

Original Research Article

Comparative analysis of radiocephalic versus brachiocephalic native arteriovenous fistula for hemodialysis in end stage renal disease

Aniket Khadatkar*, Chandrashekhar Mahakalkar, Tanu Pradhan, Akshay Bora

Department of Surgery, JNMC, Wardha, Maharashtra, India

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*Correspondence:

Dr. Aniket Khadatkar,

E-mail: aniketkhatadkar@gmail.com

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ABSTRACT

Background: Chronic kidney disease (CKD) is a long term condition caused by damage to both kidneys. The benefits of arteriovenous fistulas over other forms of chronic access are: Arteriovenous fistulas are associated with decreased morbidity and mortality among hemodialysis patients compared with arteriovenous grafts and central venous catheters. Objectives of the study were to choose the proper sites for formation of arteriovenous fistula, to find out the success rate at various sites and to study the complications of arteriovenous fistula.

Methods: This prospective study was carried out on total 150 patients over the duration of two years. The fistulae were created using radial artery and cephalic vein side to side (Radiocephalic AVF) and brachial artery and cephalic vein side to side anastomosis (Brachiocephalic AVF). Doppler studies were done before and after every procedure to demonstrate the velocity, volume of blood flow, depth from the skin, diameter of vessels and to access the time of maturation of AVF. Patients were followed up to first dialysis by AVF to assess the overall outcomes and various complications.

Results: Brachiocephalic AVF matured earlier than Radiocephalic AVF (mean maturation time Brachiocephalic 38.02 days and Radiocephalic 43.26 days) which was statistically significant. Brachiocephalic AVF matured earlier than Radiocephalic AVF with more flow rate. Complication rate was more at wrist (Radiocephalic AVF with 66.67% of overall complication) than at elbow (Brachiocephalic AVF with 33.33% of overall complication).

Conclusions: We concluded that the Brachiocephalic AVF maturation time was significantly less than the maturation time of Radiocephalic AVF and rate of complication was less in Brachiocephalic AVF. The utility of pre-operative colour Doppler to select the vessels for AVF creation was found to be as an essential parameter of pre-operative work up.

Keywords: Brachiocephalic arteriovenous fistula, Colour Doppler, Complications, Hemodialysis, Maturation time, Radiocephalic arteriovenous fistula

INTRODUCTION

Chronic kidney disease (CKD) is a long term condition caused by damage to both kidneys. It is only relatively recently that the epidemiology of Chronic Kidney Disease has been studied in detail with the finding that it is more common than previously thought.¹ Arteriovenous fistula has been the vascular access of choice for hemodialysis because of lower cost, morbidity and

mortality.² The three principal forms of chronic vascular access for hemodialysis are native arteriovenous fistulas (native AVFs), arteriovenous shunts using graft material (AV graft), and tunneled double-lumen catheters. Of these, the native arteriovenous fistula is preferred for long-term hemodialysis vascular access since it has the best long-term primary patency rate, requires the fewest interventions of any type of access, and most importantly, arteriovenous fistulas are associated with the lowest

incidence of morbidity and mortality.³⁻⁷ The benefits of arteriovenous fistulas over other forms of chronic access are: Arteriovenous fistulas are associated with decreased morbidity and mortality among hemodialysis patients compared with arteriovenous grafts and central venous catheters.⁸⁻¹⁰ Arteriovenous fistulas have the superior primary patency rates, the lowest rates of thrombosis, and require the fewest secondary interventions.^{6,11-13} Arteriovenous fistulas generally provide longer hemodialysis access survival rates.¹³⁻¹⁶ The total number of interventions during the life of the access is considerably lower for arteriovenous fistulas compared with arteriovenous grafts.^{6,11,15} Although a variety of different anatomic types of arteriovenous fistula can be created, most arteriovenous fistulas fall within three basic types: Radiocephalic, which are the radial artery and the cephalic vein, Brachial-cephalic, which is the brachial artery and the cephalic vein Brachial-basilic, which is the brachial artery and the basilic vein.

We have conducted the study with the aim to compare the overall outcomes and complications of Radiocephalic and Brachiocephalic AVF for hemodialysis in end stage renal disease. The objectives of this study were to compare the accessibility and rate of complications in Radiocephalic & Brachiocephalic arteriovenous fistula (AVF) and to evaluate the role of preoperative Color Doppler in the selection of vessels for A-V fistula creation.

