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ORIGINAL ARTICLE

Maturation rate of brachiocephalic versus brachioantecubital arteriovenous fistula; a prospective cohort study

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ABSTRACT

Background: Brachiocephalic arteriovenous fistula (BC-AVF) remains the standard procedure for arteriovenous fistula (AVF) creation in hemodialysis patients. Brachioantecubital arteriovenous fistula (BA-AVF) carried a benefit of dual venous outflow and use as an alternative choice for AVF creation. However, the maturation rate of BA-AVF is still questionable.

Objective: To compare the maturation rate of BC-AVF and BA-AVF and evaluate the risk factors for delay maturation.

Material and Methods: Sixty-nine chronic kidney disease (CKD) at least stage IV patients were enrolled in this prospective cohort study. After preoperative duplex ultrasonography mapping, patients with cephalic vein patent and diameter greater than 2.5 mm were selected into BC-AVF group. Patients with cephalic, basilic and antecubital veins patent and diameter greater than 2.5 mm were selected into BA-AVF group. All procedures were performed under local anesthesia. The primary outcome is the maturation rate of fistula at 6 weeks, 3 months and 6 months. The secondary outcome was risk factors for delayed maturation.

Results: Sixty-nine patients were enrolled, 38 patients underwent BC-AVF, and 31 patients underwent BA-AVF. There was no statistical difference in maturation rate between BC-AVF and BA-AVF at 6 weeks (65.79.32% vs 54.84%; P=0.218), 3 months (7.89% vs 19.35%; P=0.345) and 6 months (5.26% vs 6.45%; P=0.877). Univariate analysis revealed that preoperative cephalic vein less than 3 mm increased the risk of delay maturation (P=0.001). Age, gender, diabetes mellitus, hypertension, dyslipidemia, coronary artery disease and a history of hemodialysis catheter did not associate with delayed AVF maturation rate.

Conclusions: Our study supports the use of BA-AVF creation in patients with favorable venous anatomical configuration have the comparable maturation rate to BC-AVF and also provide the benefits from dual venous outflow to cephalic and basilic veins for the future hemodialysis cannulation.

Keywords: arteriovenous fistula, brachiocephalic AVF, brachioantecubital AVF, hemodialysis

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Introduction

The prevalence of Thai end stage renal disease (ESRD) patients who need renal replacement therapy has doubled in the past two decades.[1] According to the National Kidney Foundation's Kidney Disease Outcomes Quality Initiative (KDOQI) 2019,[2] Brachiocephalic AVF (BC-AVF) remains the procedure of choice when forearm vessels are not suitable for AVF creation. Brachioantecubital AVF (BA-AVF) provide an additional benefit of dual venous outflow to either cephalic and basilic veins. However, the maturation rate of BA-AVF is still questionable. Recent studies reported the maturation rate of BA-AVF is 100% compare to 77% in BC-AVF.[3] Several factors can affect the function and ultimate success of AVF. The objectives of this study are to compare the maturation rate of BC-AVF and BA-AVF and evaluate the risk factors for delay maturation.

Material and methods

This study is single center prospective cohort study that focus on the maturation rate of AVF and risk factors for delay maturation. Patients with chronic kidney disease (CKD) at least stage IV who fulfill criteria for AVF creation between November 2018 and June 2019 were enrolled. Patients who suitable for radiocephalic AVF (RC-AVF) or presence of prior central venous thrombosis were excluded. Baseline demographic data such as age, gender, comorbidities, eGFR and the history of central venous catherization were documented. Preoperative clinical assessment prior to AVF creation were made by vascular surgeon. Clinical examination consisted of inspection and palpation of the arm vessels and measurement of brachial artery blood pressure on both sides. Non-dominant arm was the primary option for AVF creation if there was no venous anatomical contraindication. Brachial and radial pulses were also documented. Pre-operative duplex ultrasonography mapping of arteries and veins were applied in all patients.

Duplex ultrasonography mapping protocol

Duplex ultrasonographic machine (GE; LOGICTM V5) with specific linear (L12) vascular ultrasonographic probe was used in all patients. Ultrasonographic venous mapping was exam by single operator who qualified in diploma of the Thai Board of Vascular surgery. Ultrasonographic venous mapping was performed with a tourniquet rubber band placed around the upper arm both sides. The diameter of cephalic, basilic and antecubital veins were evaluated. Venous scarring, thrombosis or stenosis were documented. Brachial artery diameter and flow was also assessed. After duplex ultrasonography patients were defined in BC-AVF and BA-AVF group.

