

Triplex Doppler in Planning & Management of Av Fistula

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Abstract:

Objectives: To evaluate the role of Triplex Doppler in the planning of AV Fistulas.

Material And Methods: 50 patients planned for Hemodialysis were evaluated. All patients were subjected to full history taking, clinical evaluation, and radiological assessment using triplex doppler.

Results: Factors affecting patency of AV access in our study were Co-morbid conditions: Diabetes, Hypertension & Atherosclerosis. Pre-operative imaging and diagnosis of Pre-thrombotic veins, Thrombophlebitis with assessment of Atherosclerotic and diseased arteries. Venous factors such as Diameter and distensibility with lumen patency was assessed. Arterial factors such as Diameter, Peak systolic flow velocities and atherosclerosis.

Conclusion: Triplex doppler imaging including B-mode, colour and spectral doppler imaging is the modality of choice for pre-operative mapping and post-operative imaging of access.

Keywords: Triplex doppler, CKD, HD, AVF

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I. Introduction:

Chronic kidney disease (CKD) is a global health problem, more commonly prevalent in the elderly population. However in the present scenario, there is a raising incidence and prevalence of CKD in younger individuals with poor outcomes and high cost. Renal diseases are responsible for a great deal of morbidity than mortality. Management of CKD has undergone a rapid change with the introduction of modern imaging techniques. Haemodialysis (HD) has revolutionized the management of CKD patients by providing a reliable and repeated access to the circulation. HD is the most commonly used form of long-term renal replacement therapy.

Brescia and Cimino published their landmark report in 1966 describing haemodialysis through an autologous Arterio-venous Fistula. AVF is now the established gold standard mode of repeated vascular access for hemodialysis. Triplex doppler examination including B-mode gray scale ultrasound, colour doppler & spectral doppler is emerging as the preferred modality of vascular access planning and follow up. It also aids in early detection and management of complications in post AV access placement. Serial surveillance of AV access reduces risk of thrombosis and prolongs access survival by early detection and treatment of asymptomatic stenosis.

II. Materials & Methods :

Prospective, descriptive and observational study of 50 Patients planned for Hemo Dialysis access placements referred from Department of General Medicine & Urology to Department of Radio-diagnosis Govt. General Hospital, Rangaraya Medical College, Kakinada are included in the study. The study period was 20 months from a time period of December 2017- July 2019

At Saote My lab Class C Ultrasound machine with L3-12 probe- Linear transducer (7-12 MHz) with availability of Doppler settings was used exclusively for the study. Preferred site of access placement was planned by duplex doppler sonography by assessment of vessel caliber, wall morphology, peak systolic value of arteries & patency of vessels.

Tourniquet was placed around the arm and superficial venous system namely cephalic, basilic and median cubital vein were assessed first in transverse plane and subsequently followed by longitudinal planes. Venous caliber, distensibility and diameters were recorded at distal and mid-forearm, cubital fossa, mid-arm followed by assessment of axillary and subclavian veins. Distal non dominant limb preferred first, followed by proximal non-dominant limb and dominant upper limb.

Subsequently arterial diameter, caliber & flow velocities of radial and brachial arteries were assessed. Radial artery was assessed at the wrist up to mid forearm and brachial artery from its bifurcation superiorly up to mid-arm region.

III. Observations:

Our study included 50 patients who were in need of a vascular access for Haemo Dialysis, Pre-operative mapping of arterial system and superficial venous system was done for all patients with emphasis on Radial artery, Brachial artery and Cephalic vein.

Our study included 50 patients between 16 to 65 years with mean age of 40 ± 15.4 years. Majority of the patients (43%) were between 40 to 60 years of age. Out of 50 patients studied, 26 patients underwent Radio-cephalic anastomoses and 24 underwent Brachio-cephalic anastomoses.

Out of 50 patients in our study, 32 were male patients and 18 patients were females. Radio-cephalic anastomoses was most commonly preferred in 26 cases. However both Brachio cephalic and Radio cephalic anastomoses were equally done in male patients.

Out of the 50 patients in our study, 27 were known Type 2 Diabetes Mellitus patients on oral and injectable hypoglycemic drugs over the past 10-15 years, 23 patients were known cases of Hypertension on anti hypertensive drugs over the past 10-15 years .

Venous Diameters of cephalic vein with respect to the two types of AVF constructed were as follows as denoted in Table 7. Average cephalic venous diameters increased from 2.6 to 5.1 and 5.8mm at 4 and 6 weeks respectively in BC type of anastomoses. Average cephalic venous diameter increased from 2.1mm to 4.1mm and 5.3mm at 4 and 6 weeks in RC fistula with significant p value of <0.001 at 4 weeks and <0.005 at 6 weeks.

Peak Systolic Velocity as measured and recorded with mean value and standard deviations during **pre-operative evaluation** with respect to the two types of AVF constructed. The mean pre op peak systolic velocities in the BC fistula was 73.25mm and 58.83mm in the RC fistula. In our study 2 patients had high bifurcation of brachial artery as the anatomical variant with both undergoing subsequent brachio-cephalic fistula in arm.

