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Role of Color Doppler Ultrasound In The Diagnosis Of Complications Of Hemodialysis Access Arteriovenous Fistula Causing Failed Dialysis

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Abstract

The aim of the study was to evaluate the application of color Doppler ultrasound in detecting the underlying cause for failed dialysis through autologous arteriovenous fistula.

Patients of end stage chronic kidney disease on maintenance hemodialysis through autologous arteriovenous fistula who had failed dialysis due to fistula complication were enrolled in the study. Color Doppler ultrasound was performed to detect the underlying cause of failed dialysis.

In all 25 patients were studied, 14 were male and 11 females. Age was from 18 to 80 year. 21 had AVF in left upper limb and 4 had in right upper limb. Stenosis and thrombosis together were detected in 10 patients, isolated stenosis was seen in 8 patients, isolated thrombosis in 4 patients. Pseudoaneurysm of the vein was seen in 2 patients and aneurysm near AVF was detected in one case.

Ultrasound color Doppler can detect the underlying cause of AVF complication manifesting as failed dialysis noninvasively.

Keywords: NIL

Introduction

Chronic kidney disease (CKD) is one of the major diseases threatening human health with morbidity and mortality. CKD eventually evolves into end-stage kidney disease that requires renal replacement therapy[1]. Hemodialysis is the most commonly used method of renal replacement therapy[1,2]. High-quality vascular access with the provisions of sufficient blood flow, long lifespan, and low incidence of complications is the most basic and most important issue in hemodialysis[2,3]. The 3 commonly used vascular accesses are arteriovenous fistula (AVF), synthetic arteriovenous graft (AVG), and central venous catheter (CVC). AVF is recognized as the best vascular access as it has long lifespan, low incidence of cardiovascular events and complications[2,3]. Complications like stenosis and thrombosis may lead to AVF failure increasing economic burden on the patient and lowering their quality of life[2,3,4]. When detected early, thrombosis and stenosis can be timely treated, extending the life of fistula and increasing patient's survival rate[2,3,4]. Color Doppler ultrasound is recommended as the best way to asses AVF due to its noninvasiveness, no radioactive damage, repeated usage, low price, and real-time assessment of anatomical and hemodynamic information of AVF[4,5].

This study aims to detect complications of AVF causing failed dialysis by color Doppler ultrasound.

Materials And Methods

Patients

Patients who underwent maintenance hemodialysis by autologous AVF from January, 2022 to July, 2023 were included. The inclusion criteria were as follows: failed dialysis with inadequate flow, limb edema, excessive bleeding after cannulation; age >18 years; received maintenance hemodialysis through upper limb AVF; AVF was stable for more than 3 months. Patients were excluded if they had severe heart failure or could not maintain limb during ultrasound. Prior written and informed consent was obtained from every patient.

Color Doppler Ultrasound

The Logic P 9 color Doppler ultrasound system (GE Healthcare, Illinois USA) was used with linear array transducer of frequency of 8 to 12MHz. The patients were examined in sitting position with elbow pad to stabilize the upper limb. The examination site was fully exposed, and the examination was cancelled in case of puncture bleeding. The brachial and radial artery of the upper limb of the AVF side was located. The flow and PSV of AVF artery, anastomosis, and outflow of the draining vein were evaluated for AVF stenosis and thrombosis. The probe had to be kept carefully vertical to the skin surface. Sufficient amount of coupling agent was applied with gentle touch to avoid pressures on blood vessels, especially the veins.

Thrombosis And Stenosis

Stenosis was defined if a vein segment had diameter <2.0mm, and the diameter of the narrow area was 50% less than the inner diameter of the adjacent normal segment. Thrombosis was diagnosed as hypoechoic or hyperechoic contents in part or all of vascular cavity, and when filling defect was detected by color Doppler ultrasound.

Results

25 patients were studied, 14 were male and 11 were female with age of 18 to 80 years and mean age of 58.7 years. Of the 25 arteriovenous fistulas studied, 21 were in left upper limb and 4 in right upper limb. Left radiocephalic AVF was observed in 13/25, left brachiocephalic AVF in 7/25, right braciocephalic AVF in 4/25 and left basiobasilic AVF was observed in 1/25 patients.

10/25 (40%) patients had stenosis with thrombosis, 8/25(32%) patients had isolated stenosis without any thrombosis. Thrombosis without stenosis was seen in 4/25 (16%)patients. Pseudoaneurysm of the cephalic vein was seen in 2/25 (8%) and cephalic vein aneurysm was present in 1/25 patient(4%). Stenosis with or without thrombosis was present in 18/25 (72%) patients and thrombosis with or without stenosis of the vein was seen in 14/25 (56%) patients.

