0.0009) (Fig. 2). Average secondary patency period was 1,079.3±645.7 days for autogenous arteriovenous fistula and 880.6±464.9 days for prosthetic graft. Autogenous arteriovenous fistula showed better results, but it was not significant statistically (p=0.0541).

Cox proportional Hazard model was executed to analyze risk factors related to patency rate such as age, diabetes, hypertension, and ischemic heart disease. Significant risk factor affecting secondary patency rate was age. Occurrence of diabetes and ischemic heart disease was more frequent in prosthetic graft than autogenous arteriovenous fistula, but it did not affect secondary patency rate.

Endovascular or surgical revisions for secondary patency in autogenous arteriovenous fistula were executed in 21 out of 92 cases (23%) with a total of 40 repairs (0.06 revision per patient per year). On the other hand, endovascular or surgical revisions for secondary patency in prosthetic graft were executed in 24 out of 27 cases (65%) with a total of 54 repairs (0.21 revision per patient per year). These results show that revision occurrence was significantly lower in autogeneus arteriovenous fistula than prosthetic graft (p=0.01).

For location of autogenous arteriovenous fistula's stenosis or occlusion, draining vein had the greatest occurrence with 25 cases (63%). Nine cases occurred at proximal anastomic site 3~4 cm from arteriovenous anastomose, one case occurred at central vein, one case occurred at inflow artery, and four cases at other locations. For methods of revision, balloon angioplasty was used in 15 cases, thrombectomy with graft interposition was used in 8 cases, thrombectomy with patch angioplasty was used in 5 cases, graft interposition was used in 5 cases, simple thrombectomy was used in 4 cases, and

thrombectomy with balloon angioplasty was used in 3 cases.

Complications and causes of stricture and thrombosis in prosthetic graft varied. 20 cases had mild stenosis at venous anastomosis or unknown cause. After thrombectomy, stilet with diameter of 3.5 mm easily passed through venous anastomosis site and thrill was palpated on the skin. Among discovered causes, venous anastomosis site stenosis was the most frequent with 19 cases, venous anastomosis site and draining vein occurred in 10 cases, false aneurysm occurred in 2 cases, graft infection occurred in 2 cases, and central venous occlusion occurred in 1 case. In types of revision method, simple thrombectomy was done in 20 case, thrombectomy with jump graft was done in 17 cases, thrombectomy with balloon angioplasty was done in 9 cases, thrombectomy with patch angioplasty was done in 2 cases, and resection with graft interposition was done in 4 cases.

DISCUSSION

According to Dialysis Outcomes and Practice Patterns Study (DOPPS) (studying international trends of hemodialysis access usage in chronic renal failure patients), frequency of autogenous arteriovenous fistula usage differs from country to country. According to the data after 2005, Japan, Italy, Germany, France, Spain, and England showed 67~91% of autogenous arteriovenous fistula usage rate where as United Stated showed the lowest rate of 47%. The differency of autogenous arteriovenous fistula usage rate in each countries can be assumed as the fact that occurrence rates of diabetes, angina pectoris, and peripheral vascular disease are greater in patients from the United States than in patients from Japan or other Europe countries. However, the fact that frequency of autogenous arteriovenous fistula usage in patients from the United States is lower than patients from Europe even after modifying associated other diseases can be implied as the high preference to prosthetic graft among surgeons in US [1,4]. In author's study, autogenous arteriovenous fistula usage rate was 70% coinciding the international clinical guideline.

There are no opposition on the fact that ideal hemodialysis access should be durable and has low risk of infection and frequency for revision operation to maintain patency. It is true that there are a few researches with analytical results saying there is no difference in patency between autogenous arteriovenous fistula and prosthetic arteriovenous graft [5,6]. However, according to numorous research results, autogenous arteriovenous fistula showed better results than prosthetic arteriovenous graft [7-10]. Author's study also showed that autogenous arteriovenous fistula gives better results in frequency of revision operation and primary & secondary patency rate.

According to a large research result from the United States, in 2-year patency rate, primary patency rate of autogenous arteriovenous fistula showed better reselts with 39.8% when compared with that of prosthetic graft with 24.6%. However, secondary patency rate difference between autogenous arteriovenous fistula and prosthetic graft was not significant with 64.3% and 59.5%. Also, autogenous arteriovenous fistula using venous transposition showed similar secondary patency rate when compared with simple autogenous arteriovenous fistula. It was also shown that female, elders, or patients with previous arteriovenous fistula failure had benefits using the venous transposition fistula [11].