Brachiocephalic AVF group (BC-AVF) defined as

1. Cephalic vein diameter greater than 2.5 mm without any evidence of venous thrombosis or stenosis
2. Antecubital vein or basilic vein less then 2.5mm
3. Triphasic arterial wave form of brachial artery with diameter greater than 2.0 mm

Brachioantecubital AVF group (BA-AVF) defined as

1. Cephalic, antecubital, and basilic vein diameter greater than 2.5 mm without any evidence of venous thrombosis or stenosis
2. Triphasic arterial wave form of brachial artery with diameter greater than 2.0 mm

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All patients were advised to preserve all of the superficial veins from venous cannulation to prevent the stenosis or thrombosis of the vein prior to the operation. Preoperative laboratory assessment was performed in all patients including complete blood count, electrolyte, BUN/Cr level, chest X-ray and electrocardiography.

Surgical procedure

All procedures were performed by single vascular surgeon. Procedures were performed in the operating room under local anesthesia. Transverse skin incision was created at antecubital area after ultrasonographic guidance. Cephalic vein and/or antecubital vein were dissected and mobilized freely from surrounding tissue. The vein was gently irrigated with a heparinized saline. Brachial artery was identified and dissected clearly. Arteriotomy was performed at brachial artery with limited not more than 5 mm to avoid post-operative steal syndrome. Anastomosis was performed gently by running 6/0 polypropylene (Prolene) suture material without any tension or kinking of the vein. BC-AVF was made by end-to-side anastomosis fashion of the cephalic vein and brachial artery. BA-AVF was made by end-to-side anastomosis fashion of the antecubital vein and brachial artery with dual outflow to cephalic vein and basilic vein as shown in Figure 1. Technical success was defined as the palpable thrill on the fistula after completion of procedure.

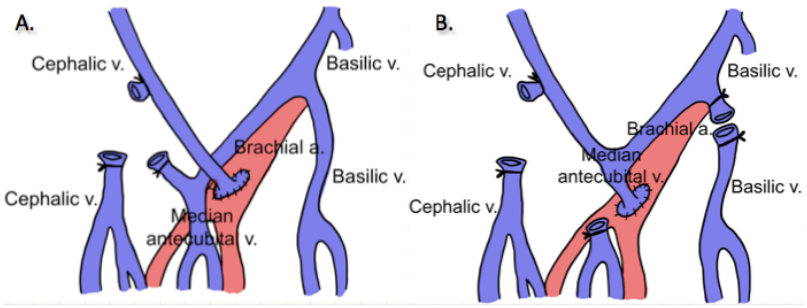

Figure1: Two types AVF creation; **A:** Brachiocephalic AVF, **B:** Brachioantecubital AVF

Postoperative assessment

All patients were followed-up at 2 weeks post operation for wound assessment and stitches removal. Then postoperative follow up at 6 weeks, 3 months and 6 months were made for assessment of fistula maturation and complications by physical examination and duplex ultrasonography. Maturation of the AVF was assessed by using Rule of 6 (diameter of vein ≥ 6 mm, fistula flow ≥ 600 mL/min and depth of vein < 6 mm). Flow measurement of the AVF was assessed by ultrasonography. All of the information was recorded in the patient record form.

Definition

Maturation of AVF defined as diameter of cephalic vein ≥ 6 mm, flow ≥ 600 mL/min and depth of cephalic vein < 6 mm.

Delayed maturation defined as AVF that do not mature within 3 months.

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Primary failure defined as AVF that thrombosed or occluded before the first successful cannulation for hemodialysis.

Statistical analysis

The statistical analysis was performed by SPSS 26.0 software (SPSS Inc, Chicago, IL). Baseline demographic were analyzed and compared between BC-AVF and BA-AVF by mean for continuous variables and percentage was expression for categorial variables. Maturation and delayed maturation were compared between two groups by Pearson chi-square test. Univariate analysis was analyzed using binary logistic regression model for identifying risk factors for delayed maturation. Variables that P-value ≤ 0.05 from the univariate analysis was considered statistical significant.

