

Successful Access Rate and Risk Factor of Vascular Access Surgery in Arm for Dialysis

Dae Woo Yoo¹, Myunghee Yoon², and Hee Jae Jun³

¹Department of Surgery, BHS Hanseo Hospital, Busan, ²Department of Surgery, Kosin University Gospel Hospital, Busan,

³Department of Thoracic and Cardiovascular Surgery, Inje University Haeundae Paik Hospital, Busan, Korea

Purpose: Preservation of adequate vascular access is of vital importance for patients undergoing chronic dialysis in renal failure. The aim of this study is to evaluate the successful access rate and risk factors of arteriovenous fistula (AVF) in the arm for dialysis at a single center.

Materials and Methods: Patients undergoing vascular access operation between January 2006 and December 2011 were retrospectively identified.

Results: A total of 362 vascular access operations were performed. There were 338 autologous AVFs (93.4%) and 24 prosthetic grafts (6.6%). Men comprised 58.3% of all subjects. Mean age was 59.5±14.7 years. There were 187 diabetes mellitus patients (51.7%). There was a mean duration of 70.3±21.1 days between access creation to first cannulation. Overall successful access rate for dialysis was 95.9%. Of 338 autologous AVFs, 326 patients had patent AVFs for dialysis (96.4% surgical success rate), while 21 of 24 prosthetic grafts were patent (87.5% surgical success rate). A total of 141 patients (38.9%) came to surgery with preoperative central venous catheters (CVC) of which 130 (35.9%) AVFs had a patent fistula in the arm. The only risk factor related to successful access rate of AVF was preoperative CVC placement (P=0.012).

Conclusion: Successful vascular access rate was 95.9%. The only risk factor related to patent access of AVF was preoperative CVC placement. At least 6 months prior to expected dialysis, AVF surgery is recommended, which may overcome the challenge of co-morbid conditions from having a preoperative CVC.

Key Words: Arteriovenous fistula, Patency, Renal insufficiency

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Corresponding author: Hee Jae Jun
Department of Thoracic and Cardiovascular Surgery, Haeundae Paik Hospital, Inje University, 875 Haeun-daero, Haeundae-gu, Busan 612-896, Korea
Tel: 82-51-797-3131
Fax: 82-51-797-3101
E-mail: cs523@dreamwiz.com
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INTRODUCTION

The incidence of dialysis-dependent end stage renal failure is increasing. Preservation of adequate vascular access is of vital importance for patients undergoing chronic dialysis in end stage renal disease. Unfortunately, access-related morbidity adds significantly to total annual expenditure on the hemodialysis population and is associated with a poorer long-term prognosis [1,2]. The goal of the dialysis surgeon, therefore, is to create a per-

manent access which is both effective and durable. The National Kidney Foundation Kidney Disease Outcomes Quality Initiative (KDOQI) standards promote the increase of native vascular access use because of superior patency rates and lower complication rates than grafts once established [3]. However, current hemodialysis patients are older, more often have diabetes and more often have cardiovascular comorbidities [2-4]. Moreover, arteriovenous fistulas (AVF) have high primary failure rates and maturation problems will increasingly challenge vascular access teams in meeting

the KDOQI goals [5,6]. Fistula dialysis patients have fewer complications, require a shorter hospital stay and have better overall survival rate than those who dialyze with a tunneled central venous catheter (CVC) or prosthetic graft [2,7]. Rooijens et al. [8] reported that there were more interventions needed for salvage in patients with prosthetic graft, but patients with poor forearm vessels may do benefit from implantation of a prosthetic graft for vascular access. Therefore, a renewed analysis of native vascular access patency rates is justified. Hemodialysis population characteristics have changed dramatically and primary AVF failure is a significant problem. In prospective, multicenter studies there are standardized definitions to analyze patency rates and risk factors for patency reduction [9].

The aim of this study is to evaluate the successful vascular access rate of arteriovenous fistula, either autogenous AVF or prosthetic graft, in the arm for hemodialysis at a single center.

MATERIALS AND METHODS

1) Patients

Three hundred and sixty two patients who underwent hemodialysis access operation between January 2006 and December 2011 were retrospectively identified. Only the first created AVF per patient in this dataset was used to determine relations between possible risk factors and AVF successful vascular access. Data on age, sex, diabetic status, primary renal disease, and prior tunneled CVC use were analyzed.

2) Definitions

The successful vascular access was defined as a patent fistula vessel at the time of first cannulation of the vascular access for hemodialysis after AVF surgery. When dialysis was known to have taken place through a surgically-created access, the fistula surgery was defined as successful.

A functional AVF is an access that is able to deliver a flow rate of 350-400 mL/min without recirculation for the total duration of dialysis. A nonfunctional AVF is an access that is not being successfully used for hemodialysis whether it is patent or not [10].

Inadequate maturation was defined as insufficient access flow to maintain dialysis or the unavailability to cannulate an AVF, if required, at 6 weeks after surgery. Primary failure (PF) was defined as an AVF that did not develop to maintain dialysis or thrombosed before the first successful cannulation for hemodialysis treatment, regardless of eventual AVF abandonment or not.

