



ORIGINAL ARTICLE

Frequency of arteriovenous fistula stenosis and access recirculation in patients undergoing maintenance hemodialysis.

Shahid Anwar¹, Shireen Jafar², Mateen Akram³, Sobia Mazhar⁴, Hafiz Tahir Usman⁵, Rashad Rasheed⁶

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ABSTRACT... Objective: To determine the frequency of Arteriovenous Fistula (AVF) Stenosis and Access Recirculation (AR) among Hemodialysis patients. **Study Design:** Cross-Sectional Study. **Setting:** Dialysis Unit, Nephrology Department, Fatima Jinnah Medical University, Sir Ganga Ram Hospital, Lahore. **Period:** July 2017, to December 2017. **Material & Methods:** Eighty-four patients on maintenance hemodialysis fulfilling selection criteria were enrolled in the study. All the patients underwent Doppler ultrasonography for AVF stenosis detection and Peak systolic velocity (PSV) of more than 500 ml/sec predicted 50% or greater stenosis of AVF. A two-needle urea-based method was used for the calculation of AR and the AR value of more than 10% was considered significant. Data were analyzed in Statistical Package for Social Science (SPSS) v23.0. Data were stratified according to age, sex, BMI, hypertension, smoking, and duration of dialysis. Post-stratification, Chi-square was used. P-value ≤ 0.05 was taken significantly. **Results:** Among ESRD patients, 60(71.4%) were males and 24(28.6%) were females. 65(77.4%) had hypertension and 21(25.0%) were smokers. Among these patients, 6(8.3%) had AV fistula stenosis, and 10(11.9%) had access re-circulation. Statistically, a significant correlation was only present between AVF stenosis and AR (p-value 0.003) **Conclusion:** The periodic measurement of AVF stenosis and AR have diagnostic implications in maintenance hemodialysis patients because these are important causes of inadequate dialysis.

Key words: AVF Stenosis, Access Recirculation, Hemodialysis.

INTRODUCTION

Globally there is a rise in the number of patients suffering from chronic kidney disease (CKD) with a mean prevalence of 13.4%.¹ Most of the patients at CKD stage 5 opt for dialysis either due to the non-availability of kidney donors or the long waiting list of renal transplants.² Hemodialysis (HD) and peritoneal dialysis are two forms of dialysis, both with some added benefits and drawbacks in terms of quality of life and life expectancy.³ However HD is a preferred choice for most CKD stage 5 patients around the world.⁴ In Pakistan prevalence of CKD is 16 to 25%.⁵ According to the Pakistan kidney foundation 2014 report, there are 891 hemodialysis machines in the country and 5935 patients are receiving dialysis.⁶ In CKD stage 5 thrice-weekly maintenance HD is recommended but in our country, due to economic and social

issues, 67% of patients get dialysis twice per week.⁷ For HD requires permanent arteriovenous access and Arteriovenous Fistula (AVF) is the best option for arteriovenous access.⁸ The AVF should be adequate to allow repeated needle punctures and blood flow rates of 600ml/min. If AVF functioning is not appropriate, it will lead to inadequate HD (urea reduction ratio $< 60\%$ and Kt/V < 1.4). There are several causes of dysfunctional AVF, most important are stenosis, aneurysmal dilation, Infection, thrombosis, and AVF access recirculation (AR).^{9,10,11}

VF stenosis could be at the arterial segment (in-flow stenosis/ juxta anastomotic stenosis) or venous site (out-flow stenosis). The majority of AVF stenoses occur at the venous part due to neointimal hyperplasia caused by turbulence in

1. MBBS, FCPS (Nephrology), Associate Professor Nephrology, Fatima Jinnah Medical University, Sir Ganga Ram Hospital, Lahore.
2. MBBS, Post Graduate Trainee Nephrology, Fatima Jinnah Medical University, Lahore.
3. MBBS, FCPS (Medicine), FCPS (Nephrology) Assistant Professor Nephrology, Shaikh Zayed Medical College, Lahore.
4. MBBS, FCPS (Radiology), Consultant Radiologist, Mayo Hospital, Lahore.
5. MBBS, FCPS (Nephrology), Medical Officer Nephrology, Fatima Jinnah Medical University, Lahore.
6. MBBS, FCPS (Radiology), Senior Registrar Radiology, Fatima Jinnah Medical University, Lahore.