Preferred limb for AVF construction was the Non dominant Upper limb in 35 cases (70%). AVF construction was avoided in non-dominant upper limb in patients with thrombus/ thrombophlebitis / inadequate cephalic venous diameter (<2.0 mm). AVF construction in dominant upper limb was done in such cases. Overall number of 15 cases , 9 BC type and 6 RC type fistula were constructed in dominant upper limb due to inadequacies or pathologies in the contralateral upper limb.

Depth of Fistula from the skin surface post-operatively at the end of 6th week with respect to the two types of AVF constructed was observed as follows as mentioned in Table 10 and cone diagram1. Mean depth of BC fistula and RC fistula from the skin surface was observed to be 6.0mm and 5.6mm respectively and were associated with good outcome.

Width of anastamotic site of fistula post-operatively on 6th week with respect to the two types of AVF constructed were as follows in table 11 and cone diagram 2. Mean anastamotic site diameters were 2.9mm for BC and 2.5mm for RC fistula associated with significant p value of <0.001

Peak systolic value at the site of anastomoses of fistula **post-operatively** at the end of 6th week with respect to the two types of AVF constructed were as follows as mentioned in Table 12. Mean peak systolic velocity was observed to be approx 573mm for BC fistula and 481mm for Radio-Cephalic fistula with a significant p value of 0.016

Maturity of RC fistulas to a minimum venous diameter of more than 5.0 mm post operatively at the end of 6 weeks and most BC fistulas matures to a minimum venous diameter of more than 5.0mm post operatively at the end of 4 weeks. Over all maturity rate post operatively was 75%, with no interventions at the end of 6 weeks. Post interventions a primary 1 year patency rate of 80% was recorded.

IV. Discussion:

The present study **ROLE OF TRIPLEX DOPPLER IN PLANNING AND MANAGEMENT OF AV FISTULA** was done at Government General Hospital, Rangaraya Medical College, Kakinada between December 2017 to June 2019 on fifty (50) patients suffering with Chronic kidney disease (CKD) and were planned for Hemo Dialysis.

Age of the patients selected for the study has an impact on the pre operative and post operative follow ups. In the patients above 40-60 years, the increased incidence of co morbidities (Diabetes, Hypertension, Atherosclerosis, Peripheral vascular disease etc) have a direct influence on the post op maturity, patency of the fistula. The age at presentation in our study varied from 16-65 years and above with mean age range being 41-60 years.

In the Hemodialysis (HEMO) Study, female sex was identified as a significant predictor of graft use rather than primary AVF use, but there is little specific evidence for AVF patency differences between sexes. Numerous studies have reported more failures in women but the reasons for the same is not very elaborate except for the fact that vessels are of smaller caliber in women than in men. The same has been noted in our study.

Sedlacek et al reported that despite increased arterial calcifications, vessel diameters and peak systolic velocities were not significantly different between diabetic and non-diabetic patients in their population. Klaus Konner et al reported increased use of proximal fistulas in diabetic patients but with primary access, the survival was similar to that of non-diabetic patients. However, steal syndrome was more common in the diabetic group. Functional maturity rates for AVFs in diabetic patients have been suggested to be increased by the use of routine vessel mapping. In our study 70% of the failure patients were in diabetic patients, thus claiming significance in our hospital setup.

Main etiology of CKD in our study was diabetes and hypertensive nephropathy. Shemesh D et al observed 55% cases to be hypertensive and diabetic by etiology. In our study a significant 27 patients and 23 patients were known diabetic and hypertensive patients with a significant number of patients being both diabetic and hypertensive.

The presence of peripheral vascular disease has been associated with an increased risk of AVF failure. Modern high-frequency US machines capable of high-resolution imaging can determine the intima media thickness (IMT) of small arteries such as the radial artery at the wrist.

Ku et al reported that IMT measurements during preoperative doppler imaging correlated significantly to histologic measures and more importantly to AVF thrombosis and to inadequacy of an AVF to maintain dialysis at 1 year. Similarly, ankle-brachial pressure index, a reliable marker for peripheral vascular disease, had a significant association with access failure after adjusting for other variables. In our study 33% of the failure patients had pre-operative atherosclerotic changes.

Wells et al recorded alteration in planned surgical sites for AVFs due to doppler findings and also the assessing physician's perception of the need for further imaging. Results suggested that doppler imaging was of little benefit in patients with adequate physical examination findings. A total of 17 patients were picked up in our study with thrombus/ thrombophlebitis of superficial veins which altered planned surgical site, accounting for 15 dominant hand (BC-9 and RC-6) AVF constructions.

Current guidelines suggest minimum venous diameter of 2 mm for a cephalic AVF at the wrist, and no agreed minimum measures exist for other sites till date. These measures have been evidenced by meta-analysis demonstrating significant differences in fistula success rates between cephalic venous diameter of more than 2.0 mm (71%) and less than 2.0 mm (29%). Mean venous diameter of cephalic vein in RC type was 2.1mm and BC type was 2.6mm in our study with veins having lesser diameter going in for failure.

