Original Article

Frequency of Access Recirculation in Hemodialysis Dependent Patients

Access Recirculation in Hemodialysis

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ABSTRACT

Objective: The aim of this study was to find out the health of vascular access in our patients focusing on vascular recirculation as a marker of vascular insufficiency.

Study Design: Descriptive cross-sectional study

Place and Duration of Study: This study was conducted at the department of Nephrology Khyber teaching hospital and Khyber medical college Peshawar for a period of six months from 1st January to 1st July 2020.

Materials and Methods: A total of 104 hemodialysis dependent patients of both genders and all ages were randomly selected, utilizing consecutive non-probability sampling technique. Patients on hemodialysis secondary to Acute Kidney Injury were excluded. Prior Approval of synopsis was obtained from the institutional research evaluation and ethical committee. Informed consent was obtained from each patient before data collection.

Results: A total of 104 patients were studied in this study, of which 53 (51.0%) were males. The Mean age of the group was 39.65 years (SD+-13.84). Mean duration of hemodialysis was 18.78 (SD+-12.93) months. Radio-cephalic AV fistula was the commonest access (45.19%) in this cohort, followed by Brachio-cephalic and Brachio-basilic fistulas. Overall, 46 (44.2%) patients were found to have access recirculation in this study which was statistically significant. The factors involved in access recirculation included inappropriate needle placement (n=51, 49%. p=0.001), Venous stenosis (n=5, 4.8%, p=0.015) and different types of AV fistulas.

Conclusion: This study shows that a high percentage of our patients have access recirculation during hemodialysis. Recirculation is significantly associated with inappropriate needle placement and venous stenosis.

Key Words: Dialysis, Hemodialysis, AV fistula, Dialysis catheter, Recirculation

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INTRODUCTION

End Stage Renal disease patients require some form of Renal Replacement Therapy (RRT). This involves either some form of dialysis or renal transplantation. Dialysis can be provided by two major modalities which are Hemodialysis and Peritoneal Dialysis. Hemodialysis is the most commonly employed modality of Renal Replacement Therapy[1].

Vascular access is required to establish a good blood supply to the hemodialysis machine, at an adequate flow rate, to achieve proper dialysis dose. These accesses are commonly in the form of double lumen catheters, arterio-venous fistulas and Polytetrafluoroethylene (PTFE) grafts[2].

Vascular access is the life line of hemodialysis dependent patient. Access related complications are the major cause of morbidity in hemodialysis dependent patients contributing to about 25% hospital admissions and up to 50% of hospitalization costs[3]. Access related problems can result in inadequate blood supply to the hemodialysis machine and thus can substantially reduce the efficiency of dialysis. In a study by SuatUnver, insufficiently functioning AV fistulas were associated with abnormalities of all the patient and dialysis adequacy parameters including serum albumin, hemoglobin, parathyroid hormone levels, and Calcium-Phosphate product[4]. It is proven that inadequate dialysis dose is strongly associated with increased morbidity and mortality of hemodialysis patients[5].

Considering the importance of a properly functioning vascular access for hemodialysis dependent patients, KDOQI guidelines recommend routine monitoring of vascular access for any signs of complications, inadequate functioning and impending failures[6].

Such a strategy can result in early identification of access dysfunction and early salvage in order to prevent the progression to overt access stenosis, thrombosis and

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ultimately failure. Monitoring of hemodialysis access includes measures such as clinical examination, sequential measurements of static and dynamic pressures, access flow rates (detected by Duplex Doppler ultrasound and Thermo-dilution method) and access recirculation measurements (detected by urea based method and ultrasound based thermo-dilution techniques)[6].

Access recirculation is one such measure that has been recommended to assess vascular access related problems. It occurs when the dialyzed and purified blood that exits the venous end of the circuit returns back directly into the arterial line and thus to the dialyzer inlet without ever circulating and equilibrating with the systemic circulation. This reduces the solute delivery to the dialyzer causing a reduction in the solute gradient across the dialyzer membrane which ultimately reduces the efficiency of dialysis[7]. A significantly high percentage of recirculation is a marker of problems with access inflow, fistula stenosis and access outflow as occurs in central venous stenosis[8].