Type of AVF	Number	Frequency
Left radiocephalic (LRC)	13/25	52%
Left Braciocephalic (LBC)	7/25	28%
Right Braciocephalic (RBC)	4/25	16%
Left Basiobasilic (LBB)	1/25	4%

Complication	No of patients	Frequency
Stenosis (isolated)	8/25	32%
Thrombosis (isolated)	4/25	16%
Thrombosis+Stenosis	10/25	40%
Psedoaneurysm	2/25	8%
Aneurysm	1/25	4%

Discussion

Volume 7, Issue 3; May-June 2024; Page No 503-506

The long-term survival and quality of life of patients with end-stage renal disease on maintenance hemodialysis (HD) depends on the adequacy of dialysis through an appropriately placed vascular access[6,7]. Arteriovenous fistulas (AVFs) are the preferred initial HD access[1,6,7]. The creation and maintenance of a patent and well-functioning AVF have become a real challenge to the concerned care givers. Complications associated with HD vascular access are considered one of the most important causes of morbidity among patients with end-stage renal disease[1,2,6,7]. Access failure is usually owing to thrombosis associated with anastomotic or outflow vein stenosis[6,7,8,9,10]. Juxtaanastomotic stenosis affects the first 2 cm of draining vein downstream of the anastomosis and represents 80% of all venous stenosis[7,8,9]. Stenosis of the venepuncture segment can be either short or long[6,8,9,10]. High-resolution sonography defines the severity of the stenosis based on morphological or geometric narrowing of lumen or on the basis of hemodynamic criteria. Vein stenosis is critical if the diameter in the narrowed point is <2–3 mm or Peak systolic velocity is >300–400 cm/s in the outgoing vein[6,7,8].

Thrombosis is the most common cause of vascular access failure in mature AVF. In 75% of cases, it is associated with critical stenosis on the venous side[4,6,7]. Aneurysm and pseudoaneurysm appear as pulsatile mass at the physical examination. Color Doppler sampling allows for the immediate differential diagnosis between aneurysm and pseudoaneurysm versus the haematoma and seroma[5,6,7]. Usually, pseudoaneurysm appears as saccular dilatation close to the draining vein wall, while true aneurysm appears as a fusiform or saccular dilation of the vessel. Blood flow in the aneurysm cavity describes a circular vortex similar to a cloud of cigarette smoke in the B-Mode with a giant red-blue vortex, named the 'Korean flag' sign at color doppler sampling. In the pseudoaneurysm, a circular swirling may be seen on colour doppler (yin-yang sign)[4,5,6,7].

Early detection of access dysfunction and subsequent intervention may help to decrease access failure rate[4,5]. Color Doppler ultrasound is very important in a patient centered vascular access evaluation[6,7]. It is mobile, cost effective, and noninvasive, and also, it provides morphologic and functional information of the access flow[4,5,6,7]. Hence; the present study was undertaken for assessing the effectiveness of colour Doppler ultrasound in cases of dysfunctional hemodialysis arterio-venous fistula.

In our study, color Doppler ultrasound supported the diagnosis of stenosis with thrombosis in 10/25 (40%), isolated stenosis without thrombosis in 8/25(32%) patients. Thrombosis without stenosis was detected in 4/25 (16%) patients. Pseudoaneurysm of the cephalic vein was seen in 2/25 (8%) and aneurysm was present in 1/25 patient (4%). An underlying complication was detected in the AVF of all the patients who were evaluated with color Doppler ultrasound for hemodialysis access dysfuntion.

Ultrasound can clearly differentiate between extrinsic compression, intramural problems, and intraluminal causes disturbing a vascular access. It also allows the observer to evaluate the state of collateral vessels available to plan for remedial surgeries in case of retrograde venous drainage[4,5]. Thus, color Doppler ultrasound is an ideal tool to complement clinical evaluation of dysfunctional arteriovenous access. So, on the whole, our study concluded that color Doppler ultrasound is a highly sensitive and accurate noninvasive modality for detecting AVF stenosis and thrombosis, and should be used routinely in order to reduce the use of invasive digital subtraction angiography.

Conclusion

Color Doppler ultrasound is a highly sensitive and accurate non-invasive modality for detecting AVF stenosis and thrombosis, and has the potential to dramatically improve our ability of accurate diagnosis of stenosis and thrombosis. Digital Subtraction Angiography (DSA) thus can be avoided by using doppler ultrsound. So, we recommend that Color Doppler ultrasound should be used routinely as a prime modality for detecting AVF complications.

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Volume 7, Issue 3; May-June 2024; Page No 503-506

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Volume 7, Issue 3; May-June 2024; Page No 503-506