METHODS

This prospective study was carried out on total 150 patients over the duration of two years. The fistulae were

created using radial artery and cephalic vein side to side (Radiocephalic AVF) and brachial artery and cephalic vein side to side anastomosis (Brachiocephalic AVF). Doppler studies were done before and after every procedure to demonstrate the velocity, volume of blood flow, depth from the skin, diameter of vessels and to access the time of maturation of AVF. Patients were followed up to first dialysis by AVF to assess the overall outcomes and various complications.

Inclusion criteria

- All the patients with end stage renal disease on maintenance hemodialysis.
- All the patients with end stage renal disease that will require MHD as advised by treating physicians.
- All the patients with end stage renal disease that will require renal transplant surgery, now on HD.

Exclusion criteria

- Previously operated AVF
- Previously operated complicated AVF
- Previously operated Failed AVF

RESULTS

Brachiocephalic AVF were made in 81 out of total 150 patients. Radiocephalic AVF was made in 69 out of 150 patients. Out of total 150 patients 120 (80%) were males and 30 (20%) were females. The male to female ratio was 4:1.

Table 1: Demographic presentation.

Gender	Brachiocephalic	Radiocephalic	Total
Male	63 (77.78%)	57 (82.61%)	120 (80%)
Female	18 (22.22%)	12 (17.39%)	30 (20%)
Total	81 (100%)	69 (100%)	150 (100%)
M:F ratio	3.5 : 1	4.7 : 1	4:1

Table 2: Pre-operative colour Doppler brachiocephalic AVF (n=81).

	Brachial artery	Cephalic vein at elbow	Radial artery	Cephalic vein at wrist
Q Max	118.96±42.81	30.26±22.79	21.19±16.08	14.98±7.67
Mean depth from skin	3.41±0.87	1.11±0.31	2.41±0.57	2.45±0.50
Complication	1	1	4	1

In 81 patients of Brachiocephalic AVF the mean Qmax of brachial artery and cephalic vein at elbow were 118.96±42.81 ml/min and 30.26±22.79 ml/min respectively which were significantly greater than that at wrist. Qmax of radial artery and cephalic vein at wrist were 21.19±16.08 ml/min and 14.98±7.67 ml/min respectively. This was in favor of making

Brachiocephalic AVF in these 81 patients. In 81 patients of Brachiocephalic AVF the depth of from the skin of brachial artery, and cephalic vein at elbow were 3.41±0.87mm and 1.11±0.31mm respectively and, radial artery and cephalic vein at wrist were 2.41±0.57mm and 2.45±0.50mm respectively. These parameters were well under the optimum requirement. Hence Brachiocephalic

AVF was made in these 81 patients. The complication in the vessel walls at elbow were 1 in brachial artery and 1 in cephalic vein at elbow which were less as compared to

the vessel walls at wrist which were 4 in radial artery and 1 in cephalic vein at wrist, hence in these 81 patients Brachiocephalic AVF were made.

Table 3: Pre-operative colour Doppler Radiocephalic AVF (n=81).

	Brachial artery	Cephalic vein at elbow	Radial artery	Cephalic vein at wrist
Q Max	121.53±51.89	26.67±16.37	41.51±25.51	18.02±11.33
Mean depth from skin (mm)	4.38±0.83	1.86±0.33	2.74±0.60	2.43±0.53
Complications	3	2	0	0

In 69 patients of Radiocephalic AVF the mean depth of radial artery was 2.74±0.60mm and cephalic vein at wrist was 2.43±0.53mm at wrist was also within permissible range. Hence in these 69 patients Radiocephalic AVF was made. In 69 patients of Radiocephalic AVF the mean volume of blood flow (Qmax) at wrist i.e. radial artery and cephalic vein at wrist were 41.51±25.51ml/min and 18.02±11.33ml/min respectively which was more than the minimum requirement. This was the reason for

making Radiocephalic AVF in these 69 patients. The rate of vessel wall complication at wrist in Radiocephalic AVF group was 0%; hence it was safe to conclude that in these 69 patients of AVF the choice of site for AVF creation was at wrist (Radiocephalic AVF). In 69 patients of Radiocephalic AVF the mean depth of radial artery was 2.74±0.60mm and cephalic vein at wrist was 2.43±0.53mm at wrist was also within permissible range. Hence in these 69 patients Radiocephalic AVF was made.

