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Original Research Article

Comparison of day wise maturity and failure rates of radio-cephalic and brachiocephalic fistulas using Color Doppler ultrasound in chronic kidney disease patients

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ABSTRACT

Background: Arteriovenous fistula is an autogenous connection between Artery and a vein which is created in patients of chronic kidney disease which need frequent hemodialysis as it allows adequate blood flow during the process and has high patency rates and lower complications.
Methods: This prospective study was conducted in tertiary care centre medical college in patients of age group 18-60 yrs. involving both genders with chronic kidney disease and hemodialysis with radio cephalic or brachiocephalic fistula.
Results: In our study out of 63 patients in 38 patients radio cephalic fistula was made in (60.3%), brachiocephalic in 11 patients (17.5%) and 14 cases were not fit for the surgery. In a comparison of day wise maturity of brachiocephalic and radio cephalic fistulas the maturity at day 1 for brachiocephalic fistula was ~37% and ~32% for radio cephalic fistulas. On day 14; 8 of the 11 brachiocephalic fistula (72%) and 19 of the 38(50%) of the patients with radio cephalic had maturity. On day 42; 81% of the brachiocephalic fistula and radio cephalic fistula 27(71%) had maturity. Out of 11 total brachiocephalic 9 were mature at the end of study with failure rate of 18.2% and out of the 38-radio cephalic fistula 27 patients were mature with failure rate of 28.9%.
Conclusions: In our study involving 63 patients the most common fistula was radio cephalic fistula followed by brachiocephalic fistula, even though the brachiocephalic fistulas had an earlier maturity rate; long term complications of brachiocephalic fistula were more.

Keywords: Arteriovenous fistula, Radiocephalic fistula, Brachiocephalic fistula

INTRODUCTION

Dialysis has been the therapy of choice for individuals with end-stage kidney disease since the 1940s. Dialysis is the process of filtering blood through a membrane to remove waste, toxins and excess of fluid from the body. Dialysis is a temporary measure in cases of acute kidney injury or in patients awaiting renal transplant and as a permanent treatment in patients in whom transplant is not feasible or not possible. An early referral to Nephrology of such patients improve mortality rates.[1]

Dialysis is mainly of two types as follows- (a) peritoneal dialysis- where the peritoneum acts as a membrane to filter the wastes and toxins; and (b) haemodialysis- blood of the patient suffering from end stage kidney disease is pumped through dialyzer in the blood compartment outside the body, and is exposed to a partially permeable membrane. Survival among chronic renal disease patient depends on the vascular access type of haemodialysis at the time of kidney replacement therapy initiation and dialysis modality.[1] For haemodialysis to be successful, vascular access is of great importance. Both arteriovenous fistula

(AV fistula) and central venous catheters can be used. AV fistulas have an advantage over central venous catheters having a larger life span and relatively fewer complications.[2,3] Most common sites for AV fistula being radio cephalic fistula, brachiocephalic fistula and the brachial artery-to-transposed basilic vein fistula.[4] However due to presence of various co-morbidities like diabetes mellitus and vascular disease in patients with CKD, the AV fistulas are in threat of both pre and post Complications like failure of maturation, stenosis, aneurysms, steal syndrome and thrombus.[5] Hence the formation and maintenance of AV fistulas becomes a challenge. Doppler provides a non-invasive and inexpensive diagnostic tool for examination of vessels were AV fistulas.[5-7] Doppler provides a lot of information about the

vessels like course and diameter of the vessels as well as the quantitative assessment of blood flow, and so is used as preoperative diagnostic assessment for arteries and veins for vascular access for haemodialysis.[8] Post-operatively Doppler can be used for the assessment of the maturation of AV fistula.[9] Doppler on long term basis will help in diagnosing any complications which may arise, which are far common due to the various comorbidities present in patients with chronic renal failure.

Objectives

The primary objective of this study was to compare the day wise maturity rates and failure rates of two most common fistulas that is radio cephalic verses brachiocephalic fistula along with complications in above mentioned fistulas.

METHODS

Study setting

This study was conducted in NSCB Medical College, Jabalpur. This hospital being a tertiary care centre caters to a significant population around it. Thus 63 patients with CKD were enrolled in the study.

Study period

The study period was August 2023 to January 2025.

Data collection tool

It included inclusion criteria, clinical and socio-demographic variables and variables on follow-up of the patients.

Criteria

Patients with age 18 to 60 years with CKD of both genders were included who had visible, palpable and thrombus free veins were included.

Patients who had peripheral arterial disease, veins <2.5 mm and arteries <2 mm in diameter were excluded.

Statistical analysis

The collected data will be analyzed by using IBM- SPSS version 23.0. The appropriate statistical methods will be used to make tabulation, Frequencies and graphs.

Sample size

Following formula was used to calculate sample size.

$$N = \frac{Z^2\sigma^2}{d^2}$$

Z=1.96 at 5% level of signifance, σ= standard deviation=87.7, d= clinical significant difference=22% with 80% power, minimum sample size required for the study= 63

Outcome variables

Pre-operatively brachial artery (at upper arm and elbow), ulnar and radial artery (at wrist and proximal forearm) diameter, peak velocity (cm/s), resistive index and flow (ml/min) in the brachial artery, ulnar artery and radial artery. The cephalic and basilic vein calibres and vein depth were measured at the wrist and in the proximal forearm. Post-operatively diameter, peak velocity and flow rate at the at outflow vein.

