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**Arterio-Venous Fistula Recirculation in Hemodialysis:
Causes and Prevalences.**

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Abstract:

Introduction: The measurement of Arterio-Venous (A-V) Fistula Recirculation has important diagnostic implications because the efficiency of haemodialysis (HD) may be limited, resulting in dialysis delivery being less than that prescribed. The purpose of the study is to determine its prevalence and causes in our HD patients.

Methods and Materials: We randomly selected 100 end stage renal disease patients with A-V fistula that they were on HD more than 3 months. The degree of recirculation was also measured with Urea based two needle technique method. For each patient distances between arterial and venous and distances of needles from fistula and its directions was recorded. Echocardiography and A-V fistula Color Doppler Ultrasound were also performed.

Results: Blood flow rate and dialysate flow rate were 300 mL/min and 500 mL/min respectively. The prevalence of A-V fistula recirculation was 17% (17patients). Average degree of recirculation between these patients was 9.56 ± 2.32 %. The most common cause was misplacement and or misdirection of needles (17 patients). The second cause was heart failure with Ejection Fraction > 40% (8 patients). No difference was seen between diabetic versus non diabetic (P =0.28) and hypertensive versus normotensive (P =0.21%) HD patients.

Conclusions: A-V fistula recirculation is common occurrence in HD patients and the most common cause of recirculation is misplacement and or misdirection of needles so we should have more emphasis on education and training of HD staffs.

Keywords: A-V Fistula, Recirculation, Haemodialysis, End Stage Renal Disease.

Introduction:

End stage renal disease (ESRD) is one of the most common life-threatening diseases. The number of patients accepted for renal replacement therapy including hemodialysis (HD), peritoneal dialysis, and kidney transplantation in developed and developing countries increases each year and imposes a major social and economic burden on these communities.⁽¹⁾ Although the life expectancy of patients with ESRD has improved since the introduction of dialysis in the 1960s, it is still far below that of the general population. As an example, one, three, and five-year survival of ESRD patients on HD in a study from Iran is 89.2%, 69.2%, and 46.8%, respectively.⁽²⁾ In addition, the mean life span at age 49 in the United States is 33 years in the general population but only approximately seven years in patients receiving maintenance dialysis.⁽³⁾ Some factors affect on the survival of ESRD patients include inadequate dialysis, method of renal replacement therapy, etiology of renal failure and the presence of comorbid disease.^(4, 5, 6, 7)

It is well established that one of cause of inadequate dialysis in HD patients is arterio-venous (A-V) fistula access recirculation (AR). Hemodialysis AR is diagnosed when dialyzed blood returning through the venous side reenters the dialyzer through the arterial needle, rather than returning to the systemic circulation and as a result, the efficiency of HD is reduced.⁽⁸⁾ Thus the aim of the study was to investigate the prevalence and causes of A-V fistula recirculation in HD patients in Ahvaz city, Iran.

Subjects and Methods:

From February 2009 to August 2009, this cross sectional study was conducted on adult ESRD patients in HD centers of Emam Khomini and Golestan hospital in Ahvaz city, Iran.

The ESRD was defined as permanent and irreversible loss of renal function requiring renal replacement therapy.

HD was performed for 9-12 h, three times a week, using semi-synthetic (cellulose diacetate), or synthetic (polysulfone) dialyzer membranes, and bicarbonate-based dialysate at a delivered bicarbonate concentration of 35 mEq/L. Blood flow rate was maintained at 25-350 mL/min, and the dialysate flow rate at 500 mL/min.

A standardized questionnaire was used to collect demographic data, cause of ESRD, the date of HD onset, the type of access for HD, the date of creation and use of A-V fistula and history of a kidney transplant.

At beginning of the study, blood flow rate and dialysate flow rate were maintained 300 mL/min and 500 mL/min respectively. Then the degree of recirculation was measured with Urea based two needle method from the following formula⁽⁹⁾: Percent recirculation = $([P - A] \div [P - V]) \times 100$

Where P, A, and V refer to the urea concentrations in the peripheral blood, predialyzer arterial line, and postdialyzer venous circuit, respectively

The following protocol was used for blood sampling.

