

# Distensibility in a Small Size Vein as a Factor for Brachiocephalic Arteriovenous Fistula Maturity: A Single-centre Experience

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## ABSTRACT

**Introduction:** National Kidney Foundation Kidney Disease Outcomes Quality Initiative (NKF-KDOQI) guidelines require an arterial diameter of more than 2 mm and a venous diameter of more than 2.5 mm for arteriovenous fistula (AVF) creation. The failure rate in vein diameters of less than 2 mm is as high as 40%. An audit done in Hospital Kuala Lumpur demonstrated that up to 67% of patients who are referred for AVF creation have veins smaller than 2.5 mm. So as per the NKF-KDOQI guidelines, creation of AVF is not suitable for them.

**Objective:** The objective of this study is to demonstrate venous distensibility as a reliable assessment tool prior to fistula creation in small size veins (1.6–2.4 mm).

**Materials and methods:** A single-center prospective study was conducted at the Vascular Unit, Department of Surgery, Hospital Kuala Lumpur (HKL). Sixty patients with cephalic veins in cubital fossa 1.5–2.4 mm were assessed per the standard care for fistula creation. A tourniquet was applied using a sphygmomanometer cuff and inflated to occlude superficial venous return. Pre- and post-compression readings were taken at cubital fossa at 3 cm and at 6 cm above the cubital fossa. Patients were planned for surgery per the standard care. Follow-up was done at 2 weeks for clinical assessment, at 6 weeks to determine the maturity for early access, at 3 months to identify mature fistula, and at 6 months to identify any failure of fistula maturity if any, after the intervention.

**Results:** The mean vein diameter of selected veins was 2.1 mm. The mean percentage of vein distention preoperatively for fistula maturity with a tourniquet was 30%. Five patients did not turn up for follow-up. One fistula thrombosed, one fistula was ligated due to the steal syndrome, and three patients passed away from myocardial infarction. The total number of patients recruited was 60, five patients dropped out for reason as stated. Hence, 55 patients developed mature fistulas.

**Conclusion:** Venous distensibility as a preoperative assessment tool in patients with smaller veins can be used to select a larger number of patients for the creation of AVF without compromising fistula patency and maturation rate.

**Keywords:** Arteriovenous fistula, Brachiocephalic fistula (BCF), Dialysis, Fistula, Tourniquet, Venous distensibility.

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## INTRODUCTION

Primary arteriovenous fistula (AVF) is considered as the first choice for vascular access due to better primary and secondary patency rates along with fewer infections and thrombotic complications as compared to prosthetic arteriovenous grafts.<sup>1</sup>

The National Kidney Foundation Kidney Disease Outcomes Quality Initiative (NKF-KDOQI) guidelines recommend that at least 50% of new hemodialysis patients have a primary AVF as these have better patency rates along with lower access-related costs.<sup>2</sup> Per these guidelines, patients planned for fistula creation should be assessed clinically and vein mapping done using a duplex scan, to assess suitability of vessels for fistula creation. The arterial diameter should be more than 2 mm and the venous diameter should be more than 2.5 mm.<sup>3</sup> The failure rate in vein diameters less than 2 mm has been reported to be as high as 40% in recent literature.<sup>4–8</sup> There are no guidelines that advocate venous distensibility as a predictor for fistula maturity.

A local audit conducted in Hospital Kuala Lumpur (HKL) demonstrated that up to 67% of patients do not fulfill the criteria of vein diameter for the creation of AVF. Lockhart et al. described that prior to the creation of a radiocephalic fistula, the use of a venous tourniquet increased the number of patients suitable for forearm fistulas without compromising the patency significantly and suggested that a tourniquet be routinely used in patients with

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small cephalic veins.<sup>9</sup> An article in the *Annals of Vascular Surgery* also identified venous distensibility as an indicator of successful radiocephalic fistula creation and demonstrated that distensible veins had a four-fold higher success rate.<sup>10</sup> van der Linden et al. using forearm venous distensibility measured the venous diameter using the ultrasound duplex with strain-gauge plethysmography prior to surgery and demonstrated that venous distensibility and not the luminal diameter is a predictor for AVF success.<sup>1</sup>

The aim of this study is to demonstrate venous distensibility of small-sized veins (1.6–2.4 mm) as an evaluation tool for creating an AVF. Post-distention increase in the diameter by 40% or an increase

in the diameter to 2.5 mm or more after distention was considered suitable criteria to use the veins for fistula creation.