Table 4: Post-operative Colour Doppler at Maturation.

	Brachio-cephalic	Radio-cephalic	z-value	p-value
Q Max	806.41±273.36	601.08±216.58	5.02	0.0001,S
Time for maturation	37.59±3.30	43.78±3.43	10.86	0.0001,S

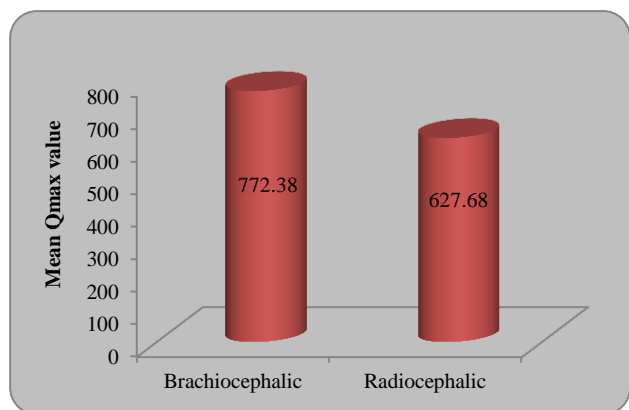


Figure 1: Volume of blood flow (flow rate) at the time maturation.

In post-operative colour Doppler at maturation, Brachiocephalic AVF matured earlier than Radiocephalic AVF (mean maturation time Brachiocephalic 38.02 days and Radiocephalic 43.26 days) which was statistically significant with p-value 0.001. The flow rate (volume of blood flow through AVF) was higher for the Brachiocephalic AVF than that of the Radiocephalic AVF (mean Qmax Brachiocephalic 772.38ml/min and

Radiocephalic 627.68ml/min) which was statistically significant with p-value 0.0001. Hence it can be concluded that Brachiocephalic AVF matured earlier than Radiocephalic AVF with more flow rate.

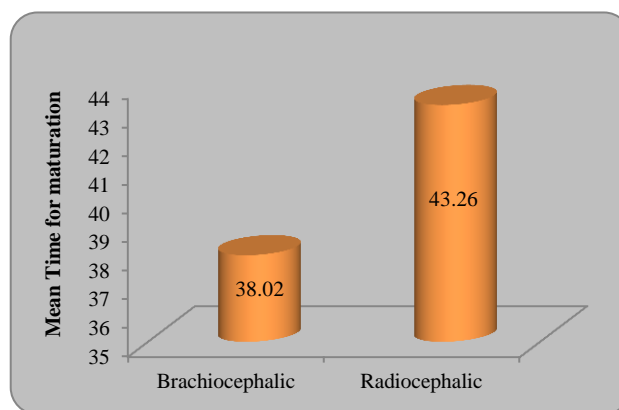


Figure 2: Time taken for maturation by AVF.

In this study the overall complication were seen in 12 (8%) patients out of 150. Infection and wound gaps were more at wrist as compared to elbow. Bleeding from the anastomotic site because of infection was equally seen at

wrist (1 patient) and at elbow (1 patient) which corresponded to 16.66% of the overall complications. Ecchymosis around the operative site was found equally at both the site (2 at wrist and 2 at elbow). Edema of the hand was seen more in Radiocephalic AVF or at wrist (4

patients) than at elbow (1 patient). Complication rate was more at wrist (Radiocephalic AVF with 66.67% of overall complication) than at elbow (Brachiocephalic AVF with 33.33% of overall complication).

Table 5: Complications of the procedure.