Woo et al. [8] showed in his research about comparison between autogenous arteriovenous fistula using venous transposition and linear shaped prosthetic graft that autogenous fistula was better than prosthetic graft in both primary(48% vs. 14%) and secondary(57% vs. 19%) patency rate at 5-year. In addition, revision frequency for secondary patency was significantly lower in autogenous arteriovenous fistula. They insisted that autogenous arteriovenous fistula should be primarily made when anatomical conditions satisfy with adequate arterial inflow bloodstream and large diameter of vein greater than 2.5 mm.

Although beginning hemodialysis with a mature autogenous arteriovenous fistula is ideal in all patients without using the catheter, there are numerous obstacles to overcome. The patients must be refered to nephrologist before terminal stage of renal failure, arteriovenous fistula operation must be executed beforehand for maturity, and a trained dialysis nurse must successfully execute needdling. However, if one of the above conditions is not met, using the catheter is inevitable. In case of the United States, approximately 60~65% of the patients begin hemodialysis with the catheter [2].

According to KDOQI clinical guideline, autogenous arterio-

venous fistula must be made approximately 6 months before the estimated hemodialysis treatment. This is because periodic evaluation for maturation and additional revisions before beginning of hemodialysis are necessary. Average maturation term of autogenous arteriovenous fistula is 2～4 months and that of prosthetic arteriovenous graft is approximately 3～6 weeks [3].

According to KDOQI (Kidney Disease Outcomes Quality Initiative) clinical guideline revised in 2006, greater than 65% of the hemodialysis patients are suggested to use autogenous arteriovenous fistula. In order to increase usage frequency of autogenous arteriovenous fistula and achieve successful hemodialysis access, preoperative thorough history investigation, physical examination, and ultrasonic vessel mapping are necessary. Using autogenous vessel might be challenging, especially in patients who are diabetic, old, female, or has peripheral vascular disease, or severe heart failure. If an arterial radius is at least 2 mm through preoperative doppler ultrasonic examination and shows positive reactive hyperemia response(changes in arterial waveform with increased blood flow after holding fist for 30 seconds), the artery is appropriate for autogenous arteriovenous fistula. Vein mapping using ultrasound can help deciding the operable site by evaluating the diameter, patency, continuity, and distensibility [3-12].

Silvia et al. [13] reported that non-invasive preoperative test could increase the use of autogenous arteriovenous fistula, reduce postoperative early failure, and improve secondary patency rate. Non-invasive tests were both arm arterial segmental pressure measurement and Doppler ultrasound examinations for arteries & veins. As a baseline for surgery, upper arm blood pressure in each side should not be different, the arterial diameter must be greater than 2 mm, palmer arch must be patent, and the venous diameter must be greater than 2.5 mm for autogenous fistula & 4 mm for prosthetic graft. Also, there should be no narrowed or blocked segment, continuity with deep vein must be maintained, and no stricture or occlusion in ipsilateral central vein.

Jo et al. [14] reported in his research that there are no difference in patency rate between autogenous arteriovenous fistula and prosthetic arteriovenous graft. However, autogenous arteriovenous fistula showed better long-term results both in primary and secondary patency rate in this research. In analysis of risk factors affecting patency rate, diabetes appeared more frequently in prosthetic arteriovenous graft. However, diabetes alone was not a risk factor of primary and secondary patency rate. In cases where diabetes was followed by ischemic heart disease, it appeared as a significant risk factor in primary patency rate. Age appeared as a significant risk factor in secondary patency rate.

CONCLUSION

In this research, autogenous arteriovenous fistula showed better results than prosthetic arteriovenous graft in both primary and secondary patency rate. It also showed lower frequency in revisions due to complications such as stricture or thrombosis. In order to increase the use of autogenous arteriovenous fistula, artriovenous fistula surgery must be executed before estimated hemodialysis start and appropriate location of vessel must be found through thorough preoperative tests such as ultrasound vessel mapping. Risk factor for primary patency rate is the case having both diabetes and ischemic heart disease. In cases like this where cardiovascular complications might follow, more thorough preoperative tests must be performed and periodical assessment for arteriovenous fistula must be done after surgery to prevent complications such as stricture. In author's case, prosthetic arteriovenous graft patency rate was relatively too low. Therefore, effort to improve patency rate of prosthetic arteriovenous graft is necessary.

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