ORIGINAL ARTICLE

Dysfunctional AV Fistula in End-Stage Renal Disease Patients at Tertiary Care Hospitals of Lahore and Peshawar

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ABSTRACT

Objective: To determine the frequency of dysfunctional arteriovenous fistula utilizing Doppler ultrasound in End stage renal disease patients receiving maintenance hemodialysis.

Study Design: Cross-sectional study.

Place and Duration of Study: The study was conducted at the Dialysis Unit, Sir Ganga Ram Hospital Lahore, Pakistan, and Department of Nephrology, Lady Reading Hospital Peshawar, Pakistan, from July 2019 to January 2021.

Methods: One hundred and seventy-seven (177) people receiving continuous hemodialysis for end-stage renal disease, fulfilling selection criteria, were included in the study. Their medical record was assessed, the clinical examination findings and Doppler ultrasound findings of dysfunctional arteriovenous fistula were recorded

Results: In this study, 177 patients who had end-stage renal disease and were on maintenance hemodialysis, fulfilling selection criteria, were included. Among these patients, 124 (70.1%) were male and 53 (29.9%) were females. The patients' average age was 48±13.29 years. In our local population, the frequency of a dysfunctional arteriovenous fistula is 30.5% on physical examination and 44.6% on Doppler ultrasound among patients on thrice weekly maintenance hemodialysis.

Conclusion: We concluded that upon physical inspection, 30.5% of individuals receiving thrice-weekly maintenance hemodialysis had dysfunctional arteriovenous fistulas and 44.6% on Doppler ultrasound in our population. Arteriovenous fistula with normal physical examination findings may be dysfunctional on Doppler ultrasonography and Doppler ultrasonography further confirm the findings of physical examination.

Keywords: *Arteriovenous Fistula, End Stage Renal Disease, Hemodialysis.*

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Introduction

The most popular kind of renal replacement treatment (RRT) for individuals with end-stage renal disease (ESRD) is hemodialysis (HD). Enough vascular access must be established and maintained for hemodialysis to be successful. A good vascular access should provide a sufficiently high blood flow rate with adequate inflow and outflow pressures to allow for efficient dialysis with minimal complications; otherwise, under-dialysis leads to increased morbidity and mortality.[1]

The preferred vascular route for maintenance

hemodialysis (MHD) is an arteriovenous fistula (AVF), as it has a reduced risk of complications and a longer survival rate than central venous catheters or prosthetic grafts.[2] It takes at least 500 to 800 mL/min of access blood flow to remove enough uremic toxins from a patient in an acceptable time during hemodialysis. Severe stenosis in the fistula's venous or arterial branch is typically the reason for a decrease in blood flow below that range. A hemodialysis access flow of less than 400 mL/min is linked to a higher risk of access stenosis and fistula failure. In comparison, a flow of more than 1200 mL/min, particularly more than 1500 mL/min, is linked to issues with the cardiac output.[3]

Even though pressures during hemodialysis are typically used to detect abnormal hemodynamics in access fistulas, early identification of access dysfunction and prompt, targeted treatments before the disease worsens may help to lower the rate of morbidity associated with access.[4] Research indicates that difficulties with vascular access construction account for around 30% of hospital stays among ESRD patients.[1] The overall frequency of complications in AVF is 16%.[5] Most important complications are central venous stenosis and obstruction (30%)[6], aneurysm (26.54%), thrombosis (17-25%), stenosis (14-42%), hematoma (3.8%), steal syndrome (2-8%), ischemic neuropathy (1-10%), and infections (2-3%).[1,5-7]

Guidelines for vascular access include routine screening with non-invasive techniques, such as clinical assessment (monitoring), and device-based surveillance, such as Doppler ultrasound (DU), to detect issues with AVF early.[8] The performance of physical examination (PE) in identifying stenosis in fistulas is also acceptable.[8] Physical examination surveillance is simple to understand, simple to carry out, quick to complete, and cost-effective. There are 3 components of PE: Look (inspection), Feel (palpation), and Listen (auscultation).[2] Doppler ultrasound (DU) is a simple, inexpensive and non invasive technique for assessment of blood flow in AVF. Additionally, it has increased AVF survival by enabling early identification and solving of problems.[3] Sixty-nine individuals with asymptomatic, functional hemodialysis access were evaluated using Doppler ultrasonography in an Iranian study. They reported high levels of abnormalities, especially higher flow volume, in clinically normal functional AVFs.[9]