Complications	Brachio-cephalic (n=81)	Radio-cephalic (n=69)	Total	p-value
Pseudoaneurysm	0 (0%)	1 (100%)	1 (0.67%)	p=0.0001,S
Ecchymosis around the operative site	2 (50%)	2 (50%)	4 (2.67%)	p=1.00,NS
Edema of the hand	1 (20%)	4 (80%)	5 (3.33%)	p=0.0001,S
Infection bleeding and wound gaping	1 (50%)	1 (50%)	2 (1.33%)	p=1.00,NS
Total	4 (33.33%)	8 (66.67%)	12 (8%)	

DISCUSSION

Age of presentation

In present study out of 150 patients 120 (80%) were male and 30 (20%) were female. The male to female ratio in total number of patients was 4:1. In Brachiocephalic group out of total 81 patients 63 (77.78%) were males and 18 (22.22%) were females. In Radiocephalic group out of total 69 patients 57 (82.61%) were males and 12 (17.39%) were females. In Brachiocephalic group male to female ratio was 3.5:1 and in Radiocephalic group it was 4.7:1.

Patel A et al studied 110 patients, 85 (77.28%) were males and 25 (22.72%) were females with male to female ratio of 3.84:1.¹⁷ Son HJ et al published a study of 461 patients, 280 (60.7%) patients were male and 181 (39.3%) were female with male female ratio of 1.5:1.¹⁸

Brachiocephalic AVF creation

Beathard GA et al stated that when the vessel is examined, the presence of any calcification should be documented.¹⁹ If the artery has calcium deposits in its wall, it may be difficult to use. If it is heavily calcified, it will be extremely difficult to use. Hence the complication with the vessel wall was the major criteria for selection of the site for AVF creation. Other complications like thrombophlebitis, atherosclerosis, and tortuosity were also taken in account. Brachiocephalic AVF were made in 81 out of total 150 patients on the basis of the volume of blood flow through the vessels (Qmax), mean depth of vessels from the skin and the complications in the vessels wall.

We observed that in these 81 patients the mean volume of the blood flow through vessels at elbow (mean Qmax brachial artery and cephalic vein at elbow 118.96±42.81 ml/min and 30.26±22.79 ml/min respectively) were

significantly greater than that at wrist (mean Qmax radial artery and cephalic vein at wrist 21.19±16.08 ml/min and 14.98±7.67 ml/min respectively).

The depth of vessels from the skin (brachial artery 3.41±0.87mm, and cephalic vein at elbow 1.11±0.31mm, radial artery 2.41±0.57mm and cephalic vein at wrist 2.45±0.50mm) were well under the optimum requirement in co-relation to the study by Beathard GA et al.¹⁹ The complication in the vessel walls at elbow (1 in brachial artery and 1 in cephalic vein at elbow) were less as compared to the vessel walls at wrist (4 in radial artery and 1 in cephalic vein at wrist), hence in these 81 patients Brachiocephalic AVF were made.

Radiocephalic AVF Creation

Radiocephalic AVF were made in 69 out of total 150 patients, on the parameters same as that for Brachiocephalic AVF i.e. the volume of blood flow through the vessels (Qmax), mean depth of vessels from the skin and the complications in the vessels wall. In these 69 patients the mean volume of blood flow at wrist (mean Qmax radial artery 41.51±25.51ml/min and cephalic vein at wrist 18.02±11.33ml/min) was acceptable to the required values as suggested by Petrovic D et al (Qmax radial artery ≥ 40ml/min).²² The mean depth of vessels from the skin (mean depth radial artery 2.74±0.60mm and cephalic vein at wrist 2.43±0.53mm) at wrist was also within permissible range as per the study by Beathard GA et al (depth ≤1cm).¹⁹

Beathard GA et al in his article "Creating an arteriovenous fistula for hemodialysis" also mentioned that the first site choice of AVF creation should be Radiocephalic AVF at wrist.¹⁹ The rate of vessel wall complication at wrist in Radiocephalic AVF group was 0%, hence it was safe to concluded that in these 69 patients the choice of site for AVF creation was at wrist (Radiocephalic AVF).

Maturation

Pisoni RL et al in his study found no significant difference in AV fistula survival whether the AV fistula was first cannulated within 15 to 28 days or had a longer maturation period of 43 to 84 days.¹⁴ However, AV fistula cannulation within 14 days of creation was associated with a 2.1-fold increased risk of subsequent AV fistula failure compared with AV fistulas cannulated at more than 14 days.

Rajiv Saran et al suggested that cannulation of AV fistulae <2 weeks old should be avoided, Cannulation between 2 and 4 weeks should be performed only if the fistula is deemed mature by the treating nephrologists/surgeon and under close supervision, electively and never as an 'emergency'.²⁰ It is probably safe to cannulate a fistula after 4 weeks of creation.