1-The ultrafiltration was turned off approximately 30 minutes after the initiation of HD and then arterial and venous line samples (A and V in the above formula) were obtained.

2- Access blood flow was reduced to 50 mL/min and 15 to 30 seconds later, the systemic blood sample (P in the above formula) from the arterial blood line was obtained (two-needle" techniques).

The measurements of all blood samples were made in one laboratory.

The patients were divided into two groups, group 1 patients without recirculation and group 2 patients with recirculation.

For each patient distances between arterial and venous needles and distances of needles from A-V fistula and its directions was recorded. Echocardiography and A-V fistula Color Doppler Ultrasound were also performed.

The findings were analyzed by SPSS statistical program. Chi square test or Fisher Exact test were used for qualitative data. For two group's quantitative data, the means were compared by using student's t test. Association between risk factors and recirculation rate was evaluated by COX regression model. Statistical significance was assessed at the 0.05 probability level in all analyses.

Results:

Overall, One hundred thirty eight patients 81 male (58.69%) and 57 female (41.30%) were on HD therapy in our centers. From them, One hundred patients have an A-V fistula and they were on HD more than three months that they enrolled for the study.

Mean age of patients was 54.7 ± 15 yr (range of 16 yr to 75 yr), male 55.9 ± 15.2 yr and female 52.9 ± 14.7 yr.

Causes of ESRD of our patients included high blood pressure in 41 patients (29.71%), diabetes mellitus in 30 pa-

tients (21.73%), glomeronephritis in 14 patients (10.14%), obstructive uropathy in 10 patients (7.24%), polycystic kidney in 9 patients (6.52%), and unknown in 34 patients (24.63%).

The number of HD patients with A-V fistula recirculation (group 2) was 17 people (17%). Average degree of recirculation between these patients was 9.56 ± 2.32 percent.

There was no statistically difference in the recirculation between diabetic versus non diabetic ($P = 0.28$) and hypertensive versus normotensive ($P = 0.21\%$) HD patients.

The distances between arterial and venous needles in group 1 and group 2 were 5.93 ± 2.89 cm and 12.47 ± 3.48 cm respectively. In addition, improper arterial and venous needle placement was seen in all patients in group 2, but it was not seen in any group 1 patients. It represents that there is a significant association between distances of needles ($P=0.002$) and improper needle placement ($P=0.000$) with degree of recirculation.

The average time between creation and use of A-V fistula in group 1 and 2 were 90 ± 22 days and 40 ± 15 days. There were also a significant difference between them ($P=0.04$).

The length of time of A-V fistula use was 26.59 ± 9.37 months in group 1 and 33.20 ± 7.35 months in group 2. There also was a significant association ($p=0.001$)

The A-V fistula flow rate in Color Doppler Ultrasound was 400-500 mill/min in 4 patients, 500-1000 mill/min in 72 patients, 1000-1600 mill/min in 19 patients and more than 1600 mill/min in 5 patients. The mean A-V fistula flow rate in

both groups was more than 400 ml/min (in group 1, 1229.41 ± 753.96 mill/min and in group 2, 653.33 ± 209.98 mill/min). The mean A-V fistula flow rate was significantly higher in group 1 ($p = 0.001$).

In echocardiography, 8 patients have heart failure with Left Ventricular Ejection Fraction (LVEF) $<40\%$, that all of them were in group 2. The average LVEF in group 1 was $46.76 \pm 5.57\%$ and in group 2 was 32.67 ± 7.52 . There also was a significant association ($p=0.002$).

Discussion:

The measurement of A-V Fistula Recirculation in HD patients is an important issue, since it appears to be an important cause of inadequate HD. In addition, some clinical guidelines are suggested regular monitoring of HD vascular access by methods such as vascular access recirculation for early detection and correction of access dysfunction.⁽¹⁰⁾ An accurate assessment of access fistula recirculation can be made by urea-based method as the same as the present study and non-urea-based techniques by ultrasound dilution technique, conductivity, or potassium-based dilutional method.^(11, 12, 13) In urea-based method, it's usually measured by comparing the systemic and dialyzer inlet blood urea concentration. Urea concentration in blood entering the dialyzer (A in the above formula) is assumed to be equal to the systemic urea concentration (P in the above formula) if there is no recirculation.