Results

From November 2018 to June 2019, 73 patients who met inclusion criteria were enrolled. Four patients were excluded, 2 patients died before the operation, 1 patient underwent kidney transplantation and did not require hemodialysis and 1 patient changed to peritoneal dialysis. A total of 69 patients were remained in the study. Thirty-eight patients were enrolled in the BC-AVF group and 31 patients were enrolled in the BA-AVF group. Baseline demographic data of patients were shown in table 1. There was no statistical difference between 2 groups in age (P=0.507), gender (P=0.570) and Comorbidities consisted of hypertension (P=0.975), diabetes mellitus (P=0.602), dyslipidemia (P=0.975), coronary artery disease (P=0.818) or prior central venous catheter insertion (P=0.334). There was no statistical difference in the diameter of cephalic vein, antecubital vein and brachial artery between groups as shown in table 2.

The overall 3 months fistula maturation rate in our study was 75.4% (52/69 patients). There was no statistically significant of 3 months maturation rate between 2 groups (BC-AVF, 76.32% vs BA-AVF, 74.19%, P =0.322) and delay maturation (BC-AVF, 18.42% vs BA-AVF, 25.41%, P=0.533). There were 2 patients with primary failure of the AVF in the BC-AVF group (Table 3).

Table 1: Baseline demographic data

Baseline demographic	Brachiocephalic AVF	Brachioantecubital AVF	*P*-value
Gender			0.57
Male	21 (55.3%)	15 (48.4%)	
Female	17 (44.7%)	16 (51.6%)	
Age	55.66 ± 13.64	60.93 ± 12.32	0.51
Underlying disease			
Diabetes	22 (57.9%)	16 (51.6%)	0.60
Hypertension	33 (86.8%)	27 (87.1%)	0.98
Dyslipidemia	5 (13.2%)	4 (12.9%)	0.98
Coronary disease	3 (7.9%)	2 (6.5%)	0.82
GFR (mL/min)/(1.73 m^2)	7.92 ± 3.76	8.4 ± 4.29	0.47
History of central venous catheterization	24 (63.2%)	16 (51.6%)	0.33

AVF, arteriovenous fistula; GFR, glomerular filtration rate

Table 2: Venous diameters between BC-AVF and BA-AVF

Venous Diameter (mm)	Brachiocephalic AVF	Brachioantecubital AVF	*P*-value
Cephalic vein	3.15 ± 0.61	3.25 ± 0.62	0.49
Basilic vein	2.32 ± 0.66	3.28 ± 0.81	0.02*
Antecubital vein	2.51 ± 0.69	3.01 ± 0.58	0.11
Brachial artery	4.34 ± 0.71	4.5 ± 0.64	0.70

AVF, arteriovenous fistula. * Statistically significant at P-value < 0.05

Table 3: Maturation rate between BC-AVF and BA-AVF

Maturation	Brachiocephalic AVF	Brachioantecubital AVF	*P*-value
Maturation within 3 months	29 (76.3%)	23 (74.2%)	0.32
- 6 weeks	25 (65.8%)	17 (54.8%)	0.22
- 3 months	4 (7.9%)	6 (19.4%)	0.34
Delay maturation (>3 months)	7 (18.4%)	8 (25.8%)	0.53
- 6 months	2 (5.3%)	2 (6.5%)	0.88
- > 6 months	4 (10.5%)	6 (19.4%)	0.19

AVF, arteriovenous fistula

When assessed the diameter of basilic vein in the BA-AVF group, 26 patients (83.37%) developed larger diameter of basilic vein more than 6 mm at 6 months-follow up period. Only 16.13%% (5 patients) has the basilic vein diameter less than 6 mm at 6 months follow-up period (Table 4).

The risk factors for delayed fistula maturation was diameter of cephalic vein less than 3 mm (OR 0.12, 95%CI 0.31-0.40, P=0.01). Age, gender, diabetes mellitus, hypertension, dyslipidemia, coronary artery disease and history of central venous catheter were not associated with risk factors for delayed fistula maturation (Table 5).

