



# The Usefulness of Duplex Ultrasound for Hemodialysis Access Selection

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**Purpose:** A native vessel is preferable to an artificial graft for dialysis access. Duplex ultrasound (DUS) is noninvasive, cost-effective modality to evaluate the vessels for dialysis. The purpose of this study was to compare the rates of utilization of native vessels after preoperative imaging with DUS and contrast venography (CV).

**Materials and Methods:** A retrospective review was performed on patients who received an arteriovenous fistula (AVF) or arteriovenous graft (AVG) between June 2006 and July 2010. Patients were classified into 3 groups. In group 1, CV was used to evaluate the vessel. Both DUS and CV were used in group 2. In group 3, only DUS was used. The frequency of utilization of a native vessel was analyzed in each group. The chi-square test was used for statistical analysis.

**Results:** During the study period, 173 patients received an AVF or AVG. Eighty-nine patients were male. The mean age was  $60.6 \pm 14.6$  years. A native vessel was used in 56/81 patients (69.1%) and 74/81 patients (91.4%) in groups 1 and 3, respectively ( $P < 0.001$ ). In group 2, all patients underwent access procedures using native vessels. AVG was initially planned for 2 patients in group 2 after vessel evaluation using CV, but a native vessel was successfully used because DUS identified optimal vessels for AVF. The 1-year primary patency rate was similar in 3 groups.

**Conclusion:** Preoperative DUS is safe and easy to use for vessel evaluation, and can be used as a primary imaging modality for creation of access.

**Key Words:** Arteriovenous fistula, Ultrasonography, Contrast venography, Imaging

Received October 17, 2016

Revised December 9, 2016

Accepted December 29, 2016

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Conflict of interest: None.

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Vasc Spec Int 2017;33(1):22-26 • <https://doi.org/10.5758/vsi.2017.33.1.22>

## INTRODUCTION

Patients with end-stage renal disease (ESRD) consume a vastly disproportionate amount of financial and human resources. Approximately 0.03% of the United States population begins renal replacement therapy every year (an adjusted incidence rate of 339 per million) [1]. The cost of ESRD continues to accelerate, with an increase in Medicare costs of 57% between 1999 and 2004, to the extent that the ESRD program now accounts for 6.7% of total Medicare

expenditures. In Korea, the number of patients with ESRD is rising rapidly as the number of elderly and patients with diabetes increases. The prevalence of ESRD was 1,113.6 patients per million population [2].

Hemodialysis (HD) is the most common renal replacement therapy, followed by peritoneal dialysis and kidney transplantation [3]. It has been reported that preoperative imaging reduces the immature or failure rate of an arteriovenous fistula (AVF) or arteriovenous graft (AVG) for HD. Conventional contrast venography (CV) has been

the standard method for preoperative vascular evaluation. However, it has several limitations including relative invasiveness, risk of allergic reaction, contrast nephropathy, and cost [4]. On the other hand, duplex ultrasound (DUS) is noninvasive, and is easy to use without the need for contrast.

A native AVF is presumed to be better than AVG in terms of patency rate [5]. The major limitation of an AVG is the propensity for recurrent stenosis and thrombosis, which requires frequent angioplasty, thrombectomy, and surgical revision to maintain long-term patency for dialysis. The frequency of intervention is 3 to 6 fold higher for AVG than for AVF [6]. The risk of infection is another main concern in the selection of HD access. It has been reported that the relative risk for infection is 2.5 times greater with AVG access than with AVF [7].

The aim of this study was to compare the utilization rates of native AVF when preoperative vascular evaluation was performed with CV or DUS.

## MATERIALS AND METHODS

### 1) Date collection

A retrospective review was performed on patients who received an AVF or AVG between June 2006 and July 2010 in our institution. Patients were categorized into 3 groups according to the imaging modality used for preoperative evaluation. Group 1 patients underwent CV from June 2006 to March 2009. Group 2 patients underwent CV and DUS from April 2009 to June 2009 after the opening of vascular laboratory on March 2009. Patients in group 3 underwent DUS only from July 2009 to July 2010. We compared the types of access created in the 3 groups and the frequency of utilization of a native vessel.

