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Endovascular management in immature arteriovenous fistula for hemodialysis

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Abstract

To evaluate the outcomes and prognostic factors of endovascular management in immature arteriovenous fistula (AVF) for hemodialysis.

From April 2007 to September 2017, 54 patients (male:female = 31:23, mean age 65.63 years, range 33–90 years) who underwent endovascular management for the salvage of immature AVF were retrospectively reviewed. Clinical data, procedural details, and results were evaluated. Primary and secondary patency rates and factors influencing the patency were also analyzed.

Technical and clinical success rates were 88.9% (48/54) and 85.2% (46/54), respectively. Mean primary and secondary patency was 42.10 (±8.85) and 91.5 (±14.77) months, respectively. Primary and secondary patency rates were 66% and 89% in 1 year, 66% and 78% in 2 years, and 51% and 78% in 3 years. In multivariate analysis, only brachiocephalic AVF and antegrade access procedures showed significantly shorter primary patency (HR 5.196; 95% CI (1.04–25.77); $P = .044$, HR 8.096; 95% CI (1.36–48.00); $P = .021$). There was no statistically significant factor associated with secondary patency in the multivariate study.

Endovascular management in immature AVF is safe and effective to make the AVF available. Brachiocephalic AVF and antegrade access procedures are the factors influencing the patency in multivariate analysis.

Abbreviations: AVF = arteriovenous fistula, AVG = arteriovenous graft, CIs = confidence intervals, HRs = hazard ratios, PTA = percutaneous transluminal angioplasty.

Keywords: arteriovenous fistula, endovascular management, percutaneous transluminal angioplasty, primary patency rate, secondary patency rate

1. Introduction

Maintaining adequate dialysis access is essential in patients receiving hemodialysis. Native arteriovenous fistula (AVF) is regarded as favorable vascular access than arteriovenous graft (AVG) or central venous catheter because of lower access failure rate and mortality.[1,2] Therefore, as many as a possible situation, AVF has been attempted as a first choice in patients receiving dialysis. However, maturation of AVF is still a major problem (up to 50%) in a large population[3,4] and salvage of maturation failure AVF is an important part of successful access acquisition.

To make these AVFs available, endovascular management, mostly percutaneous transluminal angioplasty (PTA) has been regarded as an effective technique.[5–7] Besides treating stenosis or occluded lesion with angioplasty, ligation or embolization for an accessory vein that hinders AVF growth is also considered.[5,8,9]

However, multiple procedures might be needed for a properly maturated AVF and biological effect of PTA on vascular injury is not yet fully understood.[7,10,11]

The purpose of this study was to evaluate the outcomes of endovascular management in immature arteriovenous fistula (AVF) for hemodialysis and investigate the factors that may adversely affect the patency.

2. Materials and methods

This is the retrospective study and was approved by institutional review board.

2.1. Patients

From April 2007 to September 2017, 54 consecutive patients (31 men and 23 women; mean age 65.63 years, range 33–90 years) were included in this study. All patients had immature AVF and underwent the endovascular procedure for salvage of AVF. Written informed consents were obtained from all patients before the procedures were performed.

Forty patients were diagnosed with diabetes, 43 with hypertension, and concomitant vascular disease such as cerebral, coronary and mesenteric vascular disease was found in 25 patients.

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Figure legends. Primary patency and Secondary patency

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There were 46 AVF in left arm and 8 in the right arm. Forty-two patients had radiocephalic AVFs and 12 patients had brachiocephalic AVFs. The meantime from fistula creation to PTA was 81.8 days (range 28–188 days). Less than 90% of stenosis degrees was found in 22 and complete occlusion in 15 patients. In case of multiple lesions, the most severe lesion was used as the stenosis degree measurement.

Lesion location was categorized as followings; artery, anastomosis, juxta-anastomosis vein, proximal draining vein, distal draining vein, cephalic arch, and central vein. However, for the statistical analysis, distal draining vein lesion was defined as upper arm vein, cephalic arch and central vein in radiocephalic AVF, and cephalic arch and central vein in brachiocephalic AVF.