In a study by Moghazy KM et al., they reported the efficiency of color (full abbreviation) DUS in the assessment of AVF dysfunction; DUS correctly identified stenoses, thromboses, venous aneurysms, and steal syndrome in 55 out of 177 patients with AVF dysfunction. In this study DUS was found to carry a sensitivity rate of 96.4% while taking surgical findings during operative interventions as the reference standard.[10]

In another study by Conkbayir et al. DUS correctly identified 123 of 130 lesions (sensitivity 94.6%, specificity 97.5%, PPV 98.4%, NPV 92%, accuracy 95.7%).[11]

Malik J et al. conducted a study in which 100 patients from two dialysis units were included in a cohort analysis that compared a unit assessed clinically with another unit assessed using ultrasonography flow measurements. The findings demonstrated that, as a surveillance strategy to avoid hemodialysis access thrombosis, a structured clinical assessment utilizing a formal tracking tool is equivalent to ultrasound flow measurements.[12]Treatment may enable the early identification of issues frequently linked to mature fistulas, preventing missed appointments and emergency scenarios. However, the physical examination of the arteriovenous fistula is a relatively new experience for many nephrologists, nurse practitioners, and nurses.[13]

Asif et al. published the results of a prospective study in 2007 that assessed the accuracy of PE in the diagnosis of stenotic lesions in comparison to angiography, involving 142 consecutive patients with AVF dysfunction. Regarding identifying concomitant inflow-outflow lesions, there was a high degree of agreement between the PE and angiography that went above and beyond chance (79% agreement).[14]

The three main components of PE for AV access are auscultation, palpation, and examination. Inquire about any odd or unexpected events the patient may have had between dialysis treatments, specifically related to the access, such as bleeding, swelling, bruises, redness, drainage, pain, or a change in the thrill. There is

limited data to compare the accuracy of physical examination with the Doppler examination. This study will help us in decision-making whether we should rely on physical examination or make a routine to make Doppler ultrasound to know the functional accuracy of AV Fistula.

Methods

The study was conducted at the Dialysis Unit, Sir Ganga Ram Hospital Lahore, Pakistan and Department of Nephrology, Lady Reading Hospital Peshawar, Pakistan from July 2019 to January 2021. The non-probability Consecutive sampling was applied. A sample size of 177 was determined by using 95% confidence interval, 4% margin of error with an expected percentage i.e. 8% of steal syndrome.[2] Patients of both genders, aged 25-70 years, with ESRD on MHD for > 3 months were included. Patients with open or infected wounds at the site of the fistula, making the Doppler scan difficult, were excluded.

After receiving approval from the Ethics Committee of the hospital vide letter no: 2/08/10/2019 held on dated: 10th August 2019 each patient's informed consent was obtained in order to gather data. Name, age, gender, and registration number were collected as demographic data. Co-morbidities, the length of dialysis via the AVF, the length of dialysis via central venous catheters before the AVF formed, and the quantity of previously unsuccessful fistulas were all noted as effect modifiers.

Every patient had a physical examination before DUS by the researcher. Patients were then sent to the radiology department of the same hospital for a Doppler ultrasound. Diagnosis on the basis of DU was made by the radiologist. Fistulas were labeled normal or dysfunctional as per operational definitions. An organized proforma was used to record all of the data. Data were gathered and processed into the Statistical Package for Social Science for analysis (SPSS) v23.0.

Quantitative variables like age, fistula age, flow volume, and diameter of feeding artery were presented in the form of Mean ±S.D. Qualitative variables gender, site of AV fistula and frequency of dysfunctional fistula were presented in the form of frequencies and percentages. Data were categorized according to age, gender, and dialysis duration via the AVF, duration of dialysis via central venous catheters prior to the creation of AVF, and number of sites for AVF that had previously failed fistulas to address effect modifiers.