There are two common methods of detection of access recirculation. The first involves Doppler ultrasound based Thermo-dilution technique. The second method is urea based techniques. In an Iranian study by JavadSalimi, 19.6% of dialysis dependent patients had significant access recirculation[7]. Akram et al attempted to study level of recirculation only in patients with Double lumen catheters in Pakistani population in Sheikh Zaid hospital Lahore. They found mean percentage of access recirculation to be about 10.3±6.6% (range from 3.6% to 24.8%) [9]In a study by Rafique et al the mean access recirculation of AV fistulas by urea based 2 needle method was found to be 9.55±6.64%[10]. In another study Anees et al found that Access recirculation was less than 10% in all of their patients[11].

Despite that the access recirculation measurement is now recommended by the guidelines to be performed on all hemodialysis dependent patients regularly, such a practice has not taken roots in our setup. So far only a handful studies on access recirculation have been done in Pakistan.

MATERIALS AND METHODS

This was a descriptive cross-sectional study, conducted over a period of six months, at the department of nephrology Khyber teaching hospital and Khyber medical college Peshawar, with the objective to determine the frequency of patients with significant access recirculation (>10% by urea method) among our maintenance hemodialysis patients.

A total of 104 hemodialysis dependent patients of both genders and all ages were randomly selected, utilizing consecutive non-probability sampling technique. Patients on hemodialysis secondary to Acute Kidney Injury were excluded. Prior Approval of synopsis was obtained from the institutional research evaluation and ethical committee. Informed consent was obtained from each patient before data collection.

After recording baseline biodata, Recirculation was calculated according to the standard technique. The sampling for urea based measurement of recirculation done by the 'two needle method' (all three samples taken from the dialysis circuit without giving extra prick to the patient). Considering the ease of sampling, no extra discomfort to the patient and common availability of laboratories for urea measurement, the two needle urea based technique is considered the most practical approach to determine the access recirculation. While using the urea based method a recirculation value of more than 10% is usually taken as significant and warrants further investigation.[7, 8]

Blood samples were collected 30 minutes after starting hemodialysis and after switching off Ultrafiltration (UF). The first two samples labeled arterial (A) and venous (V) were collected directly from the arterial and the venous limbs of the hemodialysis circuit. Then the blood flow was reduced to 120ml/min for 10 seconds. After which the blood pump was switched off, the arterial line was clamped above the sampling port and the third sample obtained from the arterial port. This third sample was the 'systemic sample' (S). The access recirculation was calculated using the standard formula; AR (%) = (S-A) / (S-V) ×100.

Venous stenosis was assessed considering the clinical signs including arm elevation test, presence of collateral vessels, prolonged bleeding after needle withdrawal, and formation of aneurysms in the venous channel. Similarly, clinical signs of arterial insufficiency were absence of palpable thrill over AV fistula and circuit jerking at blood flows of over 250 ml/min. Needle placement was considered inappropriate when lines were reversed, arterial needle was placed less than 2cm from AV fistula, venous needle was placed at less than 5cm from the arterial needle, and when the two needles were directed inappropriately.

All the data was recorded on prescribed proforma and analyzed as under.

Statistical analysis involved application of appropriate statistical tests according to the types of data, in SPSS software version 23. Age of the patients and dialysis vintage were correlated with recirculation values utilizing Pearson's correlation. Fisher's exact test was used for analysis of associations between recirculation status and independent variables such as gender, venous stenosis, inappropriate needle placement and arterial insufficiency. Two independent sample T-test was applied when comparing recirculation values between subcategories of independent variables. A one-way ANOVA was applied looking at the association of recirculation values with different categories of accesses used for hemodialysis. The association of recirculation reached statistical significance with the

presence of venous stenosis, inappropriate needle placement and different access types. Table 2.

RESULTS

A total of 104 patients were studied in this study, of which 53 (51.0%) were males. The mean age of the group was 39.65 years (SD+-13.84). Mean duration of Hemodialysis was 18.78 (SD+-12.93) months. Values of all other descriptive statistics including urea values of venous, arterial and systemic samples and Recirculation are given in table 1.

Radio-cephalic AV fistula was the commonest access (45.19%) in this cohort, followed by Brachio-cephalic and Brachio-basilic fistulas. Fig 1.

Overall, 46 (44.2%) patients were found to have significant access recirculation in this study. figure 2.