The correlation between cephalic vein diameter prior to the operation and maturation time were explored precisely. It appears that vein diameter less than 3 mm resulted in high percentage of delay maturation (42.4%) and if the vein larger than 3 mm, the maturation of AVF within 3 months were very high as close to 90% as shown in table 6.

Table 4: Diameter of basilic vein at 6 months in brachioantecubital AVF group

Basilic vein diameter (mm) at 6 months	Number (%)
< 6 mm	5 (16.1%)
≥ 6 mm	26 (83.9%)

AVF, arteriovenous fistula

Table 5: Risk factors for delayed fistula maturation

Factors	Odds ratio	95% CI	P-value
Gender	0.36	0.11 – 1.15	0.08
Age	0.94	0.28 – 3.10	0.91
Diabetes mellitus	0.42	0.09 – 1.36	0.13
Hypertension	0.86	0.16 – 4.58	0.85
Dyslipidemia	0.29	0.33 – 25.13	0.31
Coronary disease	0.46	0.07 – 3.01	0.40
History of central venous catheterization	0.48	0.25 – 1.57	0.23
Cephalic vein diameter less than 3 mm	0.12	0.31 – 0.40	0.001*

CI, confidence interval * Statistically significant at P-value < 0.05

Table 6 correlation of cephalic vein diameter with the rate of maturation

Cephalic vein diameter (mm)	Maturation within 3 months	Delay maturation
2.5 – 3.0	19 (57.6%)	14 (42.4%)
3.1 – 3.5	18 (94.7%)	1 (5.3%)
3.6 – 4.0	7 (87.5%)	1 (11.3%)
>4.0	8 (88.9%)	1 (11.1%)

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Discussion

Autogenous AVF is the most recommended vascular access for hemodialysis patients by the National Kidney Foundation's Kidney Disease Outcomes Quality Initiative (KDOQI).[2] When forearm fistulas cannot be performed, the upper arm AVF are the choices of fistula creation. BC-AVF usually the most prefer procedure for AVF creation because the cephalic vein anatomy is appropriate for the future hemodialysis cannulation. BA-AVF is also a good option because it results in a fistula with a dual venous outflow to either cephalic or basilic veins. Anyway, some surgeons believed that maturation of BA-AVF might be delayed because of separation of brachial artery outflow to each upper arm veins.

Our study revealed the BC-AVF and BA-AVF are equally maturation rate within 3 months (BC-AVF (76.32%) VS BA-AVF (74.19%), P=0.32). BA-AVF might carried an additional benefit with dual venous outflow increase the diameter of basilic vein for further use. Our study found that 83.4% of the patients with BA-AVF developed the large basilic vein more than 6 mm at 6 months follow up. These basilic vein can be the future alternative vascular access for hemodialysis if the cephalic veins exhausted but they might require some adjunct operation such as basilic vein transposition or superficialization of basilic vein. Our study also found that there was no steal syndrome in BA-AVF group. With minimizing the arteriotomy site not larger than 5mm and a good patient selection with good brachial arterial flow and patent fully radial pulse, we believe that the rate of steal syndrome would be very low.

When analyzed the risk factors for delay maturation, our study found that the diameter of cephalic vein less than 3 mm was associated with risk factor for delay maturation. While age, gender, comorbidities and history of prior central venous catherization were not associated with delayed fistula maturation. These results were comparable to the previous studies from which reported that increasing venous diameter are significantly associated with maturation rate.[4-6] While age, gender, diabetes and BMI had no significant effect on functional maturation.

The diameter of the cephalic vein more than 3mm were associated with very high rate (90%) of fistula maturation within 3 months. Previous study from Dageforde et al, also reported the similar result with an increased AVF maturation rate with a vein diameter more than 2.7 mm, as comparable to our result.[7] We believed that choosing the larger diameter of cephalic vein more than 3mm if possible, carry a high rate of early AVF maturation.

Limitations

The decision to perform BC-AVF or BA-AVF depends on the anatomical variation of each individual patients, the selection of patients to each group may be selection bias. Our populations are relatively small in size, validation of our findings in a larger cohort is warranted.

Conclusions

Brachioantecubital AVF creation in favorable patients have good fistula maturation rate and benefit from dual venous outflows for future use. The diameter of vein greater than 3 mm would carried a good outcome in early AVF maturation rate.

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