Original Article

# Relationship between the filter type and blood flow rate and, dialysis adequacy in hemodialysis patients

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## Abstract

**Context:** One of the main factors associated with the death of chronic renal failure patients is dialysis adequacy.

**Aims:** The present study aimed to investigate the relationship between filter type and blood flow rate with dialysis adequacy in hemodialysis patients referring to educational hospitals of Mazandaran University of Medical Sciences in 2016.

**Setting and Design:** This correlational study was performed in 2016 in educational hospitals of Mazandaran University of Medical Sciences.

**Materials and Methods:** This study was performed on 185 hemodialysis patients. Sampling was done using simple random sampling. The inclusion criteria included at least 6 months of hemodialysis history and two sessions of dialysis per week. Demographic data, as well as information on the filter type and blood flow rate, were collected using a questionnaire. Dialysis adequacy is generally measurable by two methods of urea reduction ratio (URR) and K or urea clearance, T or time of dialysis, and V, or volume of urea distribution in the body (KT/V) (K or urea clearance).

**Statistical Analysis Used:** Data were described with mean, standard deviation, and frequency and analyzed using Chi-square and Fisher's exact tests.

**Results:** Out of a total of 185 patients, 101 patients were male and 84 were female, with a mean age of 57.2 ± 0.7 years. The dialysis adequacy in high-flux and low-flux filters was, respectively, 79% and 1.5% based on the KT/V index and 70.6% and 0% according to the URR index. A statistically significant relationship was found between the filter type and blood flow rate with both KT/V and URR criteria ($P < 0.001$).

**Conclusion:** It is recommended to use high-flux filters with high blood flow rate to improve dialysis adequacy in patients with hemodialysis. However, other factors affecting dialysis adequacy should be considered.

**Keywords:** Blood flow rate, Dialysis adequacy, Filter type, Hemodialysis patients

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## INTRODUCTION

Chronic renal failure is a progressive and irreversible degeneration of renal function, the main treatment of which is renal transplantation. However, patients should be hemodialized at the time of waiting for the transplant.[1,2] The incidence of chronic kidney failure in the world is 260 cases in 1 million and is increased 6% annually.[3] It is estimated that, by the year 2030, the number of people requiring dialysis will reach more than 2 million.[4] In Iran, the average growth rate of nephritic patients requiring hemodialysis is higher than the global average and by the end of June 2015, there were 24,000 hemodialysis patients in the whole country.[5] Chronic renal failure and its therapeutic methods, including hemodialysis, affect lifestyle, health status, and the role of an individual in the community and, in the long run, reduce the quality of life and physical and psychological problems.[6] Although the use of medical and hemodialysis progress prolongs the lives of people with chronic kidney disease, the mortality rate in this disease is significantly higher.[7,8] One of the main factors associated with the death of chronic renal failure patients is the dialysis adequacy.[3] Dialysis adequacy is generally measurable by two methods of urea reduction ratio (URR) and K or urea clearance, T or time of dialysis, and V, or volume of urea distribution in the body (KT/V)[3] so that KT/V is ≥1.2 and the URR is ≥65%, meaning appropriate dialysis adequacy.[9] Dialysis adequacy is one of the most important goals of hemodialysis, which has a great influence on the prognosis of hemodialysis patients.[10] Therefore, identifying the factors affecting dialysis adequacy such as filter type, blood flow velocity, and increased dialysis time is very crucial.[11-13] Increasing the dialysis time is an important method for increasing KT/V, but is not economically feasible in many cases.[14] The hemodialysis basis is the removal of waste materials through the passage of blood from semi-permeable membranes. The filters available for this purpose include two types, namely, low-flux filters based on low-permeability dialyzer and high-flux filters that have noncellulose membranes with higher permeability than low-flux filters. Therefore, the filter type plays a key role in the dialysis adequacy and the mortality rate of dialysis patients.[15] Although the results of some studies indicate that high-flux filters are effective in dialysis,[11,16] some other studies have not reported significant correlations.[3,17] Given the different results of studies in this field and also increasing number of patients requiring hemodialysis and its complications and effects, the present study aims to determine the relationship between the filter type used and blood flow rate and dialysis adequacy of patients referring to training hospitals of Mazandaran University of Medical Sciences in 2016.

## MATERIALS AND METHODS

This study was part of the thesis titled, "The relationship between dialysis adequacy with depression, anxiety and well-being in hemodialysis patients in the teaching hospital of Mazandaran University of Medical Sciences in 2016" that as a correlational study was conducted in Emam Khomeini Hospital, Sari, Mazandaran Heart Center, and Razi Hospital, Qaemshahr, after obtaining approval from the Ethics Research Committee of Mazandaran University of Medical Sciences in 2016 (IR.MAZUMS.REC.95-2125). The sample size (185) was obtained by using the overall rate of physiological problems, which was estimated by using the results of Ahmadzadeh and Mehdi's study ($P = 0.69$, $\alpha = 0.05$, and $d = 0.07$).[18] For sampling, the total volume of the sample was divided by weight according to the size of the patients covered by each of the three hospitals, and then the samples were selected according to the list of regulations by using a random number table. The inclusion criteria were at least 6 months of hemodialysis history, at least two sessions of dialysis per week, full consciousness, ability to speak, and nonguest appearances for dialysis. In addition, patients with complications such as muscle cramps, respiratory distress, decreased consciousness, seizure and acute coronary syndrome, or those who had to stop premature hemodialysis for any reason during hemodialysis were excluded from the study.