Correspondence Address:
Dr. Shahid Anwar
Department of Nephrology
Fatima Jinnah Medical University,
Sir Ganga Ram Hospital, Lahore.
nephroshahidanwar73@hotmail.com

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blood flow, and recurrent needle stick trauma.¹² These stenotic lesions may lead to elevated pressures in arterio-venous lines, prolonged bleeding from AVF, and thrombosis. Early detection by Doppler ultrasonography (USG) and treatment by balloon angioplasty can save secondary AVF failure.¹³

AR happens when blood ejecting from the venous needle is recirculated back to the needle at the arterial end instead of mixing in the systemic circulation. Too close needle placement, reverse needle placement and AVF inflow/outflow stenosis are major factors of AR; however wrong needle placement is considered a technical error by dialysis staff, is a correctable cause that can be rectified by proper training.¹⁴ Clinically AR can be assessed easily by the two-needle urea-based method. AR value of more than 10% is considered significant and warrants further investigation to rule out the cause of AR.¹⁵ Other complex methods like dilution techniques with help of ultrasound and tracers measurement can be used¹⁶ but it requires special equipment that is not feasible in our clinical routine especially in developing countries. The prevalence of AR varies from center to center, 17 to 82.2%, depending upon the availability of facilities, dialysis staff efficiency, and method of AR calculation.^{17,18}

This study was designed to check the frequency of AR and AVF stenosis among patients on thrice-weekly hemodialysis using two needle Urea based method and duplex Doppler USG respectively.

MATERIAL & METHODS

The analytical Cross-Sectional Study was conducted at the Nephrology department, Fatima Jinnah medical university/ Sir Ganga Ram Hospital, Lahore from July 1, 2017, to December 31, 2017, after taking permission from the institutional ethical review board vide letter No. 02-Nephrology/IREB dated 17-04-2017. Using the non-probability purposive sampling technique, 84 patients were enrolled. The sample size was calculated using the WHO calculator with 95% confidence level, 10% margin of error, and taking an expected percentage of AR i.e.,

32% in HD patients.¹⁹ Patients of age 16-80 years of either gender, on thrice-weekly maintenance Hemodialysis for ≥ 6 months for End-Stage Renal Disease were included. Patients who were getting dialyzed from a double-lumen venous catheter, unable to undergo Doppler ultrasonography, acute AVF infection, and having AV grafts were excluded from the study.

After taking informed consent from patients, demographic data including name, age, gender, history of smoking, hypertension (HTN), and duration of dialysis were obtained from the medical record. All patients underwent Doppler USG of AVF for blood flow measurements. Peak systolic velocity (PSV) of more than 500 ml/sec predicted 50% or greater stenosis of AVF.²⁰ All Doppler USG were performed by a single consultant radiologist to avoid intra-observer variability. The percentage of AR was calculated with Urea based two-needle method from the formula: Percent recirculation = $([P - A] \div [P - V]) \times 100$ [Where P is peripheral blood Urea, A, and V refer to the urea concentrations in the pre-dialyzer arterial line, and post-dialyzer venous circuit, respectively]. AR of more than 10% was considered significant.¹⁵

The data were analyzed using SPSS v23.0. Mean \pm SD was calculated for quantitative variables like age, BMI, and dialysis duration. Frequency and percentage were calculated for qualitative variables like gender, hypertension, smoker, AVF stenosis, and AR. Data was stratified for age, gender, BMI, HTN, smoker, and dialysis duration. Post-stratification, the chi-square test was applied for the comparison of frequencies of AVF stenosis and AR in stratified groups. A p-value ≤ 0.05 was taken as significant.

RESULTS

The demographic data and frequencies of AVF stenosis and AR are shown in Table-I. Among these 84 patients, 60 (71.4%) were males and 24 (28.6%) were females. The mean age of the patients was 47.7 ± 13.6 with 22 and 76 as the minimum and maximum ages and most of these (78.5%) were 20 to 60 years old. When BMI was checked, 37 (44.1%) patients were above normal

weight, 14 (16.7%) were underweighted, and 33 (39.3%) patients had normal weight. Out of 84 patients, 76 patients were receiving dialysis from 6 months to 3 years and only 9 (10.7%) were receiving hemodialysis under 6 months, while 8 were being dialyzed for 3 years or more. Sixty-five patients (77.4%) were hypertensive and 21(25%) were smokers. Among these patients, 7(8.3%) had AV fistula stenosis, 10 (11.9%) had significant AR. By applying the Chi-Square test, no statistically significant difference was there

among gender, age group, BMI, HTN, smoker, duration on dialysis, and AVF stenosis (p values: 0.789, 0.157, 0.990, 0.718, 0.625, 0.721 respectively). However, a statistically significant correlation was found between AVF stenosis and AR with a p-value of 0.003 (Table-I). There was no statistically significant difference found among gender, age, BMI, smoker, duration on dialysis, HTN, and AR (p-value: 0.915, 0.776, 0.837, 0.310, 0.243, 0.184 respectively) (Table-II).