Table No.1: Descriptive Statistics

	N	Min.	Max,	Mean	Std. Deviation
Age of Patients (years)	104	20	70	39.65	13.841
Duration of Hemodialysis (months)	104	1	72	18.78	12.938
Arterial Urea (mg/dl)	104	52	204	123.27	38.859
Venous Urea (mg/dl)	104	6	58	24.54	13.814
Systemic Urea (mg/dl)	104	54	211	134.45	39.855
Recirculation (%)	104	1.69	37.50	10.9988	6.30922
Valid N (listwise)	104				

Table No.2. Inferential Statitics

	Recirculation status	Recirculation Values
		Pearson's correlation
Age of patients (years)		Correlation coefficient= -0.22. P=0.826
Dialysis Vintage (moths)		Correlation coefficient= 0.097. P=0.325
	Fisher's exact test	T-test (2 sample)
Gender	Males=53 (51.0%). p=0.693.	p=0.842 (95%CI=-2.71—2.21).
Venous stenosis	n=5 (4.8%). p=0.015.	p=0.014 (95%CI= - 8.769 — -1.444).
Inappropriate needle placement	n=51 (49%). p=0.001.	p=0.034 (95%CI= -5.033 — -0.202).
Arterial insufficiency	n=13 (12.5%). p=0.236.	p=0.146 (95%CI= -6.41 — 0.963).
	Fisher's exact test	ONE WAY ANOVA.
Different types of access	p=0.048.	P=0.006

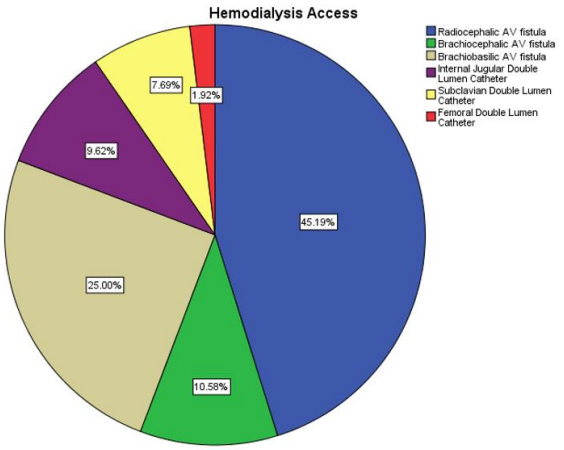

Figure No.1: Hemodialysis Access

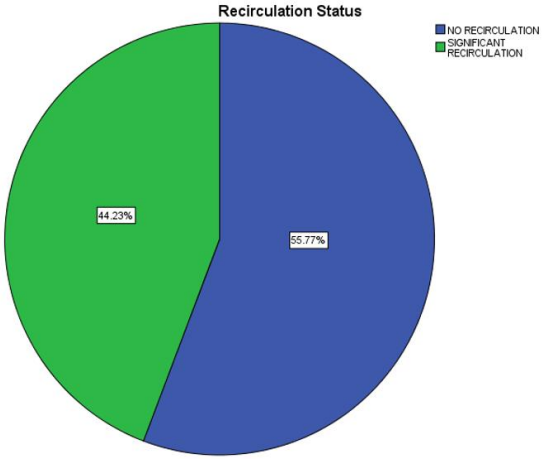

Figure No.2: Recirculation Status

DISCUSSION

Access recirculation can be assessed by multiple methods including ultrasound dilution (transonic device), hematocrit dilution (Crit-line monitor), and differential conductivity (Gambro hemodynamic monitor)[12]. Limited by the availability of expertise and equipment, we chose the conventional urea based method.

The mean value of recirculation was 10.99%, and overall, 44.2% patients were recorded to have significant access recirculation in our study. Literature search reveals a wide pattern of results in different populations. In a study conducted at Sheikh Zayed hospital Lahore, patients undergoing hemodialysis through double lumen catheters had a mean recirculation of 10.3±6.64 %[9]. Another study conducted

at the same institute estimated the mean access recirculation to be around 9.55 ± 6.64%[10]. Both these studies show results similar to our data, however, neither of these studies reported the percentage of patients having significant recirculation. Studies from Iran showed significant access recirculation in around 17% patients with the most common cause being inappropriate needle placement[13,14]. A study from Dhaka produced similar results to our findings with mean recirculation of 8.1 +/- 5.5% (Range 0-66%), and improper needle placement as the most important responsible factor[15]. An international Study estimated recirculation rates ranging from 18 +/- 4% in radial fistulas and 11 +/- 3% in more proximal fistulas[16].