Data analysis plan

The collected data will be analysed using the latest SPSS software. Descriptive statistics were frequency and percentage/mean, standard deviation will be reported for all the required parameters. Chi-square test as the basis to check association between differences of severity assessment. Sn, Sp and PPV of desired parameters.

Ethical considerations

The patients could have opted out of the study at any time. Patient information was kept confidential. Study subject was not subjected to any additional cost

Types of fistulas created

Although many types of arteriovenous fistulas are described in literature only two most common - radio cephalic and brachiocephalic fistulas were created and included in this study.

Success parameter and follow-up

When dialysis can be done from vein after 30 days then only procedure is considered successful.

The patients were followed up at day 1, day 14 and at day 42 to check for maturity and patency of fistula and further to assess any complications.

Procedure

In our study pre-operative and well post-operative examination was performed using linear transducer of frequency 5-10 MHz.

In pre-operative examination diameter of cephalic and basilic vein, radial, ulnar and brachial arteries, distance from skin and colour flow of vessels was assessed.

If the cephalic vein or radial artery were not eligible for the surgery according to the criteria/ surgeon's perspective; the vessels in the forearm/elbow were evaluated for haemodialysis access.

In post-operative examination on follow up schedule at day 1, 14 and 42 flow rates were assessed to check maturity of fistula, luminal patency of graft and involved vessels was screened along with screening of any other complications. The institutional ethical committee has reviewed and approved for research entitled: "Comparison of day wise maturity and failure rates of radio cephalic and brachiocephalic fistulas using color doppler ultrasound: a prospective study"

RESULTS

Out of 63 total cases selected for the study 32 were males and 31 were females.

Out of the 63 cases taken for the study, 14 cases were either not fit for the surgery/or were lost to follow up. Of the rest 49 cases, 11 subjects underwent brachiocephalic fistula and rest 38 cases underwent radio cephalic fistula.

Out of the 11 patients who underwent brachiocephalic fistula; 9 of them had maturity at day 42. Out of the 38 patients who underwent radio cephalic fistula; 27 patients had maturity at day 42. In a comparison of brachiocephalic and radio cephalic fistulas; the maturity at day 1 for brachiocephalic fistula was -37% and -32% of the radio cephalic fistulas were mature. On day 14-8 of the 11 brachiocephalic fistula (72%) were mature and 19 of the 38 (50%) of the patients with radio cephalic fistula had maturity. On day 42-81% of the brachiocephalic fistula were mature and 2 were thrombosed or underwent intervention. Out of the 38 patients who underwent radio cephalic fistula; 27 (71%) had maturity at day 42.

Table 1: Distribution of cases.

Age group (years)	Males	Females
18-30	01	0
31-40	03	02
41-50	12	08
51-60	16	21
Total	32	31

Table 2: Type of fistula distribution.

Type of fistula	N	%
Nil	14	22.2
Brachiocephalic fistula	11	17.5
Radio cephalic fistula	38	60.3
Total	63	100

Table 3: Failure rates with respect to type of fistula at the end of study.

Primary failure rates	Type of fistula			
	Brachiocephalic		Radio-cephalic	
	Count	%	Count	%
Yes (<500 ml/min)	2	18.2	11	28.9
No	9	1.8	27	71.1
Total	11	100	38	100

Table 4: Day wise maturity with respect to type of fistula.

Blood flow rate (ml/min)	Type of fistula	N	Mean	SD	P value
Post-op day 1	Brachiocephalic fistula	11	451.73	194.435	0.496
	Radio cephalic fistula	38	403.73	206.058	
Post-op day 14	Brachiocephalic fistula	11	627.27	272.843	0.413
	Radio cephalic fistula	37	556.26	240.662	
Post-op day 42	Brachiocephalic fistula	9	829.11	324.902	0.180
	Radio cephalic fistula	33	705.03	216.424	

DISCUSSION

Arteriovenous fistula (AVF) remains the preferred vascular access for hemodialysis. However, over the past three decades, the increasing prevalence of advanced age, diabetes, and vascular disease among patients has contributed to higher rates of AVF failure. A meta-analysis reported that radiocephalic AVFs had relatively modest patency rates at one year, with primary patency at 63% and secondary patency at 66%.[11]

The 'fistula first' initiative has significantly increased the number of patients receiving AVFs for dialysis. Despite this, maturation rates are often suboptimal. In a study by Itoga et al early Doppler ultrasound (DUS) evaluation of newly created AVFs revealed that 40% demonstrated

hemodynamically significant outflow stenosis.[10] The authors employed a proactive approach, using early DUS screening to identify and treat these lesions.

Nevertheless, a systematic review concluded that routine DUS surveillance of AVFs and arteriovenous grafts did not lead to improved patency outcomes.[12] This finding should be interpreted with caution, as the included studies were heterogeneous and often combined results from both fistulas and grafts.

