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THE RELATIONSHIP BETWEEN DIALYSIS ADEQUACY AND BLOOD PRESSURE AND NUMBER OF INTRADIALYTIC HYPOTENSIVE EPISODES IN HEMODIALYSIS PATIENTS

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Abstract: Dialysis adequacy is currently defined as the dose of dialysis that covers all functions of the kidney and is measured by adequate removal of harmful substances and excess fluid accumulated in the body. The aim of this study is to examine the relationship between dialysis adequacy and blood pressure, as well as the number of intradialytic hypotensive episodes in hemodialysis patients. The study included 50 patients receiving four-hour hemodialysis three times a week at Muş State Hospital. Dialysis adequacy was based on Kt/V and URR values. Demographic data were collected by face-to-face interviews with the participants. Blood pressure, Kt/V, and URR were measured before the hemodialysis session, and then the total number of intradialytic hypotensive episodes within one hemodialysis session was recorded. There was no statistically significant correlation between Kt/V and systolic and diastolic blood pressure and number of intradialytic hypotensive episodes (P>0.05). There was no statistically significant correlation between URR and systolic and diastolic blood pressure and number of intradialytic hypotensive episodes (P>0.05). Our study shows that there is no significant relationship between dialysis adequacy and blood pressure and number of intradialytic hypotensive episodes. Further research is needed to understand how these relationships may vary among patient groups with different demographic and clinical characteristics.

Keywords: Dialysis adequacy, Blood pressure, Intradialytic hypotension

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1. Introduction

End-stage renal failure is a serious health condition characterized by the inability of the kidneys to effectively filter waste and excess fluid. This condition usually develops as a result of chronic diseases such as diabetes and hypertension. Its treatment involves methods such as kidney transplantation or dialysis. The aim of dialysis is to filter waste products and excess fluid from the patient's blood with the help of a machine (Cheng et al., 2021; Sharanappa et al., 2021). Dialysis therapy consists of two types: hemodialysis (HD) and peritoneal dialysis (Sahathevan et al., 2020; Arasu et al., 2022). One of the important parameters determining the quality of HD is dialysis adequacy (DA) (Ding et al., 2021).

DA is a crucial indicator that is meticulously monitored to enhance patients' quality of life and improve long-term survival (Wayunah et al., 2023). Currently, dialysis dose is defined as the measure encompassing all kidney functions and assessed by the removal of solutes (Zedelenmez and Çağlar, 2019). High-quality dialysis therapy, by effectively removing waste and excess fluid, has positive effects on cardiovascular health, nutritional status, and overall health (Aghsaeifard et al., 2022). Therefore, optimizing DA is of critical importance for the well-being of patients and the effectiveness of healthcare services (Raimundo et al., 2023). Additionally, increasing DA reduces the risk of complications in HD patients, decreases hospitalization rates, and lowers overall healthcare costs (Miyata et al., 2019). DA is an important indicator determining the quality of HD, and it also depends on factors such as the patient's health status, the implementation of the dialysis method, equipment quality, dialysis duration and frequency, nutritional status, and blood pressure (Seng et al., 2020; Sola et al., 2020; Lint et al., 2023). Effective fluid removal during dialysis helps prevent intradialytic hypotension (IDH) (Flythe et al., 2020; Fotiadou et al., 2020). IDH is a condition where blood pressure drops below a certain threshold during hemodialysis, typically caused by rapid volume changes in the body during fluid removal (Karaer et al., 2021; Hamrahian et al., 2023). IDH episodes (IDHE) are defined in two different ways: asymptomatic and symptomatic. Asymptomatic IDHE is characterized by a decrease in systolic blood pressure of more than 20

mmHg from the pre-dialysis value, without the presence of any additional adverse symptoms in the patient (Kanbay et al., 2020). A symptomatic IDHE is characterized by a drop in the average systolic blood pressure of more than 10 mmHg from the predialysis value, along with symptoms such as severe abdominal pain, nausea, vomiting, dizziness, blurred vision, muscle cramps, and severe anxiety (Workgroup, 2005; Alhawari et al., 2020; Allinovi et al., 2022;).