## MATERIALS AND METHODS

This study is registered under the National Medical Research Register (NMRR), Malaysia, and has been approved by the Medical Research and Ethics Committee, Ministry of Health, Malaysia along with the Research Ethics Committee, National University Malaysia. It is a prospective cohort single-center study conducted at the Vascular Unit, Department of Surgery, Hospital Kuala Lumpur from May 2017 till January 2018. Chronic kidney disease (CKD) stage IV and above patients planned for native brachiocephalic AVF creation at the Department of Surgery, HKL, with 18 years and above of age, having cephalic vein luminal diameter between 1.6 mm and 2.4 mm which distended by more than 40% or achieved a diameter of more than 2.5 mm after distention, as measured on a duplex scan, were included in this study.

All patients fulfilling the inclusion criteria were counseled and, if agreeable, were asked to give consent to enroll in this study. Subsequently, a tourniquet (sphygmomanometer cuff) was applied to the arm of the patient and inflated to a pressure of 40 mm Hg and kept for 1 minute to occlude superficial venous return. Then a repeat duplex scan was carried out to assess the distensibility of the cephalic vein. The total number of patients meeting these criteria was 60. All these patients underwent brachiocephalic AVF creation. After surgery, all patients were followed up as follows:

- At 2 weeks for clinical assessment (wound healing, presence of thrill)

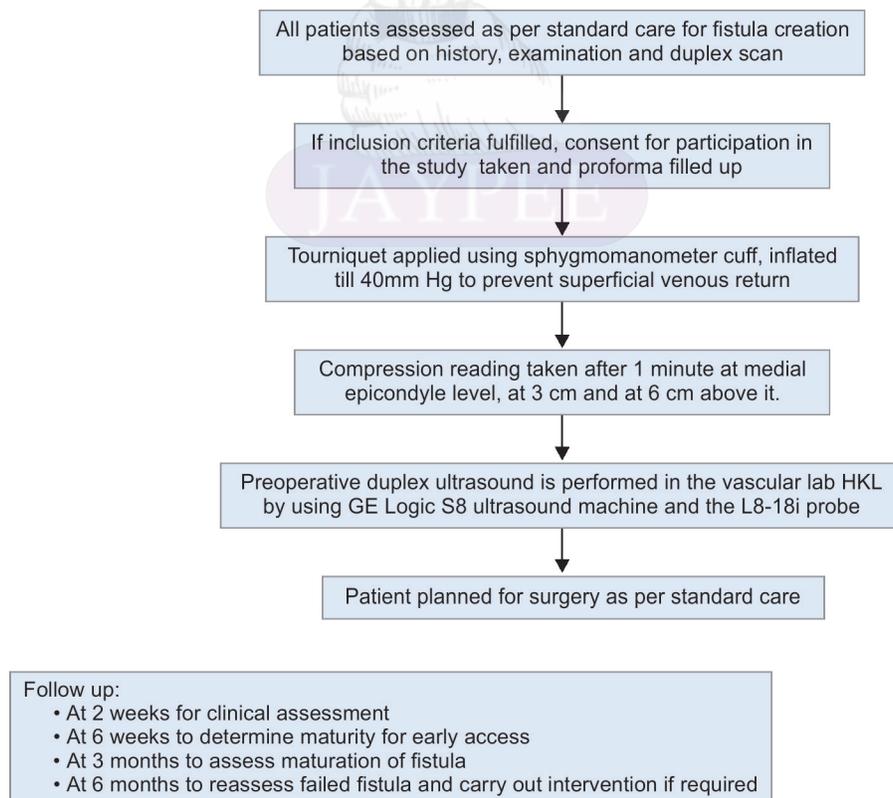
- At 6 weeks to assess if the fistula is ready for cannulation, using duplex sonography, measuring flow, depth from the skin, and diameter of the vessel
- At 3 months to assess fistula maturity
- At 6 months, if fistula fails to mature and/or requires any intervention
- At any point during the follow-up period should the patient require primary assist procedures, i.e., percutaneous transluminal angioplasty, ligation of accessory veins, creation of a more proximal neo-anastomosis, interposition of a short segment of vein graft or thrombectomy, these procedures are carried out.