The mean follow-up period was 24.62 months (range, 0.9–115.63 months). During the follow-up period, a total of 72 procedures were performed (1.3 procedure per patient). Two patients were lost to follow-up.

Retrospective review and analysis were performed for the following aspects; clinical data including demographics, comorbidities, fistula details, procedural details, and clinical results. When PTA was not performed due to the failure of cross the stenosed or occluded lesion, it was regarded as a technical failure. Subsequent to the procedure, if AVF access failed at least once for dialysis, it regarded as a clinical failure.

2.2. Endovascular management

Ultrasound was performed before the PTA to evaluate the fistula. Based on the ultrasound finding, decisions on access direction and entry site were made. In most of the cases, entry site was in the forearm in radiocephalic AVF and upper arm in brachiocephalic AVF. Two patients were accessed by the brachial artery, one via a brachial artery and draining vein, and in one case access via internal jugular vein was made. In the remaining patients, draining vein was the access site. Fistulography was performed following the access in all patients. If thrombus was found on ultrasound, 7Fr. sheath (Hoffman Sheath; COOK, Inc., Bloomington, IN) or 5Fr. a guiding catheter (Envoy; Codman, Raynham, MA) was used to aspirate the thrombus. PTA was performed for narrowed or occluded lesion. Balloon size was selected based on the adjacent normal vessel. If large accessory draining vein was still visualized after the effective PTA, coil embolization was performed. The suture was done for sheath insertion site and patients were discharged after hemostasis was confirmed. Time of AVF use was determined by the clinician.

2.3. Outcome assessment and statistical analysis

Outcome and patency rates were defined according to the reporting standards of the Society of Cardiovascular and Interventional Radiology.[12] Primary patency was defined as uninterrupted patency after intervention until the next access thrombosis or repeat intervention. Secondary patency was defined as patency achieved by all repeated endovascular interventions.

Kaplan–Meier method and the log-rank test were used for primary and secondary patency rates.

Cox proportional-hazard regression models were used to calculate hazard ratios (HRs) with 95% confidence intervals (CIs) for AVF survival. A P value <0.05 was defined to be statistically significant. Statistical analyses were performed using SPSS version 15.0 for Windows (SPSS, Chicago, IL).

Table 1

Patient demographics and baseline characteristic of AVF.

		N (%)
Age	< 65 years	22 (40.7)
	≥ 65 years	32 (59.3)
Sex	Male	31 (57.4)
	Female	23 (42.6)
Comorbidity	Diabetes	40 (74.1)
	Hypertension	43 (79.6)
	Concomitant vascular disease*	25 (46.3)
AVF location	Right arm	8 (14.8)
	Left arm	46 (85.2)
AVF location	Radiocephalic	42 (77.8)
	Brachiocephalic	12 (22.2)
Degree of stenosis†	< 90%	22 (40.8)
	90 ≤ <100%	17 (31.5)
	100%	15 (27.8)
Lesion location	Artery	1 (1.1)
	Anastomosis	5 (5.8)
	Juxta-anastomosis vein	30 (34.9)
	Proximal draining vein	33 (38.4)
	Distal draining vein	12 (13.9)
	Cephalic arch	2 (2.3)
	Central vein	3 (3.5)
Access direction	Retrograde	23 (42.6)
	Bi-directional	20 (37.0)
	Antegrade only	11 (20.4)

* Including coronary, cerebral, and mesenteric vascular disease.
† Most severe lesion.

3. Results

Patients' demographics and AVF characteristics are presented in Table 1.

Technical and clinical success rates were 88.9% (48/54) and 85.2% (46/54), respectively.

In 3 patients, aspiration thrombectomy was performed to remove thrombi; in none of the cases, thrombolytics were employed. Large accessory vein embolization using a coil that was thought to hinder the AVF growth was performed in 7 patients.

Mean primary and secondary patency was 42.10 (±8.85) and 91.5 (±14.77) months, respectively.

Primary and secondary patency rates were 66% and 89% in 1 year, 66% and 78% in 2 years, and 51% and 78% in 3 years.