Blood pressure management in dialysis patients is complex and challenging due to the inadequacy of kidney function, autonomic nervous system disorders, and the loss of other autoregulatory mechanisms. To enhance the effectiveness of DA, it is essential to meticulously monitored on blood pressure (Kanno, 2021). Because high blood pressure necessitates the removal of more fluid during hemodialysis, it increases the risk of IDH and makes it difficult to adjust the optimal ultrafiltration rate (Agarwal et al., 2014; Dekker et al., 2018). On the other hand, low blood pressure reduces dialysis tolerance, potentially leading to the early termination of sessions and inadequate treatment (Tawfik et al., 2022; Uduagbamen et al., 2022; Kim et al., 2023). Therefore, understanding the relationship between clinical parameters such as blood pressure and DA allows for a more comprehensive evaluation of treatment processes. Furthermore, the absence of studies primarily investigating this relationship in the literature will allow us to fill this gap. The aim of our study is to examine the relationship between DA, blood pressure, and number of IDHEs.

2. Materials and Methods

2.1 Participants and Sample Size

In our descriptive and cross-sectional study, the sample size was determined using the formula of sample size = $[Z\ (1-\alpha/2)\ /d]^2\ p(1-p)]$ (1) (Charan and Biswas, 2013). Here, p represents the expected proportion of hemodialysis patients. Referring to a published study, the expected proportion was assumed to be 5%, and the precision (d) was set at 0.02 (Karaaslan and Pembegul, 2023). With $\alpha = 0.05$ and $Z\ (1-\alpha/2) = 1.96$, the calculated sample size was found to be 42. Considering a potential 20% loss, 50 hemodialysis patients were included in the study. In this context, the study was completed with 50 patients who met the inclusion criteria and agreed to participate out of 64 patients receiving HD treatment at the Muş State Hospital dialysis unit (Figure 1.). Participants were selected from individuals over 18 years of age who had been receiving regular hemodialysis treatment three times a week for at least six months. The exclusion criteria included patients with health issues such as angina pectoris and uncontrolled arrhythmias, as well as those with communication difficulties, cognitive problems, or orthopedic disabilities that would prevent them from meeting the study requirements.

2.2 Data Collection Tools

Demographic information was collected from the participants included in the study through a personal information form, which included basic data such as age, gender, duration of dialysis treatment, and smoking status.

2.2.1 Measurement of dialysis adequacy

DY is typically measured by evaluating patients' Kt/V and URR values.

Kt/V: This parameter represents the ratio of the volume of blood cleared of waste (K) during dialysis to the patient's total body water volume (V) over the treatment time (t) (Liang et al., 2019). In hemodialysis, a Kt/V value higher than 1.2 is targeted. Higher Kt/V values indicate that the dialysis process effectively removes waste from the body (Ding et al., 2021).

URR: The Urea Reduction Ratio (URR) is calculated by comparing blood urea nitrogen (BUN) levels before and after dialysis (Liang et al., 2019). A higher URR value indicates a more effective dialysis process. An ideal URR is targeted to be 65% or higher (Ferreira et al., 2020). In the study, the values of all participants were based on their measurements taken before the HD session.