The statistical analysis was performed with Statistical Package for the Social Sciences (SPSS) Statistics V21 (IBM Corp., Armonk, NY). Categorical variables are presented in frequency and percentage, while the numerical variables are presented in mean and standard deviation. The usable segment of the fistula was taken between the 3-cm and the 6-cm point corresponding to the inflow and outflow points. This measurement was used due to the practicality where the fistula could be punctured during dialysis.

A mature fistula is defined as a fistula suitable for cannulation with a flow of 600 mL per minute, a luminal diameter of 6 mm, and 6 mm depth from skin.<sup>2</sup> A non-maturing fistula is defined as a fistula that fails to mature after 6 weeks. The primary failure is defined as fistulas that are not usable for dialysis or that fail within 3 months of use.<sup>11</sup> The late failure was defined as fistulas that failed to mature at 6 months, even after primary intervention.

All the ultrasonography assessment of fistula pre- and postoperatively was performed by two trained medical attendants with more than 2 years of experience in fistula assessment using ultrasound and the primary author (Flowchart 1).

**Flowchart 1:** Flowchart of methodology



## RESULTS

A total of 60 patients who fulfilled the inclusion criteria were recruited to participate. Their baseline characteristics are listed in Table 1.

Table 2 shows distensibility of veins less than 2.5 mm in diameter. Twenty-three percent of veins were distended by 40% and remaining distended by less than 40%. However, the veins which distended less than 40% fulfilled the inclusion criteria by achieving an increase in the diameter of 2.5 mm or more.

Table 3 shows that the mean comparison along with the standard deviation between pre- and post-distention was examined that demonstrated a statistically significant *p* value. The *p* value was generated using the paired *t* test analysis. Therefore, on an average, venous distention led to an increase in the diameter of the vein allowing it to fulfill NKF-KDOQI guidelines.

Table 4 shows that anteroposterior (AP) diameter of veins along with three fixed points distended by an average of 30% with a 95% confidence interval.

Five patients were dropped out of the study. One fistula thrombosed after 1 month, one fistula was ligated due to the steal syndrome 5 days after surgery, and three patients passed away from myocardial infarction before the 6 weeks follow-up review. Remaining 55 patients were available for follow-up.

Table 5 shows the size of fistula at three levels (cubital fossa, 3 cm, and 6 cm from the cubital fossa) during the follow-up at 6 weeks, 3 months, and 6 months. All 55 fistulae matured in terms of size mostly within 6 weeks. Only in two patients, the fistula took longer time to mature but their maturation was also complete at 6 months without any primary intervention.

**Table 1:** Baseline characteristics of patients with small veins (*n* = 60)

Characteristics	<i>n</i> (%)
Gender	
Male	23 (38.33)
Female	37 (61.67)
Comorbidities	
Diabetes	45 (75.00)
Hypertension	49 (81.67)

**Table 2:** Percentage of venous distensibility post-tourniquet

Anterior–posterior diameter (pre-distention)	Increase in diameter post-distention <i>n</i> (%)	
	≥40%	<40%
<2.5 mm ( <i>n</i> = 60)	14 (23%)	46 (77%)

**Table 3:** Comparisons of pre-distention and post-distention vein diameters (*n* = 60)

Vein diameter	Mean (standard deviation)		<i>p</i> value <sup>a</sup>
	Pre-distention	Post-distention	
Cubital fossa	2.32 (0.50)	3.00 (0.77)	<0.001
3 cm	2.15 (0.48)	2.77 (0.60)	<0.001
6 cm	2.10 (0.42)	2.84 (0.61)	<0.001

<sup>a</sup>Paired *t* test

**Table 4:** Mean percentage of vein distensibility (*n* = 60)

Vein diameter	Mean percentage (95% confidence interval)
Cubital fossa	30.46 (24.62, 36.29)
3 cm	30.40 (25.94, 34.85)
6 cm	36.90 (30.94, 42.86)