Blood urea nitrogen and creatinine tests were measured by Pars test kits made in Iran at the recruitment centers. To prepare the sample before dialysis, blood samples were taken from the arterial pathway after the dialysis needles were inserted, and it was cared to remove heparin or normal saline from the arterial pathway prior to sampling. At the end of the dialysis, to prevent re-circulation, 2 min prior to the sampling, the machine's round rate was set at 50 ml/min, and sampling was done after 30 s through the arterial route (before the filter). Dialysis adequacy was measured with two URR and KT/V (dialyzer clearance of urea, dialysis time/volume of distribution of urea) indices. To determine the dialysis adequacy based on the KT/V index, we used the Diagrass 12 formula as follows: $KT/V = -LN (R - 0/008 \times T) + (4 - 3/5 R) \times UF/W$ and $URR = (BUN_{pre} - BUN_{post})/BUN_{pre}$ to determine UUR. After measuring the dialysis adequacy using two URR and KT/V indicators, each of these two indicators was transformed to a two-mode qualitative variable in the form of URR <1.2 (unfavorable), URR >1.2 (favorable),

KT/V <0.65 (unfavorable), and KT/V >0.65 (favorable).[19] Demographic data, as well as information about the duration of hemodialysis treatment, the frequency of hemodialysis per week, the duration of dialysis per session, the filter type, and blood flow rate, were collected using the personal characteristics and demographic questionnaire. The blood flow rate was divided into three categories of <200, 200–250, and >250.[20] The blood flow rate was considered the same throughout each session.

The participants were assured that the information will remain confidential and can be discontinued at any stage of the study. The materials, tools, and methods of invasion that cause physical or mental harm were not used.

Data analysis was performed using Stata version 12 software (college station, Texas 77845, USA). To describe the qualitative variables, frequency was used and to describe quantitative variables, mean and standard deviation were used. Chi-square test and Fisher's exact test were used to evaluate the relationship between the dialysis adequacy with the filter type and blood flow rate after the dialysis adequacy variable (URR, KT/V) was converted into a two-mode qualitative variable. In this study, the significance level was considered <0.05.

## RESULTS

In general, 185 patients with chronic renal failure under hemodialysis (including 101 males and 84 females) were assessed in this study. The age ranged from 38 to 89 years, with an average age of 57.2 ± 0.7 years. In terms of demographic variables, most of the patients were married, were homemakers, had income more than 2 million Tomans, and were illiterate [Table 1]. The mean duration of dialysis was 2.95 ± 0.15 years. The duration of dialysis in each session in 94% of the patients was 4 h and in 6% of the patients, it was 3 h. The frequency of hemodialysis per week in 74% of the patients was three sessions and in 26%, it was two sessions.

Table 2 summarizes the mean of the dialysis adequacy indicators of KT/V and URR on the basis of the blood flow velocity. According to this table, the highest mean of dialysis adequacy with both KT/V and URR indicators was associated with blood flow rate of >250 ml/min [Table 2].

According to the KT/V criterion and URR, in high-flux filters, most patients had favorable dialysis quality, whereas majority of patients with low-flux filters had unfavorable dialysis adequacy [Table 3]. In addition, blood flow rate was associated with favorable optimal dialysis adequacy, as at a blood flow rate of 200≥ ml/min, the greater rate of patients had unfavorable dialysis quality, whereas most of the patients with a blood flow rate >250 ml/min had favorable dialysis quality. Chi-square and Fisher's exact tests showed a statistically significant relationship between filter type and blood flow rate and dialysis adequacy (KT/V and URR) [Table 3].

**Table 1: Demographic characteristics of hemodialysis patients referring to educational hospitals of Mazandaran University of Medical Sciences in 2016**

| Variable | Category of variables | *n* (%) |
|---|---|---|
| Sex | Male | 101 (54.6) |
| | Female | 84 (45.4) |
| Marital status | Single | 23 (12.4) |
| | Married | 85 (45.9) |
| | Divorced | 41 (22.2) |
| | Widow | 36 (19.5) |
| Occupation | Homemaker | 84 (45.4) |
| | Employee | 49 (26.5) |
| | Informal | 23 (12.4) |
| | Retired | 29 (15.6) |
| Habitat | Urban | 100 (54.1) |
| | Rural | 85 (45.9) |
| Education | Illiterate | 55 (29.7) |
| | Under diploma | 46 (24.9) |
| | Diploma | 20 (10.8) |
| | Associate degree | 23 (12.4) |
| | Undergraduate | 29 (15.7) |
| | Postgraduate | 12 (6.5) |
| Monthly income | Under 1 million Toman | 55 (29.6) |
| | 1-1.5 million Toman | 27 (14.5) |
| | 1.5-2 million Toman | 36 (19.4) |
| | >2 million Toman | 67 (36) |