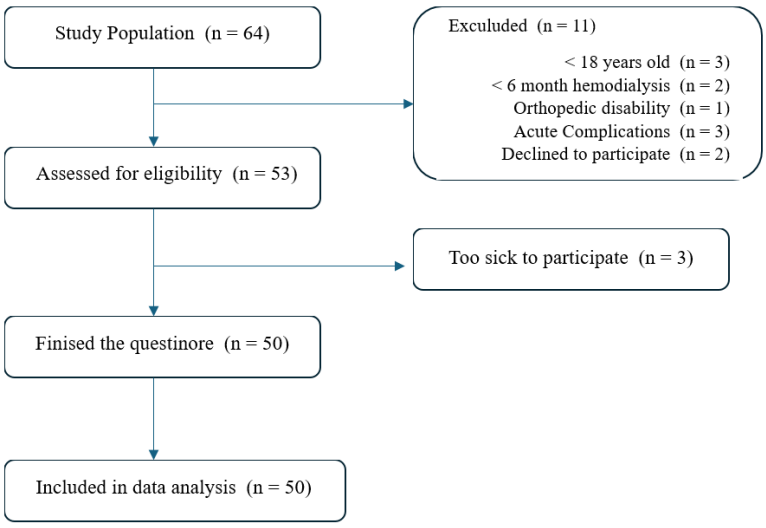

Figure 1. Flowchart to study.

2.2.2. Measurement of blood pressure

Digital blood pressure monitors are widely used to measure blood pressure and pulse. These devices inflate the cuff automatically or semi-automatically and display the patient's systolic and diastolic blood pressure values on a digital screen (Lurbe et al., 2016). In our study, we used the Omron IntelliSense HEM-907XL, IL brand device. Blood pressure was measured before the HD session. The measurement was performed 5 minutes after the patient was lying in bed.

2.2.3 Measurement of İDHA

During data collection, the number of symptomatic IDHEs within one HD session was recorded.

2.3. Statistical Analysis

SPSS (Statistical Package for Social Sciences) Windows v25.0 (SPSS Inc, IBM Corp, Armonk, New York) was used for all statistical analyses in this study. Initially, the basic statistical properties (mean, standard deviation) of the variables in the data set were calculated. The Shapiro-Wilk test was used to examine whether the variables followed a normal distribution. Pearson and Spearman correlation analyses were applied to evaluate the relationships between variables; Pearson correlation was used for normally distributed variables, while Spearman correlation was used for non-normally distributed variables. Finally, the obtained correlation coefficients and p-values were examined to determine statistical significance. A P-value of less than 0.05 was considered statistically significant.

3. Results

The mean age of the participants was 53.72±12.14 years, with an age range of 24 to 80 years. The average duration of hemodialysis treatment was 2.60±1.32 years. The mean Kt/V ratio was 1.34 ± 0.41 (ranging from 0.56 to 2.61), and the mean URR ratio was 64.27±14.26 (ranging from 41.59 to 78.50). Regarding blood pressure values, the average systolic blood pressure was 141.68±19.69 mmHg (ranging from 85 to 181 mmHg), and the average diastolic blood pressure was 82.02±11.27 mmHg (ranging from 56 to 124 mmHg).

The number of IDHEs was recorded as five in total, with three occurring in women and two in men. No patients experienced two different IDHE within the same HD session. The gender distribution showed that 50% of the participants were female and 50% were male (Table 1).

There was no statistically significant relationship between Kt/V and systolic and diastolic blood pressure (P=0.897 and P=0.976, respectively). Similarly, no statistically significant relationship was found between Kt/V and IDHE (P=0.987). These results indicate that there is no meaningful relationship between Kt/V and blood pressure or IDHE (Table 2).

There was no statistically significant relationship between URR and systolic and diastolic blood pressure (P=0.131 and P=0.596, respectively). Similarly, no statistically significant correlation was found between URR and IDHE (P=0.873). These results indicate that there is no meaningful relationship between URR and blood pressure or IDHE (Table 3).

Table 1. Demographic data

Variable		N=50	
		X ± SS	Min-Max
Age		53.72 ± 12.14	24-80
Duration of dialysis treatment (years)		2.60 ± 1.32	1-4
Kt/v Ratio (Male 1,38; Female 1,32)		1.34 ± 0.41	0.56-2.61
URR Ratio (Male 65,5; Female 66,29)		64.27±14.26	41.59-78.50
Systolic Blood Pressure		141.68 ± 19.69	85-181
Diastolic Blood Pressure		82.02 ± 11.27	56-124
		n	(%)
Total Number of IDH Episodes		5	10.0
	Female	25	50.0
Gender	Male	25	50.0
	Total	50	100
	Yes	9	18.0
Smoking Status	No	41	82.0
	Total	100	100

X= arithmetic mean, SD= standard deviation.