### 2) Contrast venography

CV has been the primary imaging modality before creation of arteriovenous access for HD, and was performed by an experienced interventional radiologist. After placement of a tourniquet on the forearm, an 18-gauge cannula was placed into a superficial vein on the dorsum of the hand, either bilaterally or unilaterally. If there was no visible vein in the hand, a superficial vein in the distal forearm was cannulated. The arm was positioned in supination and slight abduction at the side of the imaging table to enable anatomically positioned images without pseudostenosis in the axillary region. Iodixanol-320 (Visipaque; GE Healthcare, Chalfont St. Giles, UK) was used for venography. For opacification of the upper extremity and central veins including the subclavian and innominate,

a digital subtraction angiographic series of the forearm, upper arm, and chest was performed by manually injecting 10 mL of contrast material per series.

### 3) Duplex ultrasound

Preoperative DUS of the upper extremity was performed after a vascular laboratory for noninvasive imaging became operational. DUS was performed by an experienced sonographer with certification as a Registered Vascular Technologist (RVT) and interpreted by a vascular surgeon with certification as a Registered Physician for Vascular Interpretation (RPVI). Vascular evaluation of the upper extremity was performed using B-mode ultrasound with a linear array probe and variable frequencies of 5–12 MHz. The entire arterial tree from the axillary to the brachial artery and branches into radial and ulnar arteries was examined for size and branching patterns. For the evaluation of upper extremity veins, a tourniquet was applied at the elbow to ensure accurate assessment of the entire superficial venous system. Transverse view scanning was done for evaluation of the cephalic, median cubital, and basilic veins from the tourniquet to the wrist, with measurement of anteroposterior vein diameters. Then a tourniquet was moved to the axilla for evaluation of upper arm veins. Subclavian vein patency and waveform were also assessed.

### 4) Hemodialysis access selection

The site selected for AVF formation was the most distal site on the non-dominant arm at which either CV or DUS criteria for vessel suitability were present. A prosthetic graft was used if fistula placement was not possible.

### 5) Statistical analysis

Categorical data were analyzed with a chi-square test, and a t-test or Mann-Whitney U-test was used for interval/ordinal data. P-value <0.05 was considered to indicate statistical significance. All analyses were performed with IBM SPSS ver. 22.0 software (IBM Co., Armonk, NY, USA).

The Institutional Review Board of Kyung Hee University Hospital at Gangdong waived the patients' informed consent because all records were anonymized and we surveyed data retrospectively.

## RESULTS

### 1) Patient demographics

During the study period, a total of 173 patients

underwent AVF or AVG. Eighty-nine patients were male and 84 were female. The mean age was  $60.6 \pm 14.6$  years. The patient demographics are shown in Table 1. There were 81 patients in group 1. The gender distribution was similar. AVF using a native vessel was created in 56 patients. A radiocephalic fistula was created in 39 patients (48.1%). A brachiocephalic fistula was created in 17 patients (21.0%). An AVG was placed in 25 patients (30.9%). Group 2 had 11 patients, 8 males and 3 females. Native vessels were used in all patients. Group 3 had 81 patients. Arteriovenous access was performed using a native vessel in 74 patients (91.4%). A radiocephalic or brachiocephalic AVF was created in 38 patients (46.9%) and 33 patients (40.7%), respectively. Basilic vein transposition was performed in 3 patients (3.7%).

## 2) The utilization rates of native vessels

The frequency of utilization of a native vessel was analyzed in groups 1 and 3 (Table 2). AVF using a native vessel was created in 56 cases (69.1%) and 74 patients

(91.4%) in groups 1 and 3, respectively, with statistical significance ( $P < 0.001$ ). An artificial graft was more commonly used in group 1 ( $P < 0.001$ ). In group 2, all patients underwent access procedures using native vessels. An AVG was initially planned in 2 patients after vessel evaluation using CV, but a native vessel was successfully used because DUS demonstrated adequate caliber. The 1-year primary patency rate was similar in 3 groups (Fig. 1).

## DISCUSSION

The number of patients who need dialysis has increased as the mean age of patients with ESRD has increased as a result of advances in medical and surgical treatments for renal diseases. There are 3 methods for access to vessels for dialysis: AVG, AVF, and a catheter. The advantages and disadvantages of each method have been reported. AVG allows a short lag-time from insertion to maturation; 3–6 weeks for a PTFE graft had been reported as adequate maturation time [8]. A comparatively long maturation time (1–4 months) is required for autologous access. In spite