Results

177 patients with end-stage renal disease who were on maintenance hemodialysis and met the study's inclusion criteria were included from the dialysis unit of the nephrology department of the Sir Ganga Ram Hospital in Lahore and the Department of Nephrology Lady Reading hospital the Department of Nephrology Lady Reading Hospital Peshawar. 124 (70.1%) were male and 53 (29.9%) were females. Of these patients, seven (4.0%) belonged to the 18 to 29 age group, 61 (34.5%) to the 30- to 45-year age group, 79 (44.6%) to the 46 to 60-year age group, and 30 (16.9%) to the over-60 age group. The average age was 48$\pm$13.2 years.

In this study, 16 (9.0%) patients were hypertensive and 99 (55.9%) as diabetic. Majority of the patients 104 (58.8%) had duration of dialysis via AVF >3 years. While 3 (1.7%) and 70 (39.5%) patients had duration of dialysis via AVF 6-12 months and 1-3 years respectively. Majority of the patients 104 (58.8%) had duration of dialysis via central venous catheter prior to AVF formation <3 months. While 30 (16.9%) and 43 (24.3%) patients had a duration of dialysis via CVC prior to AVF formation, started directly via AVF and >3 months, respectively.

According to the site of AVF distribution, 24 (13.6%) had right radio cephalic site followed by left radio cephalic at 51 (28.8%), right brachiocephalic at 24 (13.6%), and left brachiocephalic as 78 (44.1%). According to a number of previously failed fistulas distribution, 129 (72.9%) did not fail, followed by one time as 43 (24.3%), more than 1 one as 3 (1.7%), and three times as 2 (1.1%). According to blood flow through AVF distribution, 12 (6.8%) had blood flow <500 ml/min, followed by 501-1500 ml/min in 87 (49.2%), 1501-2000 ml/min in 19 (10.7%) and >2000 ml/min in 59 (33.3%). According to clinical examination, 123 (69.5%) had normal findings, and 54 (30.5%) had dysfunctional findings. Among 177 patients, 13 (7.3%) had signs of outflow obstruction followed by weak or

Table-1: Frequency distribution of duration of dialysis via arteriovenous fistula

Duration of dialysis via AVF	Frequency	Percent
6-12 months	3	1.7
1-3 years	70	39.5
>3 years	104	58.8
Total	177	100.0

Table-2: Frequency distribution of site of arteriovenous fistula

Site of AVF	Frequency	Percent
Right radio cephalic	24	13.6
Left radio cephalic	51	28.8
Right brachiocephalic or brachiobasilic	24	13.6
Left brachiocephalic or brachiobasilic	78	44.1
Total	177	100.0

Table-3: Frequency distribution of clinical findings

Clinical Findings	Frequency	Percent
Normal	123	69.5
Signs of outflow obstruction	13	7.3
Weak or absent thrill / bruit	14	7.9
Localized swelling / paper thin skin	23	13.0
Poor augmentation and weak thrill	4	2.3
Total	177	100.0

Table-4: Frequency distribution of Finding on doppler ultrasound

Finding on Doppler Ultrasound	Frequency	Percent
Normal	98	55.4
Stenosis	20	11.3
Thrombosis	20	11.3
Aneurysm	39	22.0
Total	177	100.0

absent thrill/bruit in 14 (7.9%), localized swelling/paper thin skin in 23 (13.0%) and poor augmentation and weal thrill in 4 (2.3%). On Doppler ultrasound, 98 (55.4%) patients had normal functioning fistulas and 79 (44.6%) were dysfunctional. According to dysfunctional findings on Doppler Ultrasound, 20 (11.3%) had stenosis, in 20 (11.3%) had thrombosis, followed by aneurysm in 39 (22.0%). Frequency of duration of dialysis has been shown in table-1 while frequency of site of AV fistula has been shown in table-2.