Important factors that cause access recirculation are:

- Improperly placed needles.
- Central or proximal venous obstruction.
- Arterial insufficiency.

In our study the relationship of recirculation was not statistically significant with Age of patients, Dialysis Vintage, Gender and clinical impression of arterial insufficiency. However, access recirculation was found to be significantly associated with the presence of venous stenosis, inappropriate needle placement and different types of access. We found inappropriate needle placement in nearly half of all the cases, by far the commonest cause followed by arterial insufficiency and venous stenosis. These factors are well established, and our study is in concordance with the current literature[17]. Needle placement is the most important factor in determining the access recirculation during hemodialysis. We reviewed an interesting study comparing the recirculation with different patterns of needle cannulation. In this study, recirculation was lowest (8.51 +/- 4.90%) when the needles were placed in the recommended fashion (in opposite directions and 5 cm apart), while it was the highest (20.68 +/- 4.92%) when needles were placed in a single direction, less than 5cm apart. Other patterns of needle placement gave intermediate results[18]. Venous stenosis, producing reverse flow of blood in the veins, is also a frequent underlying cause of recirculation[8]. Arterial insufficiency is an important contributor to access recirculation especially when the access blood flow rate becomes less than the dialyzer blood flow rate suggesting a marked blood flow impairment[19, 20].

Recirculation is not just limited to AV fistulas, but is also observed in patients with temporary or tunneled double lumen catheters. Different sites of double lumen catheters also give different rates of recirculation with internal jugular line giving the least amount of recirculation (2.38 +/- 1.09%), followed by subclavian catheters (3.03 +/- 3.15%) and lastly Femoral lines (9 +/- 6.56%)[21,22]. At any site, the reversal of lines results in a higher value of recirculation, although the dialysis dose may still increase with increasing blood flow rates[23]. Tunneled catheters may similarly show recirculation, which increases with line reversal.[24]

In addition to causing a reduction in the delivered dose of hemodialysis, access recirculation is also considered to be an important clinical marker of AV fistula dysfunction. Research has shown recirculation status to be an important predictor of the need for Av fistula revision if blood flow is found to be < 500ml/min[25]. One study suggested that nearly one quarter of patients with significant access recirculation needed intervention or access revision for vascular access dysfunction[26]. It is therefore recommended that recirculation be measured at regular intervals in all patients on hemodialysis. This is however not practiced in our setup. We find that a significant proportion of our patients have access recirculation. Further study is needed to identify and correct the underlying cause. Considering inappropriate needle placement as the most common cause, we propose re-evaluation and training of dialysis technicians regarding appropriate needle placement. Furthermore, formal assessment of venous and arterial limbs must be undertaken in all patients with access recirculation to identify patients with impending access dysfunction.

CONCLUSION

This study shows that a significant percentage of our patients have access recirculation during hemodialysis, which can be predicted to reduce the efficiency of hemodialysis. Recirculation is significantly associated with inappropriate needle placement and venous stenosis.

There is a need to ascertain and correct the underlying causes of recirculation, to improve the efficiency of hemodialysis and ultimately patient well-being.

Author's Contribution:

Concept & Design of Study:	Farman Ullah
Drafting:	Irfan Mirza, Mufti Baleegh-ur-Raheem Mahmood
Data Analysis:	Ahmed Zeb Khan, Mufti Baleegh-ur-Raheem Mahmood
Revisiting Critically:	Farman Ullah, Irfan Mirza
Final Approval of version:	Farman Ullah

Conflict of Interest: The study has no conflict of interest to declare by any author.

REFERENCES

1. Kalantar-Zadeh K, et al. Renal Replacement Therapy and Incremental Hemodialysis for Veterans with Advanced Chronic Kidney Disease. Seminars in dialysis 2017;30:251–261.