**Table 1.** Patient demographics (n=173)

Characteristic	Group 1 (n=81)	Group 2 (n=11)	Group 3 (n=81)
Age (y)	$59.1 \pm 14.9$ (22-91)	$62.9 \pm 8.7$ (51-75)	$61.8 \pm 14.9$ (23-87)
Gender			
Male	40 (49.4)	8 (72.7)	41 (50.6)
Female	41 (50.6)	3 (27.3)	40 (49.4)
Type of access	81/173 (46.8)	11/173 (6.4)	81/173 (46.8)
AVF, radiocephalic	39 (48.1)	6 (54.5)	38 (46.9)
AVF, brachiocephalic	17 (21.0)	4 (36.4)	33 (40.7)
Basilic vein transposition	0 (0)	1 (9.1)	3 (3.7)
AVG, forearm loop	18 (22.2)	0 (0)	2 (2.5)
AVG, brachioaxillary	7 (8.6)	0 (0)	5 (6.2)

Values are presented as mean  $\pm$  standard deviation (range) or number (%). Group 1 patients underwent contrast venography from June 2006 to March 2009. Group 2 patients underwent contrast venography and duplex ultrasound from April 2009 to June 2009 after the opening of vascular laboratory on March 2009. Patients in group 3 underwent duplex ultrasound only from July 2009 to July 2010. AVF, arteriovenous fistula; AVG, arteriovenous graft.

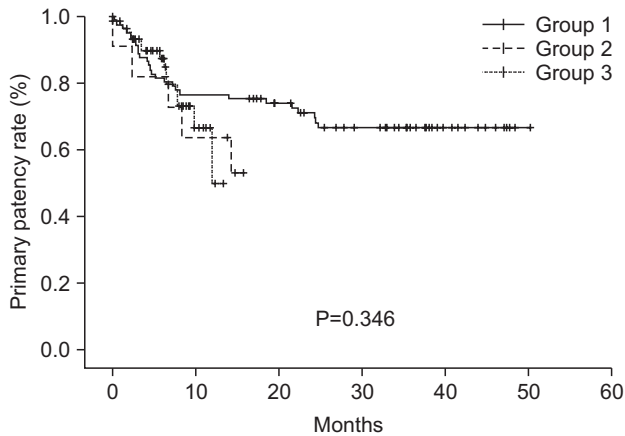
**Table 2.** The utilization rates of native vessels for dialysis

Access type	Group 1	Group 2	Group 3	P-value <sup>a</sup>
AVF	56 (69.1)	11 (100)	74 (91.4)	<0.001
AVG	25 (30.9)	0 (0) <sup>b</sup>	7 (8.6)	<0.001
Total	81 (100)	11 (100)	81 (100)	-

Values are presented as number (%). Group 1 patients underwent contrast venography from June 2006 to March 2009. Group 2 patients underwent contrast venography and duplex ultrasound from April 2009 to June 2009 after the opening of vascular laboratory on March 2009. Patients in group 3 underwent duplex ultrasound only from July 2009 to July 2010.

AVF, arteriovenous fistula; AVG, arteriovenous graft.

<sup>a</sup>Chi-square test used to compare group 1 and group 3. <sup>b</sup>AVG was planned in 2 patients based on conventional venography, but an AVF was created because ultrasonography showed adequate vessel caliber.



Months		0	3	6	9	12
Group 1	At risk patency, n (%)	81 (100)	71 (87.7)	65 (80.2)	62 (76.5)	61 (75.3)
Group 2	At risk patency, n (%)	11 (100)	9 (81.8)	8 (72.7)	7 (63.6)	6 (63.6)
Group 3	At risk patency, n (%)	81 (100)	59 (93.1)	37 (87.3)	15 (73.1)	4 (66.5)

**Fig. 1.** One year patency rate. Group 1 patients underwent contrast venography from June 2006 to March 2009. Group 2 patients underwent contrast venography and duplex ultrasound from April 2009 to June 2009 after the opening of vascular laboratory on March 2009. Patients in group 3 underwent duplex ultrasound only from July 2009 to July 2010.

of the short lag-time, AVG has a higher rate of infection than an autologous fistula [9]. The reported infection rates are 1% to 4% for primary AVF and 11% to 20% for AVG [10]. Thrombus formation is another risk factor for access failure, and the rate of thrombus occurrence is higher in AVG than AVF (0.5-2 episodes/graft-year and 0.25 episodes/patient-year, respectively) [10]. With regular monitoring, the rate of thrombus occurrence can be lowered [11]. If a thrombus is detected during monitoring, intervention may be needed to maintain access patency. Perera et al. [12] reported that secondary interventions were required in 87% of a prosthetic cohort (average 0.92 procedures/patient/year) and 57% of an autogenous cohort (average 0.53 procedures/patient/year). As a result, the cost to maintain

access patency is much higher for an AVG than an AVF. According to reports by Eggers and Milam, the annual incremental cost of AVG versus fistula in 1997 to 1998 was about USD 4,500 [13].