Table-3 shows the distribution of clinical findings, table-4 shows the findings on doppler ultrasound and table-5 shows the clinical examination findings with respect to the duration of dialysis via AV fistul

Discussion

The rationale for monitoring AVF for MHD is to extend the life of AVF, and all vascular access guidelines recommend monitoring and surveillance to screen subclinical dysfunction and prevent fistula failure. Physical examination (PE) is the earliest, most cost-effective, andeasiest method to evaluate access dysfunction. In addition to physical examination, Doppler ultrasound (DUS) is a non-invasive tool that confirms the findings of a physical examination and is helpful for the early identification and localization of AVF problems.[13]

Table-5: Stratification of clinical examination with respect to duration of dialysis via arteriovenous fistula

Duration of dialysis via AVF	Clinical Examination		Total
	Normal	Dysfunctional	
6-12 months	3	0	3
	100.0%	0.0%	100.0%
1-3 years	51	19	70
	72.9%	27.1%	100.0%
>3 years	69	35	104
	66.3%	33.7%	100.0%
Total	123	54	177
	69.5%	30.5%	100.0%

In this study, the frequency of dysfunctional arteriovenous fistulas in patients with end-stage renal disease receiving maintenance hemodialysis was comparable with the literature; females were more common. This gender inequality may be related to sociocultural factors attributing to fewer females with ESRD opting for or having hemodialysis access. In another study, it was also found that patients beginning renal replacement treatment (RRT) appear more likely to be men.[14]

On PE, 54 (30.5%) had dysfunctional fistula compared to 79 (44.6%) on DUS. Abnormal PE findings included localized swelling (13%), weak thrill (7.9%), outflow obstruction (7.3%), and poor augmentation with a weak thrill (2.3%). Dysfunctional AVF on DUS included stenosed 20 (11.3%), thrombosed 20 (11.3%), and aneurysm 39 (22.0%); none had retrograde flow distal to the fistula that could cause steal syndrome.

On comparing the findings of Doppler ultrasound (DUS) with those of clinical examination, it was seen that Doppler is more accurate as compared to physical examination, which is supported by other studies.[15] Outflow stenosis, aneurysms, and thrombi causing dysfunctional fistulas were not missed on clinical examination, and DUS further confirmed the PE findings in these conditions. On DUS, 12 (6.8%) had less than adequate flow of 500ml/min, 59 (33.3%) had high flow of more than 2000ml/min. blood flow less than 500ml/min is associated with inadequate hemodialysis, and very high flow fistulas can lead to high output cardiac failure.[16] The mean diameter of the feeding artery as measured by Doppler ultrasound was 4.58 +/- 2.31mm. On stratification of DUS findings with respect to age, among patients aged 18-29yr, 4 out of 7 had dysfunctional AVF, among those aged 30-45yr, 24 out of 61 had dysfunctional AVF; among 46-60yr olds, 43 out of 79 had dysfunctional AVF, and among those aged over 60yr, 8 out of 30 had dysfunctional AVF. The frequency of dysfunctional AVF was 19 out of 53 among females and 60 out of 124 among males.[17] Among the 79 out of our total 177 patients who had dysfunctional AVF on DUS, 47 were diabetic, and all 79 were hypertensive. Fistulas of age less than a year were all normal; among fistulas that were functional now for 1-3yr, 24 out of 70 were dysfunctional, and 55 of 104 fistulas functional for over 3 years were dysfunctional. Thus, fistulas that were being used for a more extended period of time were more likely to be dysfunctional.[18]

When data was categorized according to the site of AVF, 24 out of 51 right radio cephalic fistulas, 24 out of 51 left radio cephalic, 12 out of 24 right brachiocephalic, and 38 out of 78 left brachiocephalic AVF were dysfunctional on DUS.[19-22]

Conclusion

It is concluded that Doppler ultra sound is superior to simple physical emanation to diagnose the problems in the arteriovenous fistula.

Limitations of study: This study was conducted on small sample in two centers and should be

conducted on larger population at multicenter.

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Conflict of Interest: The authors declare no conflict of interest

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Authors Contribution

SK: Data collection
NM: Idea conception
FA: Study designing
AB: Data analysis, results and interpretation
MWK: Manuscript writing and proofreading
MUK: Idea conception