There are different protocols for systemic blood urea sampling in the urea-based method measurement of access recirculation. In the three-needle or traditional

method, the systemic urea concentration has been obtained from a peripheral vein in the contralateral arm. However, it is now recognized that this approach is inaccurate and tends to overestimate access recirculation because the BUN obtained from a peripheral vein is often higher than the BUN in the blood entering the dialyzer inlet, even in the absence of recirculation.⁽¹⁴⁾

Two factors contribute to this problem: Cardiopulmonary recirculation and venovenous disequilibrium.^(15, 16, 17) Thus three-needle method dose not routinely use due to its requirement for additional venipuncture, unpredictable manner, and overestimation of access recirculation. Sampling peripheral arterial blood eliminates the effects of both cardiopulmonary recirculation and venovenous disequilibrium. However arterial puncture during HD is not also practical and does not recommended.

Preferred alternatives to the peripheral vein or three-needle method and arterial puncture is two needle technique as same as use in the present study. In the study, systemic urea concentration is obtained from the dialyzer blood inlet line after slowing the blood pump to 50 mL/min for about 30 seconds (P in the above formula).⁽¹⁸⁾ This "two-needle" technique as opposed to the use of three needles are presumably more accurate for the determination of access recirculation.⁽¹⁹⁾

In our study, the average degree of A-V fistula recirculation was 9.56 ± 2.32 percent and it was almost similar to findings of salimi et al in 2008, Bay et al in 1998, Besarab et al in 1997. These groups used two needle technique urea-based method as same as present study for measure-

ment of recirculation. The average degree of recirculation in these groups were 8.7%, $11.8 \pm 9.9\%$ and $5.5 \pm 0.8\%$ respectively.^(20, 21, 22)

Depner et al have measured recirculation by ultrasound dilution technique and they reported recirculation rate of 8.82% during 34 HD session in 28 patients.⁽²³⁾

The most common causes of A-V fistula recirculation in HD patients are the presence of high-grade venous stenoses, improper needle placement, inadequate arterial inflow and congestive heart failure.^(24, 25)

Moderate to severe venous stenoses can obstruct or restrict venous outflow from A-V fistula and as a result some dialyzed blood reenters to the dialytic circuit through the arterial needle for some times, thereby blood entering the dialyzer can become diluted with blood that has just left the dialyzer. Thus it can reduce the effective clearance obtained in the course of a dialysis session.

Backflow or recirculation may increase with improper needle placement.⁽²⁵⁾

Close proximity and or misdirection of needles will increase the reentry of dialyzed blood into the arterial needle. Unfortunately, the role of misplacement of needles in recirculation, usually ignore but according to the present study it was the most common source of recirculation. Some other centers have also reported that improper needle placement is a common source. Schneditz, for example, reported that improper needle placement is a common cause of A-V fistula recirculation, even after such placement had been previously recognized.⁽²⁵⁾

Therefore we should have more emphasis on specific training and education of HD nursing staffs. HD staffs should also

know anatomy and physiology of A-V fistula and A-V fistula recirculation.

On the other hand, access recirculation can also be facilitated by inadequate arterial inflow.⁽²⁴⁾ In this setting, backflow from the venous side of the access is necessary to support the dialytic blood flow rate set by the blood pump. It appears that inadequate arterial inflow was not a cause in our study because although A-V fistula flow rate was between 400- 500ml/min in four patients, dialytic blood flow rate was lower and it was maintained at 300 mill/min.

According to current protocol fistulography should be performed if recirculation is greater than 10% by two-needle urea-based method or 5% using non-urea method.⁽²⁶⁾ However we didn't perform this protocol, because the most common cause of recirculation in our patients was misplacement and or misdirection of needles and Color Doppler Ultrasound didn't show a significant stenosis in both groups.

Conclusions:

The measurement of A-V Fistula Recirculation has important diagnostic implications in HD patients because it is an important cause of inadequate dialysis. According to the study it was a common occurrence. Although, the role of improper arterial and venous needles placement in recirculation usually ignore, it was the most common cause in our HD patients. Therefore we should have more emphasis on education and training of HD staffs.

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