In our study, cephalic vein at the end of 4 weeks in BC type fistula increased from 2.6mm to 5.1mm and subsequently measured 5.8 mm at the end of 6 weeks. In RC fistula cephalic vein diameter increased from 2.1mm to 4.1mm at the end of 4 weeks and 5.3mm at the end of 6 weeks. Thus with 5mm being minimum venous diameter, BC type attained maturity at the end of 4 weeks and RC type at the end of 6 weeks.

Preoperative imaging should include assessment of the arteries from the subclavian to the wrist to document anatomic variants, patency, stenosis, and calcification. Smaller artery diameters have been associated with increased failure rates, but variation in exact minimal figures exists. Present guidelines suggest a minimum diameter of 2 mm for successful AVF creation at the wrist, but agreement on minimal arterial diameters for other sites is lacking till date. This minimal value is evidenced by meta-analysis findings of the fistula success rate being significantly different between radial artery diameters of < 2.0 mm (59%) and >2.0 mm (40%) In our study, pre-operative arterial diameter of 2.8 mm and above in brachial artery and 2.4mm in radial artery were considered significant below which high failure rates were noted.

Width and depth of anastomoses along with PSV are few of the most important factors balancing the AV access. Three types of anastomotic arrangements can establish an AVF for dialysis : end-to-end, end-to-side, or side-to-side. Historically, the first few AVFs described by Brescia and Cimino in their landmark report was a side-to-side anastomosis. They stated that postoperative hand swelling was a common complication. In a randomized controlled study 20 years later, Wedgwood et al reported that the incidence of venous hypertension could be markedly reduced with the use of the end-to-side technique, which has now become common place. Patency in their study was similar between the groups, and only the incidence of complications appeared to separate the techniques. In our study end to side anastomoses was done in all cases.

Mean anastomotic site diameter of 2.5mm in RC and 2.9 mm in BC was obtained. Depth of fistula considered as 6.0mm according to previous studies. In our study, mean depth in RC was 5.6 mm and 6.0mm in BC groups. Dominant upper limb was preferred in patients with cephalic vein showing short/ long segment

thrombus / thrombophlebitis / inadequate cephalic venous diameter of less than 2.0mm. In an overall number of 15 such cases, 9 BC type and 6 RC type fistula were constructed in dominant upper limb.

Infection accounted for 20% of all AVF complications, which is ten times lower than the rate of infection of AVGs. Most AVF infections involve peri vascular cellulitis, which manifests as localized erythema with edema. Much more serious is an infection associated with anatomical abnormalities, such as aneurysms, hematomas or abscesses, which require surgical incision and drainage.

A developed AVF can cause reduced blood flow distal to the arterio venous anastomosis, which leads to hypoxia, ischemia and necrosis. The risk of ischemia and the emergence of this syndrome, known in the literature as the steal syndrome, are especially high in diabetics and elderly people. Clinical signs include reduced movement of the wrist with a cold sensation in the hand and a color change to pale yellow or purple, along with pain at rest and during exercise. Low resistance in the system of fistula veins and retrograde flow in the area of the palmar arch jeopardize adequate perfusion of the hands. This phenomenon remains clinically asymptomatic until the moment when compensatory mechanisms for perfusion by peripheral arteries are exhausted.

An aneurysm is a pathological enlargement of the blood vessel wall resulting from repetitive puncture. False aneurysms are hematomas located outside the vessel wall, formed due to a leaking hole in the intima of the artery, most often due to iatrogenic trauma - primarily repeated needle punctures. Color doppler ultrasound can differentiate false-aneurysm expansion from a hematoma. The presence of a thrombotic mass, requires possible surgical correction. Surgical intervention is recommended when there is a risk of perforation and ulceration of thrombotic mass.

Potential sources of discrepancies include: Spectral data miscorrelating with US B-mode images. Focal velocity of >300cm/sec with no apparent lumen diameter reduction, was noted in a few cases in which follow up was considered. Absent or low velocity in the presence of lumen diameter reduction was attributed to inflow stenosis or thrombosis causing low systemic pressure.

Low peak velocity should not be attributed to immature fistula and further follow up is necessary for the same. Clinically fistula adequacy was defined prospectively as the ability to sustain HD with two needles and blood flow of at least 350ml/min on at least 6 dialysis sessions completed in one month.

A fistula was considered inadequate access for HD if it clotted before use or was still not useable after 6 months post construction. Primary access failure was deemed as access that never achieved the adequacy for dialysis.

V. Conclusion:

Triplex doppler imaging including B-mode, colour and spectral doppler imaging is the modality of choice for pre-operative mapping and post-operative imaging of access. Post-operative sonographic evaluation of AVFs and their complications ensures their timely detection and allow measures to be taken that might prevent deleterious consequences. Serial surveillance of arteriovenous access reduces the risk of thrombosis and prolong access survival by early detection and treatment of asymptomatic stenosis. Thus with rising prevalence of end stage renal disease (ESRD) and the impact caused on health care economics, doppler imaging with its unique ability to assess structure and functional aspects of the peripheral vessels, is established as the preferred modality of vascular access planning and follow up.

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