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Original Research Paper

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EARLY POSTOPERATIVE ULTRASONOGRAPHY ROLE FOR AV FISTULA FAILURE PREDICTION IN HEMODIALYSIS PATIENTS.

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ABSTRACT Doppler ultrasonography is the main modality for imaging of hemodialysis AV fistula as it is safe and non-invasive. This study is to measure the Arterio-venous (AV) fistula blood flow during early postoperative period (0–7days) and assess its role in AV fistula failure prediction. Doppler ultrasonography was used to estimate the blood flow in the AV fistula of 50 patients at (0–7days) after the fistula was made. The blood flow in fistula during early postoperative period for fistula failure was evaluated, and long term failure was predicted. **Method** Blood flow rates measured in arteriovenous fistula created in upper extremity were measured in first week and sixth week post-operative. **Results** After follow up evaluation out of 50 patients, 40 fistulas considered to be matured; 10 considered failed. 30% failure were males and 70% were female. In early post operative period, cut off was set at 182 ml/min and the sensitivity of blood flow for prediction of fistula failure is 98%, specificity 90 %, PPV 95% and NPV 90%. **Conclusion** Measurements of the AV fistula blood flow in proximal artery and draining vein with its diameter of lumen were noted in the early postoperative period has a role predicting AV fistula failure. There is risk of failure if the blood flow less than 182 ml/min (day 0–7).

KEYWORDS : AVF:Arteriovenous fistula, CDU:Color Doppler ultrasonography, ESRD: End stage renal disease, US: Ultrasound, PSV: Peak systolic velocity

INTRODUCTION

Arteriovenous fistula are preferred vascular access for hemodialysis. Use of central venous catheters are now discouraged due to increased risk of infections, cardiovascular mortality events in comparison with arteriovenous fistula.[1] Adequacy of dialysis via vascular access improve the long-term survival of the patients on hemodialysis.[2] In comorbid patients pre and post-operative evaluation by colour doppler and arteriovenous mapping help achieve better placement and patency rates for the fistula.[3]

Doppler ultrasound is used as an imaging modality to monitor maturation and development of fistula over weeks for assessing functionality during hemodialysis.[4] With early detection of inefficiency of AV fistula detection we would be able to reduce rate of failure with medical intervention. Rapid increase in the blood flow rates reaching maximum by 6-8 weeks noted compared to post-operative day 1. [5]

Doppler ultrasound proves low cost, non-invasive modality in its prediction. In this article we hypothesized the role of blood flow and depth of fistula from superficial surface in its maturation.

MATERIALS AND METHODS-

This study was done in the Radio diagnosis Department from July 2021 to December 2021 with written consents of all patients for participation.

This study was carried on 50 patients with End stage renal disease coming for AVF creation.

Inclusion Criteria:

1. Both gender patients who required a hemodialysis by AVF.
2. Patients who required creation of new fistula at the other limb due to malfunctioning AVF.
3. Patients who attended follow-up postoperative (day 1–7) and between 6- 8 weeks.

Exclusion criteria:

1. Previous fistula formation in the same upper limb.
2. Patients with vascular diseases.

Equipment

1. Use of linear transducers.
2. B mode and Doppler mode ultrasound scanner (GE LOGIQ 7 version) which includes display of both two-dimensional structure and motion in real-time.
3. Tourniquet for measuring vein size.
4. Standard supplies for ultrasonic exam: acoustic gel, gloves, and wipes.

All patients were subjected to:

- Careful history taking (age, sex, primary renal disease) and physical examination.
- Preoperative vascular mapping:

1. Gray scale B mode to get the morphological criteria of the vessels (the diameter of the cephalic Vein, basilic vein, radial artery, ulnar artery at wrist and brachial Artery at the elbow).
2. Color Doppler imaging to assess the hemodynamics including Peak Systolic Velocity (PSV) of the radial, ulnar and brachial arteries.

- Postoperative: day 1- 7

1. Gray scale B mode to check the feeding artery, the anastomosis, and the draining vein to exclude stenosis or other complications
2. Doppler imaging to estimate the blood flow and depth of fistula from skin at the fistula site.

Technique of examination:

1.The arm of patient was abducted at 45° from body, in a comfortable position.

2.Care was taken to ensure adequate coverage of probe by coupling gel with gentle compression to avoid compression of the superficial veins.

3.Vessels were examined in both longitudinal planes and transverse planes.

4.Preoperatively, we determine the compressibility and the patency of the veins and their diameters examined by B mode. The diameter was determined in a transverse plane. Color images were obtained to assess the direction of blood flow.

Lastly, Doppler studies were performed, using 7-12 MHZ probe in transverse and longitudinal planes with Doppler angle always between (45–60°), with the angle kept relatively constant for each vessel throughout the study.

5. Peak systolic velocity (PSV) (cm/sec) in brachial and radial arteries was measured. The sample volume size (SV) was adequate to include the whole luminal cross section of the vessel.

6. Postoperatively, CDU examination of a dialysis fistula was performed prior to dialysis, to avoid examination related infection or post procedural bleeding from the puncture site.

7. The fistulae blood flow measurements were done at the same location which was at the anastomosis, without compression.

8.When measuring the blood flow at the anastomosis, the Doppler angle was set between 45° and 60° to limit one potential aspect of measurement variability, and the sample volume (SV) was oriented parallel to the direction of blood flow, positioned at the center of the vessel but the amplitude adjusted to allow sampling of 70% of the vessel lumen. Pulse repetition frequency (PRF) was adjusted to eliminate artifacts.