	Number (%)	AVF Stenosis		P-Value
		Present (%)	Absent (%)	
Total (84)		6 (7.1%)	78 (92.9%)	
Gender				0.789
Male	60 (71.4%)	4 (6.7%)	56 (93.3%)	
Female	24(28.6%)	2 (8.3%)	22 (91.7%)	
Age (mean±SD)	48.6±13.3			0.157
20-40 years	27(32.1%)	2 (7.4%)	25 (92.6%)	
41-60 years	39(46.4%)	1 (2.6%)	38 (97.4%)	
≥61 years	18(21.4%)	3 (16.7%)	15 (83.3%)	
BMI (mean±SD)	23.9±5.3			0.990
Under weight	14 (16.7%)	1 (7.1%)	13 (92.9%)	
Normal	33(39.3%)	2 (6%)	31 (94%)	
Overweight	25(29.8%)	2 (8%)	23 (92%)	
obese	12(14.3%)	1 (8.3%)	11 (91.7%)	
HTN				0.718
Yes	65 (77.4%)	5 (7.7%)	60 (92.3%)	
No	19 (22.6%)	1 (5.3%)	18 (94.7%)	
Smoker				0.625
Yes	21 (25%)	2 (9.5%)	19 (90.5%)	
No	63 (75%)	4 (6.3%)	59 (93.7%)	
HD duration				0.721
<6 months	9 (10.7%)	1 (11.1%)	8 (88.9%)	
6 m to 1 year	29 (34.5%)	1 (3.4%)	28 (96.6%)	
1-3 years	38 (45.2%)	4 (10.5%)	34 (89.5%)	
3-6 years	4 (4.8%)	0 (0%)	4 (100%)	
>6 years	4 (4.8%)	0 (0%)	4 (100%)	
AR (mean±SD)	4.7±11.3			0.003
Yes	10 (11.9%)	3 (30%)	7 (70%)	
No	74 (88.1%)	3 (4.1%)	71 (95.9%)	

Table-I. Demographic data and its association with AVF stenosis.

AVF: arteriovenous fistula, HD: hemodialysis, AR: access recirculation, BMI: body mass index, HTN: hypertension.

	Number (%)	Access Recirculation (AR)		P-Value
		Present (%)	Absent (%)	
	Total (84)	10 (11.9%)	74 (88.1%)	
Gender				0.915
Male	60 (71.4%)	7 (11.6%)	53 (88.3%)	
Female	24(28.6%)	3 (12.5%)	21 (87.5%)	
Age (mean±SD)	48.6±13.3			0.776
20-40 years	27(32.1%)	3 (11.1%)	24 (88.9%)	
41-60 years	39(46.4%)	4 (10.2%)	35 (89.8%)	
≥61 years	18(21.4%)	3 (16.7%)	15 (83.3%)	
BMI (mean±SD)	23.9±5.3			0.837
Under weight	14 (16.7%)	1 (7.1%)	13 (92.9%)	
Normal	33(39.3%)	4 (12.1%)	29 (87.9%)	
Overweight	25(29.8%)	4 (16%)	21 (84%)	
obese	12(14.3%)	1 (8.3%)	11 (91.7%)	
HTN				0.310
Yes	65 (77.4%)	9 (13.8%)	56 (86.2%)	
No	19 (22.6%)	1 (5.3%)	18 (94.7%)	
Smoker				0.243
Yes	21 (25%)	4 (19%)	17 (81%)	
No	63 (75%)	6 (9.5%)	57 (90.5%)	
HD duration				0.184
<6 months	9 (10.7%)	1 (11.1%)	8 (88.9%)	
6 m to 1 year	29 (34.5%)	3 (10.3%)	26 (89.7%)	
1-3 years	38 (45.2%)	4 (10.5%)	34 (89.5%)	
3-6 years	4 (4.8%)	0 (0%)	4 (100%)	
>6 years	4 (4.8%)	2 (50%)	2 (50%)	
AVF Stenosis				0.003
Yes	6 (7.1%)	3 (50%)	3 (50%)	
No	78 (92.9%)	7 (9%)	71 (91%)	

Table-II. Demographic data and its association with AR.