3) Statistical analysis

Means are depicted \pm standard error of the mean unless otherwise described. The life table method was used to calculate patency rates, and the Fisher's exact test was used to compare variables differences between both groups. Differences between means of operation site was determined by Pearson's chi-squared test. Statistical significance was assumed when two-sided P-value was <0.05 . Analyses were carried out using PASW Statistics 18.0 (IBM Co., Armonk, NY, USA).

RESULTS

1) Characteristics of patients

During this study period, 362 primary upper limb access operations were performed. Men comprised 58.3% of the study subjects. Mean age was 59.5 ± 14.7 years. There were 338 autogenous AVFs (93.4%) and 24 prosthetic grafts (6.6%): 241 forearm AVFs (66.6%), 97 upper arm AVFs (26.8%), 15 forearm prosthetic grafts (4.1%) and 9 upper arm prosthetic grafts (2.5%). There were 187 diabetes mellitus (DM) patients (51.7%). A total of 141 patients (38.9%) came to surgery with preoperative CVC (Table 1). During

Table 1. Clinical characteristics of patients

Clinical characteristic	Value
Total number of patients	362 (100.0)
Male	211 (58.3)
Female	151 (41.7)
Age (y)	59.5 ± 14.7
Diabetes mellitus	
(+)	187 (51.7)
(-)	175 (48.3)
Arteriovenous fistula	
Autologous	338 (93.4)
Graft	24 (6.6)
Operation site	
Wrist (radial a. - cephalic v.)	241 (66.6)
Cubital (brachial a. - cephalic v./basilic v.)	97 (26.8)
Graft (brachial a. - brachial v./basilic v.)	15 (4.1)
Graft (brachial a. - axillary v.)	9 (2.5)
Preoperative central venous catheter	
Insertion	141 (38.9)
No insertion	217 (61.1)
Other arteriovenous fistula	18 (5.0)
Kidney transplantation	16 (4.4)
Death	31 (8.6)

Values are presented as number (%) or mean \pm standard deviation. a., artery; v., vein.

Table 2. Risk factors related to successful vascular access rates of arteriovenous fistula

Clinical characteristic	Pass/fail	P-value
Sex		0.290
Male (n=211)	200/11 (55.2/3.0)	
Female (n=151)	147/4 (40.6/1.1)	
Method		0.069
Autologous (n=338)	326/12 (96.4/3.6)	
Graft (n=24)	21/3 (87.5/12.5)	
Operation site		0.498
Wrist (n=241)	234/7 (64.6/1.9)	
Cubital (n=97)	92/5 (25.4/1.4)	
Graft (brachial a. - brachial/basilic v.) (n=15)	12/3 (3.3/0.8)	
Graft (brachial a. - axillary v.) (n=9)	9/0 (2.5/0.0)	
Preoperative central venous catheter		0.012
Insertion (n=141)	130/11 (35.9/3.1)	
No insertion (n=221)	217/4 (59.9/1.1)	
Diabetes mellitus		0.433
+ (n=187)	181/6 (50.0/1.7)	
- (n=175)	166/9 (45.9/2.4)	

Values are presented as number (%).
a., artery; v., vein.

the follow up period, 347 patients had patent AVFs, 16 patients had undergone kidney transplantation, 18 patients had other AVF operations, and 31 patients died (Table 1). There was a mean duration of 70.3 ± 21.1 days between access creation to first cannulation. Overall successful access rate was 95.9% (347/362). Of 338 autogenous AVFs, 326 patients had patent AVFs (96.4% surgical success rate). Of 24 prosthetic grafts, 21 patients had patent AVFs (87.5% surgical success rate). Of 141 patients with preoperative CVC, 130 AVFs were used successfully. Age, sex and operation site did not significantly affect the patency for the first cannulation of vascular access. Only prior use of a CVC resulted in earlier loss of primary patency of AVF ($P=0.012$, Table 2).

2) Risk factors related to successful vascular access rates of AVF

In univariate analyses, male gender ($P=0.290$), operation method ($P=0.069$), operation site ($P=0.498$), combined DM ($P=0.433$) and preoperative CVC ($P=0.012$) were related to loss of primary functional patency. The only risk factor related to successful access rate of AVF was preoperative CVC placement ($P=0.012$).

3) Patients with failed patency after AVF surgery (n=15)

Fifteen patients had non-patent AVFs at the time of first

cannulation for hemodialysis. There were 11 males and 4 females. Of 15 patients, 8 patients had DM. Autologous AVFs were performed in 12 patients and prosthetic graft in 3 patients. There were 12 patients with CVC prior to hemodialysis before AVF placement. To confirm the PF of maturation in these AVFs, we followed up the patients for 7.03 ± 1.14 months.