Table 2 shows univariate statistics for primary and secondary patency. Right arm AVF showed significantly lower primary patency than left arm AVF ($P=.029$). Longer primary patency in radiocephalic AVF was revealed compared with brachiocephalic AVF ($P=.003$). The direction of PTA access also showed statistical significance for primary patency, especially in antegrade access only compared to either retrograde only access or bidirectional access ($P=.003$). AVF with distal draining vein PTA lesion revealed shorter primary patency (mean 7.54 vs 49.41 months, $P=.001$).

Multivariate statistics for primary patency is demonstrated in Table 3. Brachiocephalic AVF and antegrade access only PTA showed significantly shorter primary patency in multivariate analysis (HR 5.196; 95% CI (1.04–25.77); $P=.044$, HR 8.096; 95% CI (1.36–48.00); $P=.021$).

For secondary patency, right arm AVF and brachiocephalic AVF showed significantly low patency in univariate analysis ($P=0.048$, $P=0.041$). There was no statistical significant factor

Table 2

Primary patency and secondary patency.

		Mean primary patency, months	*P* value	Mean secondary patency, months	*P* value
Age	< 65 years	36.91 ± 3.4	.137	31.88 ± 4.87	.35
	≥ 65 years	35.39 ± 8.93		101.14 ± 9.61	
Sex	M	41.33 ± 13.44	.795	38.38 ± 12.05	.967
	F	34.62 ± 6.86		80.70 ± 18.96	
Diabetes	Present	35.62 ± 8.92	.304	84.99 ± 11.22	.683
	Absent	35.56 ± 5.96		41.10 ± 0	
Hypertension	Present	45.15 ± 10.03	.951	83.08 ± 15.0	.860
	Absent	31.96 ± 6.16		87.98 ± 20.19	
Concomitant vascular disease	Present	44.50 ± 11.07	.215	46.55 ± 12.43	.124
	Absent	40.85 ± 6.18		108.10 ± 7.27	
AVF location	Right arm	5.18 ± 1.96	.029	7.21 ± 3.17	.048
	Left arm	43.67 ± 9.24		82.58 ± 12.85	
AVF location	Radiocephalic	50.04 ± 10.37	.003	89.0 ± 13.22	.041
	Brachiocephalic	6.74 ± 1.00		17.28 ± 2.32	
Stenosis degree	< 90%	41.67 ± 11.56	.483	58.64 ± 11.62	.817
	90 ≤ <100%	27.10 ± 4.92		99.36 ± 14.84	
	100%	26.57 ± 4.57		32.72 ± 4.89	
PTA access direction	Including retrograde	45.66 ± 9.53	.003	82.54 ± 13.03	.741
	Antegrade only	5.15 ± 0.50		33.18 ± 6.18	
Distal draining vein lesion	Absent	49.41 ± 10.36	.001	89.14 ± 13.23	.058
	Present	7.54 ± 1.68		23.40 ± 5.86	

associated with secondary patency in multivariate analysis (Table 4).

There were no major complications. However, multiple minor complications were reported; a controlled rupture in 10 cases, rupture and dissection in 1 case, hematoma in 1 case, dissection in 1 case, and puncture site delayed bleeding in 1 case.

Among the 8 patients with clinical failure, 6 underwent re-creation of new vascular access and 2 patients continued hemodialysis with the central venous catheter.

The mean follow-up period in technical success patients was 24.62 months (range, 0.9–115.63 months). During the follow-up period, 45 patients still underwent hemodialysis either AVF or central catheter, 4 had kidney transplantation, and 3 died.