9. Fistulae blood flow for each fistula was measured three times repetitively, and the mean value was documented.

10. The flow volume formula is blood flow (milliliters per minute) = time-averaged mean velocity (meters per seconds) × cross-sectional area (square millimeters).

11.This was calculated electronically by the machine.

Signs of maturity of the fistula by Doppler examination:

1. Flow volume at the fistula site > 356ml/min in at least 3 dialysis sessions.
2. No complications are detected.

Statistical analysis

Data were collected, tabulated, and statistically analyzed using an IBM personal computer with the Statistical Package of Social Science (SPSS) version 22 (SPSS, Inc, Chicago, IL, USA) where the following statistics were applied:

1. Descriptive statistics: mean (X^{-}), standard deviation (SD) was used to describe the quantitative data as in (age, BMI, cephalic vein diameter, radial artery diameter and PSV, brachial artery diameter and PSV, early postoperative blood flow, and late postoperative blood flow).

Qualitative data were presented in the form of numbers and percentages as in causes of renal disease, mature, and failed fistula, and causes of fistula failure, gender, diabetes mellitus, and type of anastomosis.

Sensitivity, specificity, positive and negative predictive value, and diagnostic accuracy were calculated according to the following formulas:

- Sensitivity = $a/(a + c)$
- Specificity = $d/(b + d)$
- Accuracy = $(a + d)/(a + b + c + d)$
- Negative predictive value = $d/(c + d)$
- Positive predictive value = $a/(a + b)$

where a is the true positive cases, b is the false positive cases, c is the false negative cases, and d is the true negative cases.

RESULTS

Our study included 50 patients planned for AV Fistula aged between 38 to 68 years with 23 males and 27 females. Of them 18 were diabetic and 32 were non-diabetic..

During AV Fistula creation in preoperative mapping of upper limb vessels, cephalic vein mean diameter is 2.05 ± 0.28mm, radial artery mean diameter is 1.92 ± 0.45mm and brachial artery is 4.35 ± 0.6mm. Mean PSV of radial artery is 45.62 ± 6.76 cm/s, brachial artery is 57 ± 6.7 cm/s.

Out of these 50 cases in the follow up study, 40 fistulas considered to be matured; 10 considered failed. 30% failure were in males and 70% were female.

Diabetes incidence was higher in failure group 70% than the mature group 30% thus outcome of fistula and DM turn out to be significant (P value = 0.001)

	Diabetes Present (18)	Diabetes Absent (32)
Mature fistula (40)	11	29
Failure fistula (10)	7	3

	Males (23)	Females (27)
Matured (40)	20	20
Failed (10)	3	7

During pre-operative evaluation study outcome of fistula to be mature in relation to cephalic vein diameter (P value = 0.001), PSV of radial artery (P value = 0.001) and PSV of Brachial artery (P value = 0.001).

In postoperative evaluation (day 1) mature fistula show mean blood flow of 289 ± 13 than with failure group 178 ± 45 and during further follow up period show 458 ± 12 in mature group and 268 ± 17 in failure group.

Early and late post operative volume flow show significant relation with outcome of fistula (P value of- 0.001). similarly cephalic vein diameter brachial artery diameter and their corresponding PSV show highly significant relation with outcome.

In early post operative period, cut off was set at 182 ml/min and the sensitivity of blood flow for prediction of fistula failure is 98%, specificity 90 %, PPV 95% and NPV 90%.

In late post operative period, cut off was set at 356 ml/min and the sensitivity of blood flow for prediction of fistula failure is 99%, specificity 99 %, PPV 99% and NPV 90%.

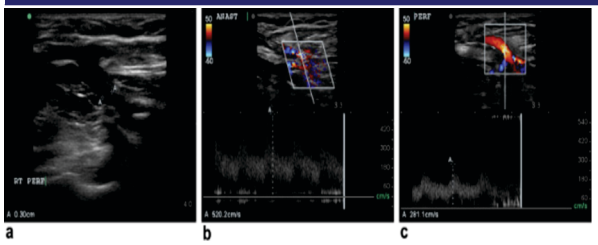
DISCUSSION

Hemodialysis proves efficient method in preventing high mortality rates associated with end stage kidney disease[6].Increasing need for hemodialysis lead to new advancements in this field. It proves effective modality catering for almost 70% of end stage renal disease patients[7].

Favoured form of access for dialysis is arteriovenous fistula according to hemodialysis vascular access guidelines[7]. Timely intervention for diagnosis of av fistula is crucial as it takes 2-3 months clinically for its confirmation. Thus, better non-invasive modality for diagnosis of failure is a necessity in this scenario.

Blood flow volume gradually starts increasing immediately after its creation and takes 8-10 weeks to reach its peak. If this fistula access does not provide adequate blood flow by feeding artery or draining vein does not dilate sufficiently, this inability to sustain flow results into failure.9 In this study we assess blood flow through fistula in its early post operative period and after 6 weeks. Data we collected show significant outcome of maturity of av fistula with its early post operative evaluation.

With agreement with previous studies conducted by Robbin ML, Greene T et al. US measurements at 2 weeks may be of value in the early identification of fistulas[8].



Limitations -

We are aware that our study had limitations as study included limited number of patients and short period of follow-up.

Color doppler assessment of AV fistula by intraoperative measurement would provide more clear prediction of maturity and flow assessment in different type of anastomoses were not taken into consideration.

CONCLUSION –

Doppler assessment of AV fistula in early post-operative period prove efficient parameter for prediction of fistula maturation.

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