## DISCUSSION

According to the results of this study, the mean KT/V and URR in patients using high-flux filters were higher than those using low-flux filters. The mean dialysis adequacy of KT/V and URR also increased with increasing blood flow velocity. Desirable dialysis adequacy ratio in patients using high-flux filters as well as in people with high blood flow rate was higher. Hence, the difference of ratios was statistically significant. The results of this study showed that there is a significant relationship between filter type and dialysis adequacy so that most people using high-flux filters had KT/V >1.2 and URR <0.65. The results of the study conducted by a study in Iran showed that about 60% of patients using low-flux filters and 80% of patients using high-flux filters had sufficient dialysis adequacy (KT/V of >1.2), but this difference was not statistically significant, which is not consistent with the results of the present study.[3] In another study., there was no significant relationship between the filter type and the dialysis adequacy.[17] The inconsistency between the results of the above studies may be due to the higher sample size in the present study. The results of the study conducted

**Table 2: Mean and standard deviation of Kt/V and urea reduction ratio based on blood flow rate in hemodialysis patients**

| Variable | Variable levels | Kt/V*, mean±SD | *P* | URR, mean±SD | *P* |
|---|---|---|---|---|---|
| Blood flow rate (ml/min) | ≥200 | 0.98±0.02 | <0.001 | 0.56±0.005 | <0.001 |
| | 200-250 | 1.15±0.014 | | 0.63±0.011 | |
| | >250 | 1.72±0.03 | | 0.7±0.005 | |

*Dialyzer clearance of urea, dialysis time, volume of distribution of urea. URR: Urea reduction ratio, SD: Standard deviation

**Table 3: The relationship between blood flow and filter type with dialysis adequacy based on Kt/V and urea reduction ratio in hemodialysis patients**

| Variable | Variable level | Kt/V*, *n* (%) | | URR, *n* (%) | | Kt/V | | URR | |
|---|---|---|---|---|---|---|---|---|---|
| | | 1.2< unfavorable | ≥1.2, favorable | 0.65, unfavorable | ≥0.65, favorable | *P* | Pearson's $\chi^2$ | *P* | Pearson's $\chi^2$ |
| Filter type | High flux | 25 (21) | 94 (79) | 35 (29.4) | 84 (70.6) | <0.001 | 102 | <0.001 | 85.3 |
| | Low flux | 65 (98.5) | 1 (1.5) | 66 (100) | 0 | | | | |
| Blood flow rate | ≤200 | 75 (96.1) | 3 (3.9) | 77 (98.7) | 1 (1.3) | <0.001 | 158 | <0.001 | 135.7 |
| | 201-250 | 15 (51.7) | 14 (48.3) | 23 (79.3) | 6 (20.7) | | | | |
| | >250 | 0 | 78 (100) | 1 (1.3) | 77 (98.7) | | | | |

*Dialyzer clearance of urea, dialysis time, volume of distribution of urea. URR: Urea reduction ratio

in Italy, consistent with the results of the present study, showed that mean KT/V with high-flux filter was 1.42 and that with low-flux filter was 1.07.[16] In a study to assess and evaluate the dialysis adequacy in patients using high-flux filters based on KT/V criteria, it was reported that 40% of dialysis patients had desirable and 50% had completely desirable dialysis,[11] which was consistent with the results of the present study. Increasing the dialysis adequacy in high-flux filters can be due to the fact that the blood flow rate in this filter type increases to 400–500 ml/min such that this increase can be associated with increased dialysis adequacy.[16,17,21] In this study, there was a significant relationship between blood flow rate and dialysis adequacy. The results of the studies, consistent with the results of the present study, showed that increased blood flow rate can increase the dialysis adequacy.[14,22] A study found that an increase of 15%–20% in blood flow was associated with an increase in dialysis adequacy.[23] However, the factors such as patient tolerance, attention to hemodynamic changes in the patient, the use of filters proportional with the patient's weight, and appropriate blood flow rate should be considered because excessive increase in blood flow rate does not significantly increase urea removal.[24] According to that, there were three different dialysis devices in these hospitals, patients used different devices for dialysis, and it would be better to use one dialysis device for all patients during the study.

## CONCLUSION

According to the results of this study, the filter type and blood flow rate are the factors that affect the dialysis adequacy; therefore, it is recommended to use high-flux filters in order to increase the dialysis adequacy in hemodialysis patients. In addition, increasing the blood flow rate can also increase the desirable dialysis adequacy. Because excessive blood flow rate does not significantly increase urea removal, in order to improve the dialysis adequacy, it is recommended to consider other factors that can affect the dialysis adequacy, such as the filter type, blood pressure before and after dialysis, how to access the vessels, for injection direction of arterial needle and venous needle, blood type, and dialysis time for each session in addition to increasing the blood flow rate and the filter type.

### Conflicts of interest

There are no conflicts of interest.

### Authors' contribution

All authors contributed to this research.

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