Abbreviations: AVF: arteriovenous fistula, HD: haemodialysis, BMI: body mass index, HTN: hypertension.

DISCUSSION

Adequate HD not only improves the quality of life but also reduces morbidity and mortality. Adequacy of HD in terms of urea reduction ratio and Kt/V should be periodically checked as per recommendations of The Kidney Disease Improving Global Outcomes (KDIGO) guidelines. As checking AR is not a routine practice in many hemodialysis centers, these guidelines further emphasize checking AVF recirculation and warrant extensive investigations for any AR more than 10% by the two-needle urea-based method.⁸ There are non-urea-based methods

of calculating AR that uses dilution technique of different tracers like sodium, potassium, glucose, hematocrit, and hemoglobin. The gold standard technique for detecting AR is Ultrasound Dilution Transonic Hemodialysis Monitor (USM).²¹ With these non-urea-based methods accurate results are obtained and the AR value of zero signifies absent recirculation. However, false-positive rates are high with the two-needle method due to systemic sampling delay and laboratory error of urea measurement. Therefore, an AR value of more than 10% is considered significant in fistulas and 5% in double-lumen venous

catheters.²² We have used the urea-based two-needle method in this study and found 11.9% AR among our patients. This value is consistent with other international studies like 13.5% of T Buur study²³ and 8.75% by Javad Salimi.²⁴ However study from Egypt showed 55% and a study from Bangladesh described 82.2% significant AR among hemodialysis patients.^{25,26} Latest study from Egypt published in 2021 showed 17.7% of patients with AR especially in left brachiocephalic fistulas.²⁷ Among the causes of AR, reverse needle placement and too close needle placement are the biggest factors. If dialysis staff is properly trained and dialysis needles are adequately placed about 2 inches apart in the proper direction, then AR can be rectified.^{28,29} Probably neglect in this factor has led to high AR rates in studies from Bangladesh and Egypt. In our study, no statistically significant difference was found between male and female patients with AR whereas females exhibit more AR than males in other studies.^{30,25}

AVF stenosis ultimately leads to thrombosis and secondary AVF failure. With repeated needle punctures endothelial injury occurs which triggers hyperplasia and proliferation of vascular smooth muscle cells. Most commonly stenosis occurs at the peripheral vein (70%), followed by the AVF anastomosis site and arterial segment of AVF (30%). On clinical examination, AVF stenosis signs can be observed especially if it occurs in the peripheral vein. However accurate diagnosis of fistula stenosis can be made by doppler USG with 93% sensitivity and 60% specificity.³¹ Frequency of AVF stenosis is 10-30% which may rise to 30-70% especially with previous histories of fistula stenotic and thrombotic lesions. A Romanian study that conducted doppler USG on 97 patients, showed the highest prevalence of AVF stenosis (54.6%).³² In contrast, our study showed only 7.1% stenosis. This difference is either due to criteria used for detection of stenosis; this Romanian study used strict criteria that have included even minor degree of stenosis, or due to the lack of agreement on diagnostic criteria of AVF stenosis.³³ AVF stenosis is also an important cause of AR, likewise, our study showed a statistically significant association between stenosis and AR. The main aim of this study was

to check the burden of AVF stenosis and AR, we have not investigated the causes of AR and sites of AVF stenosis.

CONCLUSION

According to this study, AR is a common finding in hemodialysis patients and 11.9% had an unacceptable range of recirculation i.e., more than 10%, which warrants further research into the possible causes. AV fistula stenosis is relatively uncommon present only in 7.1% of patients and it is an important cause of AR.

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

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AUTHORSHIP AND CONTRIBUTION DECLARATION

No.	Author(s) Full Name	Contribution to the paper	Author(s) Signature
1	Shahid Anwar	Design of study, Research paper writer, Final approval.	
2	Shireen Jafar	Data collection.	
3	Mateen Akram	Data analysis.	
4	Sobia Mazhar	Doppler USG data analysis, Manuscript analysis.	
5	Hafiz Tahir Usman	Research coordinator.	
6	Rashad Rasheed	Radiology data collection and coordinator.	