Doppler ultrasound is a valuable tool for vascular mapping prior to AVF creation. It allows assessment of arterial and venous anatomy, identification of suitable vessels for access, and optimization of surgical planning, thereby improving fistula outcomes. In addition to being rapid and cost-effective, ultrasound provides objective quantitative data that can reduce selection bias in access site choice.

This is particularly important for elderly and diabetic patients, in whom arterial narrowing and atherosclerotic changes are common. Preoperative assessment should carefully evaluate arterial patency, wall morphology, diameter, and course, as well as venous patency, diameter, length, and depth.

Once an AVF is created, rapid hemodynamic changes occur. Definitions of fistula maturation vary across studies, but Doppler assessment remains an important method for evaluating both qualitative and quantitative parameters. Furthermore, it can help predict complications such as stenosis before secondary failure occurs, enabling timely intervention to extend fistula longevity. In our study, a draining vein flow rate greater than 500 ml/min was considered the threshold for adequacy.[13]

As compared to the Robbin et al on day 1 of the study; we got comparable results for radio cephalic fistula. However, brachiocephalic fistulas in their study matured more as compared to our study with comparison.

On day 42 we can see as compared to Robbin et al study of 2016, we had blood flow rates in the radio cephalic fistulas comparable to their study. Brachiocephalic fistula had a slightly poor blood flow rates in our study as compared to their study.

Comparing maturity in radio cephalic fistula between our study and Robbin et al, we found that on day 1 the maturity was more in our study as compared to Robbin et al comparable results were found on day 14 and again our study maturity was more as

compared to Robbin on day 42. Whereas the brachiocephalic fistula had near comparable results especially on day 14 and day 42.

The comparison between radio cephalic and brachiocephalic fistula showed that brachiocephalic fistula matured earlier as compared to the radio cephalic fistula especially on day 1 and day 14 of the post-operative evaluation. The results were more or less comparable on day 42 for the maturity of the study.

Table 5: On day 1, 14 and 28 of the study; comparison of blood flow rates performed by Robbin et al for maturity.

Study (day 1)	Radio-cephalic	Brachiocephalic
Robbin et al 2016	375	750
Present study	402	451
Study (day 14)		
Robbin et al 2016	510	1004
Present study	558	627
Study (day 42)		
Robbin et al 2016	684	1065
Present study	718	830

Table 6: Comparison of maturity b/w our study and Robbin et al to compare maturity at day 1, day 14 and day 42 for radio cephalic fistula.

Parameters	Day 1 (%)	Day 14 (%)	Day 42 (%)
Robbin et al 2016	12	44	53
Present study	32	50	71

Table 7: Comparison of maturity b/w our study and Robbin et al to compare maturity at day 1, day 14 and day 42 for brachiocephalic fistula.

Parameters	Day 1 (%)	Day 14 (%)	Day 42 (%)
Robbin et al 2016	67	79	76
Present study	36	72	81

Table 8: When both radio cephalic and brachiocephalic fistula are compared to each other in our study.

Day	Radio-cephalic (%)	Brachiocephalic (%)
Day 1	32	36
Day 14	50	72
Day 42	71	81

Limitations

Ultrasound is an operator dependent modality and this may result in variable outcomes. This was a small cross-sectional study with a small sample size. Only radio cephalic and brachiocephalic fistula were included the study; other types of fistulas like brachiobasilic fistula and grafts were not included in the study. Although this study

was a prospective study the patient was followed up for a short period of time (6 weeks).

CONCLUSION

The use of ultrasound Doppler in the preoperative and post-operative assessment of the arteriovenous fistula acts as a definitive adjunct as well as a vital diagnostic tool. As per the findings in the study, the most commonly found features in the arteriovenous fistulas are as follows: in our study the most common fistula was radio cephalic fistulas followed by brachiocephalic fistula. In our study even though the brachiocephalic fistulas had in earlier maturity rate; long term complications of brachiocephalic fistula were more. The study also showed improved maturity of both brachiocephalic and radio cephalic fistulas who had undergone preoperative Doppler evaluation with 71% of radio cephalic fistula being mature at day 42 and 82% of the brachiocephalic fistula being mature at day 42. Few of the patients who underwent this study came with serious complications like cephalic vein thrombosis, pseudo aneurysm and hematoma for which patient had to undergo secondary intervention. Various literature shows that cephalic vein more than 2.5 mm is essential for successful maturity of arteriovenous fistula. However, in our study this would have made almost 50 % of patients ineligible for haemodialysis. Hence in our study the cut off taken was more than 2 mm. If the KDIGO guidelines were to be accepted; which state, the rule of 6 i.e.; blood flow rates of more than 600 ml/min; diameter of more than 6mm and vein depth of less than 2mm more than 50% of the radio cephalic and ~46% of the brachiocephalic fistula would not mature on day 42. The UAB criteria which states blood flow rates more than 500 ml/min and vein diameter more than 4 mm as the criteria for maturity is more feasible in patients with chronic renal disease looking for site for haemodialysis access.

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

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