Original Article

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

Mohsen Nezami Ghale Noee[1], Jalil Hasani[2], Saeed Erfanpoor[3], Hedayat Jafari[4]

[1]Department of Medical Surgical Nursing, School of Nursing and Midwifery, Mazandaran University of Medical Sciences, [4]Department of Medical Surgical Nursing, Traditional and Complementary Medicine Research Center, Mazandaran University of Medical Sciences, Sari, Iran, [2]Msc of Epidemiology, Student Research Committee, Torbat Jam Faculty of Medical Sciences, Torbat Jam, [3]Department of Social Medicine, Social Determinants of Health Research Center, Faculty of Medicine, Gonabad University of Medical Sciences, Gonabad, Iran

ORCID:
Mohsen Nezami Ghale Noee: https://orcid.org/0000-0003-3571-1219; Hedayat Jafari: https://orcid.org/0000-0001-8613-4787

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

Access this article online	
Quick Response Code:	**Website:** www.jnmsjournal.org
	DOI: 10.4103/JNMS.JNMS_10_19

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 $\geq 65\%$, 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),

95

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,

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)

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].

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 χ^2	P	Pearson's χ^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.

REFERENCES

1. Heidarzadeh M, Atashpeikar S, Jalilazar T. Relationship between quality of life and self-care ability in patients receiving hemodialysis. Iran J Nurs Midwifery Res 2010;15:71-6.
2. Erfanpoor S, Etemad K, Khalili D, Khodakarim S, Kazempoor Ardebili S, *et al*. Association of diabetes and hypertension with the incidence of

chronic kidney disease: Tehran lipid and glucose study. J Shahrekord Univ Med Sci 2017;18:75-90.

3. Moslem A, Naghavi M, Basiri Moghadam M, Moghadam B. Assessing the adequacy of dialysis and its relationship with kind of filter in patient under hemodialysis referred to 22-Bahman hospital of Gonabad. Ofoghe Danesh 2008;14:20-3.

4. Schoolwerth AC, Engelgau MM, Hostetter TH, Rufo KH, Chianchiano D, McClellan WM, *et al*. Chronic kidney disease: A public health problem that needs a public health action plan. Prev Chronic Dis 2006;3:A57.

5. Kariman N, Alamolhoda S, Panah H, Alavi Majd H. Relationship between cigarette smoking and gestational diabetes mellitus. J Zanjan Univ Med Sci 2010;18:34-41.

6. Rafii F, Rambod M, Hosseini F. Perceived social support in hemodialysis Patients. Hayat 2009;15:5-12.

7. Anderson D. Harrison's principles of internal medicine. Neurology 2005;64:1488-9.

8. Chauveau P, Nguyen H, Combe C, Chêne G, Azar R, Cano N, *et al*. Dialyzer membrane permeability and survival in hemodialysis patients. Am J Kidney Dis 2005;45:565-71.

9. Atashzadeh Shoorideh F. Frequency of gestational diabetes and its related factors in pregnant women in prenatal clinics of educational hospitals, in Tehran (Oct 2000-March 2002). J Rafsanjan Univ Med Sci 2006;5:175-80.

10. Prado M, Roa L, Palma A, Milán JA. A novel mathematical method based on urea kinetic modeling for computing the dialysis dose. Comput Methods Programs Biomed 2004;74:109-28.

11. Kaviannezhad R, Oshvandi K, Borzuo R, Gholyaf M. Dialysis adequacy of low-flux membrane in hemodialysis patients. J Mazandaran Univ Med Sci 2016;26:170-4.

12. Cigarran S, Coronel F, Torrente J, Sevilla M, Baylón J. Risk of inadequate dialysis dose in hemodialysis patients with high Watson volume. A warning. Hemodial Int 2004;8:84.

13. Hauk M, Kuhlmann MK, Riegel W, Köhler H. *In vivo* effects of dialysate flow rate on kt/V in maintenance hemodialysis patients. Am J Kidney Dis 2000;35:105-11.

14. Borzou S, Gholyaf M, Amini R, Zandieh M, Torkaman B. The effect of increasing blood flow rate on dialysis adequacy in hemodialysis patients. J Shahrekord Univ Med Sci 2006;8:60.

15. Oshvandi K, Kavyannejad R, Borzuo R, Gholyaf M, Salavati M. Dialysis adequacy with high flux membrane in hemodialysis patients at Shahid Beheshti hospital, Hamedan. J Urmia Nurs Midwifery Fac 2012;10:540-8.

16. Santoro A, Mancini E, Bolzani R, Boggi R, Cagnoli L, Francioso A, *et al*. The effect of on-line high-flux hemofiltration versus low-flux hemodialysis on mortality in chronic kidney failure: A small randomized controlled trial. Am J Kidney Dis 2008;52:507-18.

17. Eshghizadeh M, Basiri Moghadam K, Baloochi Beydokhti T, Safarpoor Gharib Z, Mokhtari S. Dialysis adequacy in diabetic and non-diabetic patients. Med Surg Nurs J 2014;3:83-77.

18. Ahmadzadeh GH, Mehdi M. The prevalence of depression, anxiety and psychosis among hemodialysis patients in Nour and Ali Asghar hospitals in Isfahan. J Isfahan Med Sch 2012;29:1-9.

19. Kerr P, Perkovic V, Petrie J, Agar J, Disney A. Caring for Australians with Renal Impairment (CARI). The CARI guidelines. Dialysis adequacy (HD) guidelines. Nephrology (Carlton) 2005;10 Suppl 4:S61-80.

20. Malik AS, Ghali EJ. Effect of blood flow rate on dialysis adequacy in Al-Kadhimiya teaching hospital. Iraqi J Med Sci 2012;10:260-4.

21. Shariati A, Mojerloo M, Hesam M, Mollae E, Abbasi A, Asayesh H, *et al*. Hemodialysis efficacy in patients with end stage renal disease (ESRD) in Gorgan, Northern Iran (2008). J Gorgan Univ Med Sci 2010;12:80-4.

22. Hassanzadeh J, Hashiani AA, Rajaeefard A, Salahi H, Khedmati E, Kakaei F, *et al*. Long-term survival of living donor renal transplants: A single center study. Indian J Nephrol 2010;20:179-84.

23. Borzou SR, Gholyaf M, Zandiha M, Amini R, Goodarzi MT, Torkaman B. The effect of increasing blood flow rate on dialysis adequacy in hemodialysis patients. Saudi J Kidney Dis Transpl 2009;20:639-42.

24. Daugirdas J, Van Stone J, Boag J. Hemodialysis apparatus. Daugirdas JT, Blake PG, Ing TS, editors. Handbook of Dialysis. 3rd ed. Philadelphia: Lippincott, Williams and Wilkins; 2001. p. 46-8.