It is important to identify the vessels that meet the requirement for an adequate AVF. The anastomosis luminal diameter should be greater than 2.5 mm. There should be no segmental artery or vein stenosis and no central vein obstruction. A segment of at least 20 cm is required for straight vein cannulation, and the vein cannulation segment should be less than 5 mm below the skin surface. In addition, the flow rate is an important factor in maintaining the function of the access; a minimum flow rate is 500 to 600 mL/min, and Doppler testing is essential to evaluate the flow rate in the vessels [14]. When DUS was performed in this study as the first method for determination of access for dialysis, the rate of native vessel utilization was higher than when conventional venography was used. Therefore, we conclude that DUS is a better method than venography to evaluate vessel for dialysis.

Subclavian vein stenosis is sometimes found in patients with a long-term central HD catheter. Long-term sequelae of subclavian vein stenosis include reduced vascular access flow, graft thrombosis, and pronounced venous hypertension. As subclavian vein stenosis has been shown to have an adverse impact on the efficiency of dialysis, stenosis must be identified before the placement of vascular access [15]. However, a major limitation of DUS is the relative inability to assess central vein patency, so that CV may still be needed if a central venous stenosis or occlusion is suspected [4]. Contrast-enhanced magnetic resonance venography uses a contrast agent that does not compromise renal function [4].

## CONCLUSION

In conclusion, the utilization of native vessels was evaluated and compared, and results showed that the utilization rate was higher with DUS than with venography. A study comparing AVF patency rates evaluated by DUS and venography would be useful to evaluate the effectiveness of vessels selection with DUS.

## REFERENCES

- 1) Foley RN, Collins AJ. End-stage renal disease in the United States: an update from the United States Renal Data System. *J Am Soc Nephrol* 2007;18: 2644-2648.
- 2) Jin DC. Current status of dialysis therapy in Korea. *Korean J Intern Med* 2011;26:123-131.
- 3) Jin DC, Han JS. Renal replacement

- therapy in Korea, 2012. *Kidney Res Clin Pract* 2014;33:9-18.
- 4) Brown PW. Preoperative radiological assessment for vascular access. *Eur J Vasc Endovasc Surg* 2006;31:64-69.
  - 5) Allon M, Lok CE. Dialysis fistula or graft: the role for randomized clinical trials. *Clin J Am Soc Nephrol* 2010;5: 2348-2354.
  - 6) Allon M, Robbin ML. Increasing arteriovenous fistulas in hemodialysis patients: problems and solutions. *Kidney Int* 2002;62:1109-1124.
  - 7) Taylor G, Gravel D, Johnston L, Embil J, Holton D, Paton S, et al. Prospective surveillance for primary bloodstream infections occurring in Canadian hemodialysis units. *Infect Control Hosp Epidemiol* 2002;23:716-720.
  - 8) Fan PY, Schwab SJ. Vascular access: concepts for the 1990s. *J Am Soc Nephrol* 1992;3:1-11.
  - 9) Ryan SV, Calligaro KD, Scharff J, Dougherty MJ. Management of infected prosthetic dialysis arteriovenous grafts. *J Vasc Surg* 2004;39: 73-78.
  - 10) Gilmore J. KDOQI clinical practice guidelines and clinical practice recommendations--2006 updates. *Nephrol Nurs J* 2006;33:487-488.
  - 11) Brouwer DJ. ...the road to improvement? Part 2. The care and feeding of the AV fistula. *Nephrol News Issues* 2003;17:48-51.
  - 12) Perera GB, Mueller MP, Kubaska SM, Wilson SE, Lawrence PF, Fujitani RM. Superiority of autogenous arteriovenous hemodialysis access: maintenance of function with fewer secondary interventions. *Ann Vasc Surg* 2004;18:66-73.
  - 13) Schon D, Blume SW, Niebauer K, Hollenbeak CS, de Lissovoy G. Increasing the use of arteriovenous fistula in hemodialysis: economic benefits and economic barriers. *Clin J Am Soc Nephrol* 2007;2:268-276.
  - 14) Davidson I, Chan D, Dolmatch B, Hasan M, Nichols D, Saxena R, et al. Duplex ultrasound evaluation for dialysis access selection and maintenance: a practical guide. *J Vasc Access* 2008; 9:1-9.
  - 15) Surratt RS, Picus D, Hicks ME, Darcy MD, Kleinhoffer M, Jendrisak M. The importance of preoperative evaluation of the subclavian vein in dialysis access planning. *AJR Am J Roentgenol* 1991; 156:623-625.