In our study the mean cumulative maturation period for both types of AVF were more than 4 weeks which follow the conclusions by Pisoni RL et al and Rajiv Saran et al.^{14,20} We also found that the criteria for maturation as stated by Michelle L et al and Petrovic D et al were fulfilled by Brachiocephalic AVF significantly earlier (mean 37.59days) than the Radiocephalic (mean 43.78 days) suggesting that the Brachiocephalic AVF matured significantly earlier than the Radiocephalic AVF.^{21,22}

According to the findings of Petrovic D et al, Michelle L. et al and Beathard GA et al for maturation of AVF, both Brachiocephalic AVF group and Radiocephalic AVF group matured in coherence to these studies.²¹⁻²³

In comparison between Brachiocephalic and Radiocephalic AVFs Brachiocephalic AVF matured significantly earlier than Radiocephalic AVF (mean maturation time Brachiocephalic 38.02 days and Radiocephalic 43.26 days) statistically with p-value 0.001. We also found that the flow rate (volume of blood flow through AVF) was significantly higher for the Brachiocephalic AVF than that of the Radiocephalic AVF (mean Qmax Brachiocephalic 772.38ml/min and Radiocephalic 627.68ml/min) statistically with p-value 0.0001. Hence it can be concluded that Brachiocephalic AVF matured earlier than Radiocephalic AVF with more flow rate.

Complications

Hammes et al stated that complications occur in approximately one-third of fistulas and include: aneurysms, infection, stenosis, thrombosis, steal syndrome and heart failure.²⁴ Beathard GA et al in his study said that the AVF is associated with fewer complications than are seen with other types of vascular access, they do occur and they should be dealt with effectively.²⁵ He categorizes the major complications that are seen in conjunction with arteriovenous fistulas under the headings of early failure, late failure, excessive flow,

aneurysm formation and infection. Both early and late failures have multiple causes. A fistula that is never usable for dialysis or that fails within three months of use should be classified as an early failure.

The complication that were encountered during this study were oedema of the hand, Ecchymosis around the operative site, infection and wound gaping and Pseudoaneurysm. Mahakalkar CC et al in his study found that the rate of complications was more at wrist region or for Radiocephalic site. In the series overall complications were seen in 26 (18.57 %) patients out of 140.²⁶

In present study the overall complication were seen in 12 (8%) patients out of 150. In our study we found that infection, bleeding and wound gaping were equal in number both at wrist (1 patient) and at elbow (1 patient). The source of bleeding was the anastomotic site. It is the most dangerous complication and associated with greater morbidity and mortality.

In Mahakalkar CC et al study Edema and Ecchymosis around the operated site were seen in 17 (65.38%) all at wrist region.²⁶ In present study Ecchymosis around the operative site were found equally at both the site (2 at wrist and 2 at elbow) and oedema of the hand was seen more in Radiocephalic AVF or at wrist. In presence of infection, the underlying fistula became non-functioning. It was associated with the surrounding hematoma. Infection treated with antibiotics and regular dressings.

In Mahakalkar CC et al study Pseudoaneurysm developed in one (0.71%) patient. Angiography demonstrated leak from arterial side.²⁶ In present study also only one patient suffered from this complication. In present study it was also evident that complication rate was more at wrist (Radiocephalic AVF with 66.67% of overall complication) than at elbow (Brachiocephalic AVF with 33.33% of overall complication).

CONCLUSION

This prospective study conducted to compare the overall outcomes and complications of Radiocephalic & Brachiocephalic arteriovenous fistula (AVF) for hemodialysis in end stage renal disease concluded that,

- Brachiocephalic AVF maturation time was significantly less than the maturation time of Radiocephalic AVF.
- The flow rate was more for Brachiocephalic AVF.
- The rate of complication was less in Brachiocephalic AVF as compared to Radiocephalic AVF.
- Brachiocephalic AVF was found to be an early access for cannulation for maintenance haemodialysis.
- The utility of pre-operative colour Doppler to select the vessels for AVF creation was found to be as an essential parameter of pre-operative work up.

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Ethical approval: The study was approved by the Institutional Ethics Committee

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