2. Roy-Chaudhury P, Sukhatme VP, Cheung AK. Hemodialysis Vascular Access Dysfunction: A Cellular and Molecular Viewpoint. J Am Society Nephrol 2006;17**:**1112–1127.
3. Schwab SJ. Vascular access for hemodialysis. Kidney International 1999**;55:**2078–2090.
4. Unver S, Atasoyu EM, Evrenkaya TR. Effects of comorbidity from AV fistula insufficiency on fistula blood flow rate in hemodialysis patients. Dialysis Transplantation 2006;35:682–688.
5. Hakim RM, Breyer J, Ismail N, Schulman G. Effects of Dose of Dialysis on Morbidity and Mortality. Am J Kid Diseases 1994;23**:**661–669.
6. Lok CE, et al. KDOQI Clinical Practice Guideline for Vascular Access: 2019 Update. Am J Kid Dis 2020;**75:** S1–S164.
7. Salimi J, et al. Predicting hemodialysis access failure with the measurement of dialysis access recirculation. Saudi J kidney diseases and transplantation : an official publication of the Saudi Center for Organ Transplantation, Saudi Arabia 2008;19**:**781–4.
8. Zeraati A, BeladiMousavi SS, BeladiMousavi M. A Review Article: Access Recirculation Among End Stage Renal Disease Patients Undergoing Maintenance Hemodialysis. Nephro-Urol Monthly 2013;**5:**728–32.
9. Akram M, Abbas G. Double Lumen Catheters. Profess Med J 2011;18**:**470–474.
10. Rafique Z, Abbas G, Shafi T. Comparison of arteriovenous fistula recirculation by thermo-dilution and urea-based method. Journal of the College of Physicians and Surgeons--Pakistan: JCPSP 2007; 17:603–606.
11. Adequacy of Hemodialysis. J Coll Physicians Surg Pak 2002;12**:**692–5.
12. Lindsay RM, et al. A Comparison of Methods for the Measurement of Hemodialysis Access Recirculation and Access Blood Flow Rate. ASAIO J 1998;44**:**54.
13. Beladi MS, Tavazoe M, Hayati F, Sametzadeh M. Arterio-Venous fistula recirculation in hemodialysis: causes and prevalences 2010.
14. Hayati F, Shayanpour S, Faramarzi M. Access Recirculation in Hemodialysis. Shiraz E Med J 2015;16.
15. Mahbub T, et al. Factors responsible for increased percent recirculation in arterio-venous fistula among the haemodialysis patients. Bangladesh Med Research Council Bulletin 2013**;**39:28–33.
16. Collins DM, et al. Fistula dysfunction: Effect on rapid hemodialysis. Kidney Int 1992;41:1292–1296.
17. Kalinin R, Suchkov I, Egorov A, Klimentova E. Recirculation syndrome in hemodialysis patients. Khirurgiia 2019;24—28.
18. Dias TS, Neto MM, Cardeal da Costa JA. Arteriovenous Fistula Puncture: An Essential Factor for Hemodialysis Efficiency. Renal Failure 2008;30:870–876.
19. Besarab A, Sherman R. The relationship of recirculation to access blood flow. Am J Kid Diseases 1997;29: 223–229.
20. Daniels ID, Berlyne GM, Barth RH. Blood Flow Rate and Access Recirculation in Hemodialysis. Int J Artificial Organs 1992;15**:**470–474.
21. Sefer S, Kes P, Degoricija V, Heinrich B, Vrsalović M. Recirculation of urea and dialysis efficiency using dual-lumen dialysis catheters in various locations: may the venous lumen of the catheter be used as the arterial lumen and vice versa? Lijecnickivjesnik 2003;125:1–5.
22. Leblanc M, Fedak S, Mokris G, Paganini EP. Blood recirculation in temporary central catheters for acute hemodialysis. Clin Nephrol 1996;45**:** 315–9.
23. Kousoula V, et al. Reversed connection of cuffed, tunneled, dual-lumen catheters with increased blood flow rate maintains the adequacy of delivered dialysis despite the higher access recirculation. Int Urol Nephrol 2019;51**:**1841–1847.
24. Sencal L, Saint-Sauveur E, Leblanc M. Blood Flow and Recirculation Rates in Tunneled Hemodialysis Catheters. ASAIO J 2004;50**:**94–97.
25. Wang E, Schneditz D, Ronco C, Levin NW. Surveillance of Fistula Function by Frequent Recirculation Measurements During High Efficiency Dialysis. ASAIO J 2002;48**:**394–397.
26. Vega A, et al. Comparison of urea recirculation and thermodilution for monitoring of vascular access in patients undergoing hemodialysis. J Vascular Access 2018;19:283–290.