**Table 5:** Fistula size during follow-up visits (*n* = 55)

Anterior–posterior diameter	Mean (standard deviation)		
	Week 6	Month 3	Month 6
Cubital fossa	6.51 (1.11)	6.30 (1.10)	5.90 (0.14)
3 cm	6.61 (1.12)	6.37 (0.88)	6.20 (0.00)
6 cm	6.63 (1.07)	6.37 (0.88)	6.20 (0.28)

## DISCUSSION

In 2014, there were 34,767 patients in Malaysia receiving dialysis, which shows a two-and-half-fold increase from 13,356 patients in 2005. While the new dialysis patients included in 2005 were 3,167, the number had increased to 7,055 in 2014.<sup>12</sup> Among the dialysis patients, 13.4% were on peritoneal dialysis. There was also significant demographic change in dialysis population. Patients above 55 years made up 58% of all new dialysis patients in 2014 vs 52% in 2005. In 2014, the death rate was 12% among hemodialysis patients and 16% in the peritoneal dialysis group.<sup>12</sup> A majority of dialysis patients died due to cardiovascular disease.<sup>12</sup>

Compared to AVFs, tunneled central venous catheters are associated with a 15-fold greater risk for bacteremia.<sup>13</sup> Infection-related hospitalizations were higher in patients on peritoneal dialysis as compared to those on hemodialysis.<sup>14</sup> This leads to the increase in healthcare costs in patients undergoing peritoneal dialysis as compared with hemodialysis. Hemodialysis, using native access of AV fistula, remains the renal replacement therapy of choice.

Satisfactory maturation of AV fistulae for use in hemodialysis is largely dependent on the size of veins. The failure rate of veins less than 2.5 mm size is as high as 40%. But, in practice, we do have many patients with small caliber cephalic veins (less than 2.5 mm) in cubital fossa. According to NKF-KDOQI guidelines, such patients would not qualify for brachiocephalic fistula creation. So, we carried out this prospective study to identify if patients with small caliber cephalic veins (less than 2.5 mm) can undergo the creation of brachiocephalic fistula successfully. We hypothesized that if we can use distensibility of veins prior to surgery as an assessment tool and accept those veins which distend by 40% or more or achieve a post-distention diameter of 2.5 mm or more, we can create a fistula in such patients. Our results show encouraging outcomes. There are many other modifiable and non-modifiable factors influencing fistula maturity which have been summarized by Smith et al.<sup>16</sup> These include smoking, obesity (body mass index >35), and cannulation before 14 days, which lowered patency rates.

Complications, which may arise from small vein AVF creation, are similar to those of normal sized fistula creation, namely infection, pseudoaneurysm formation due to repeated puncture at the same site, ischemic neuropathy, thrombosis of fistula, and the possibility of central vein stenosis due to the presence of the previous indwelling catheter.<sup>15</sup> In our study, thrombosis of the fistula was seen only in one patient that may be because the patient was returning early to his labor-intensive work. The steal syndrome was seen in one patient which is most likely due to the surgical technique as it was seen within 3 days from surgery.

This study was limited to only brachiocephalic fistulas. We believe that this finding can be extrapolated for all types of native fistula creation. If possible, a future randomized trial with a larger number of patients and accepting venous distensibility of even less than 40%, as in this study, will provide more useful data in success rates of creating AV fistulae in small caliber veins.

## CONCLUSION

Hemodialysis using native access AV fistulae remains the best option for renal replacement therapy of the end-stage renal disease patients. To create a successful AV fistula, a minimum vein size of 2.5 mm is recommended. However, in practice, especially in the Asian population, many patients have cephalic veins less than 2.5 mm in size. This study demonstrated that venous distensibility can be used as a reliable assessment tool prior to operation to create AV fistulae in patients with small-sized veins. If veins are distensible by 40% or if they achieve a diameter of 2.5 mm or more post-distention, they can be used with a predicted maturity rate of 90%. This will enable us to offer construction of brachiocephalic AV fistula in a larger number of the end-stage renal disease patients requiring hemodialysis.

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