DISCUSSION

We retrospectively identified 368 patients who underwent their first access surgery over a six-year period. Our policy was to use AVFs where possible, in preference to prosthetic grafts. Consequently prosthetic grafts were constructed in only 6.6% of patients, in accordance with the recommendations of international guidelines such as KDOQI [2,3]. The recommendations of these 'European guidelines' included 1) for nephrologists: vein preservation, patient referral to vascular surgeon at least 6 months prior to expected hemodialysis, performance of a standard preoperative duplex examination and referral to ultrasound technician, surgeon or radiologist in case of suspected inadequate maturation at 4–6 weeks; 2) for vascular surgeons: order of preference of access placement is i) distal arm AVF, ii) proximal arm AVF and iii) basilic vein transposition or graft insertion, artery and vein internal diameters should both be at least 2.0 mm, and end-to-side anastomosis is preferred over side-to-side; 3) for radiologists: aggressive treatment of the failing and failed fistula; 4) for dialysis unit: a surveillance program including access flow measurements.

Reported rates of early AVF failure among Western dialysis populations range from 12% to more than 50%, with one-year primary patency rates of 33%–78% and one-year secondary patency rates of 54%–85% [11–13].

Several factors have been associated with early fistula failure, including diabetes, female sex, patient age, and incident dialysis via CVC [12,14,15]. In a prospective study by Lok et al. [16] predictors of maturation failure included age >65 years, peripheral vascular disease, and coronary artery disease.

Diabetic patients, who comprise an ever-increasing proportion of the renal failure population in Asia, appear prone to inadequate maturation and early failure of AVF. This is at least in part due to the characteristic distribution of atherosclerosis, which is usually more pronounced distally on the limbs. Such arteriopathy inhibits the adaptive dilatation required for AVF maturation. The overall one-year assisted primary patency of forearm AVF among this cohort was 40%—significantly lower than the overall rate of 53.95% [17].

Compared with other forms of access, dialysis by CVC is well known to be associated with higher rates of infection, central vein stenosis, and death [18]. The findings of our study in patients who commenced dialysis by CVC is of considerable concern. The increasing duration of incident catheter dialysis is also worrying, as it reflects both the burden of patients commencing dialysis without permanent access, and a steadily increasing gap between CVC insertion and fistula use. In addition, those who commence dialysis by CVC appear to have poorer outcomes in subsequent permanent access surgery.

Our rate of incident dialysis by catheter was not so high. In five Western countries reported in the Dialysis Outcomes and Practice Patterns study, 58%-73% of patients commenced dialysis by CVC, whereas only 26% did so in Japan. Unsurprisingly, pre-dialysis care was demonstrated to be influential in establishing timely permanent access. Early referral to a nephrologist and a shorter time from referral to surgical assessment and access construction decreased the likelihood that dialysis was commenced by CVC [19]. In this prospective multicenter study, it has been shown that AVF patency and functional patency are markedly different. This difference appears to be caused by high PF rates. After adjustment for potential risk factors, primary functional patency was only decreased in diabetics. Secondary failure rate among participating hospitals varied from 0%-38% and was not related to patient characteristics or cardiovascular risk factors.

A significant proportion of AVFs suffer from PF during the first week after surgery [11,20]. We described that the successful vascular access was defined as a patent fistula vessel at the time of first cannulation of the vascular access for hemodialysis after AVF surgery. A functional AVF is an access that is able to deliver a flow rate of 350-400 mL/min without recirculation for the total duration of dialysis. Functional patency starts when a vascular access is successfully used for hemodialysis treatment for the first time [10].

Next to careful physical examination and pre-operative duplex scanning, additional 'vascular wall-quality' tests such as the arterial resistance index at reactive hyperemia

may be useful in determining the best location for creation of the anastomosis [21]. Optimal anastomosing techniques, alternative locations for anastomosing, and aggressive treatment of primary failing fistulas should also further increase the proportion of functional AVFs [22-26].

Large randomized multicenter trials reporting thrombosis rate, access loss rate, CVC use, hospitalization or intervention rates and costs between treatment groups are needed to definitively determine which, if any, surveillance method should be used and the usefulness of proactive intervention protocols. Thrombosis causing AVF failure is usually preceded by development of an underlying stenosis. Consequently the detection of stenosis in AVF before thrombosis could offer a strategy to improve AVF survival by early intervention by the use of Doppler ultrasonography imaging, measurement of access flow, and assessment of blood recirculation. Fistula thrombosis was previously attributed to the presence of venous stenosis, and intra-access pressure ratios (which will rise in the setting of venous stenosis) were thus proposed to survey access function. Surveillance programs with regular measures of flow are designed to detect trends over time, which may indicate progressive stenosis at a subclinical level and instigate proactive referral for further imaging and intervention. Our study has several potential limitations. We had no information on several vascular access characteristics (vessel diameter, flow rate and intervention prior to cannulation) that are associated with vascular access dysfunction.

CONCLUSION

In our study, successful access rate of vascular access surgery for hemodialysis was 95.9%. The only risk factor related to patent access of AVF was preoperative CVC placement. We face the challenge of achieving a higher rate of preemptive AVF placement with a subsequent reduction in CVC use. At least 6 months prior to expected hemodialysis, AVF surgery is recommended, which may overcome the challenge of co-morbid conditions from having a preoperative CVC.

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