4. Discussion

Because of the relatively high failure rate of newly created vascular access[3,4] and importance of the fate AVF in dialysis patients, data about the endovascular salvaging AVF have been published with various results.[6,11,13,14] However, controversies still exist that an AVF matured by these assisted procedures may require more frequent intervention to maintain its patency and has decreased long-term patency.[10,11]

The Kidney Disease Outcomes and Quality Initiative (K-DOQI) guidelines suggest that all newly created fistulae must be examined for appropriate maturation 4 to 6 weeks postoperatively, and if poor prognostic signs are evident, immediate referral should be needed to the surgeon or interventionalist for prompt evaluation and intervention.[15]

Causes of maturation failure are stenosis or occlusion in in- and outflow vessel, aggressive neointimal hyperplasia, and lack or appropriate outward remodeling in histology.[11]

To solve this problem, several reports suggest mapping, vascular access counseling as well as surgical ligation or embolization of accessory vein and PTA.[3,5,8]

Overall primary and secondary patency rates were 66% and 89% in 1 year, 66% and 78% in 2 years, and 51% and 78% in 3 years in our study, which are comparable with other studies despite the existence of different background.[6,14,16–18]

Right arm AVF and brachiocephalic AVF showed relatively poor patency in our study. Although relatively small number of this condition, it statistical significance was evident in primary and secondary patency. Considering that the left arm radiocephalic AVF is usually the first choice of operation site in most of the patients, right arm and/or brachiocephalic AVF means that patients could not use a first choice vessel or already abandoned that access. However, the exact history of each patient was not obtained.

Ultrasound evaluation of AVF before the procedure is helpful to locate the stenosis or thrombus and identify the vessel

Table 3

Cox regression analysis for primary patency.

	Hazard ratio	95% CI	*P* value
Age ≥ 65 years	2.563	0.48–13.42	.265
Right arm AVF	1.259	0.18–8.46	.813
Brachiocephalic AVF	5.195	1.04–25.77	.044
Antegrade access	8.096	1.36–48.00	.021
Distal draining vein lesion	1.439	0.29–7.06	.654

CI = confidence interval.

Table 4

Cox regression analysis for secondary patency.

	Hazard ratio	95% CI	*P* value
Age ≥ 65 years	0.153	0.021–1.119	.064
Concomitant vascular disease	2.476	0.211–29.128	.471
Right arm AVF	7.231	0.410–127.550	.177
Brachiocephalic AVF	4.444	0.329–60.040	.261
Distal draining vein lesion	1.771	0.132–23.741	.666

Reference value is concomitant vascular disease = present.
CI = confidence interval.

anatomy. Therefore, determination of puncture site becomes easier based on the ultrasound finding. We performed an ultrasound to evaluate the AVF and choose the entry point. Therefore, antegrade access means that there was no lesion near the anastomosis site. Some investigators suggest the brachial artery or radial artery as the entry site,[19,20] but this approach still has a potential for arterial injury or future stenosis. Therefore, we chose the draining vein as the first choice of entry site except in 2 cases.

We defined the distal draining vein lesion as upper arm vein, cephalic arch, and central vein in radiocephalic AVF, and as cephalic arch and central vein in brachiocephalic AVF. The draining vein lesion in association with antegrade access suggests that the lesion requiring treatment is located apart from the anastomosis site. That presumes the poor underlying vascular condition not related with the operation. Woods et al[1] reported that a history of peripheral vascular disease was associated with a higher risk of AV graft or fistula failure. However, despite these presumptions, concomitant vascular disease failed to show statistical significance related to patency ($P = .215$ for primary patency, $P = .124$ for secondary patency) in our study.

Age has been described as an important factor influencing the AVF patency in several studies,[5,17,21] but, no significance was observed in our study. On the contrary, patients more than 65 years of age showed longer secondary patency, but this is not concluded with statistical significance in our study.

Recently, a few other treatment methods have been reported for immature AVF, such as stent graft placement or drug-eluting balloon angioplasty;[22,23] however, they lack concrete evidence. It is anticipated that future studies might reveal the results of the novel techniques.

There are several limitations in our study. First, it was a retrospective study and selection bias could not be avoided. According to the surgeon's decision, there is a high likelihood that they have been selected as likely candidates for treatment. Second, this study includes small number of patients and their statistical results. Larger data and complicated data processing techniques are needed.[24,25] Third, data regarding current medication of each patient were not completely obtained; therefore our study cannot postulate the effect of the medication.

In conclusion, endovascular management in immature AVF is safe and effective for making the AVF. Brachiocephalic AVF and antegrade access procedures were identified as the factors influencing the patency in multivariate analysis.

Author contributions

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