Table 2. Relationship between Kt/v blood pressure and number of IDHEs

Variable		SYSTOL	DIASTOL	Number of IDHEs
Kt/V	Correlation Coefficient	0.018	0.004	0.002
	P	0.897*	0.976 β	0.987 β

* Pearson correlation analysis, β Spearman correlation analysis

Table 3. Relationship between URR blood pressure and number of IDHEs

Variable		SYSTOL	DIASTOL	Number of IDHEs
Kt/V	Correlation Coefficient	-0.0216	0.076	-0.023
	P	0.131*	0.596 β	0.873 β

* Pearson correlation analysis, β Spearman correlation analysis

4. Discussion

In our study, the relationship between dialysis adequacy (DA) and blood pressure and the number of IDHEs was examined in hemodialysis patients. Our findings indicate that Kt/V and URR values do not have a significant relationship with blood pressure parameters or the number of IDHEs.

Examining the demographic data reveals that, although middle-aged individuals are predominant, there is a wide age distribution encompassing various age groups. The mean duration of HD treatment suggests that patients typically have a relatively short duration of dialysis treatment, while the standard deviation indicates significant variability in this duration among the patients. Additionally, it was determined that 28% of the participants are smokers.

An examination of the gender distribution revealed that 50% of the participants were female and 50% were male. Although there is no complete consensus in the literature, differences in DA between male and female hemodialysis patients have been reported (Djukanovic et al., 2022). Some studies suggest that women may have higher Kt/V values due to generally lower muscle mass, while others contend that men may have higher Kt/V values than women. Additionally, these studies indicate that the impact of gender on clinical outcomes is minimal (Davenport, 2013; Weigert et al., 2020; Ding et al., 2021). In our study, the observation that men had higher average Kt/V values while women had higher average URR values is consistent with the existing literature.

Our findings indicate that there is no statistically significant relationship between Kt/V and URR values and blood pressure parameters. This result supports the idea stated by Flythe et al. that Kt/V values alone may be insufficient as a determinant of blood pressure management due to the individual differences of patients, different haemodialysis durations and the influence of other clinical factors (Flythe et al., 2020). Liu et al. (2022) posited that the URR value is an inadequate indicator of the impact of haemodialysis on cardiovascular outcomes. They argued that, in addition to the dialysis dose, other factors, including the patient's age, dialysis duration and other clinical variables, must be considered. The absence of a significant relationship between DA and blood pressure suggests that factors such as antihypertensive treatment management, fluid intake, and diet may have a more predominant influence. Indeed, there is evidence to suggest that the regular use of antihypertensive drugs represents a fundamental approach to the control of high blood pressure, with fluid management also playing an important role in ensuring haemodynamic stability in dialysis patients (Saran et al., 2006; Amirul Islam et al., 2021; Kim et al., 2024). Furthermore, the broad age range of patients, variations in the dialysis protocols administered, and individual differences in lifestyle factors may have contributed to the absence of a significant relationship.

The findings of this study revealed that the mean Kt/V ratio was 1.34±0.41, with values ranging from 0.56 to 2.61, and the mean URR ratio was 64.27±14.26, with a range of 41.59 to 78.50. These observed values are generally consistent with the recommended target thresholds for dialysis adequacy, indicating that the dialysis procedures employed were largely effective in achieving the desired solute removal (Ferreira et al., 2020; Ding et al., 2021). However, the absence of a statistically significant correlation between Kt/V and URR values and both blood pressure parameters and the number of intradialytic hypotensive episodes suggests that other clinical variables, such as the management of dry weight, may exert a more prominent influence on patient outcomes. This highlights the complexity of managing dialysis adequacy and suggests a multifactorial approach may be necessary to optimize clinical results.

In our study, no significant relationship was found between DA and IDHE. A comparable study in the literature to directly compare these findings was not identified. However, it is recognized that the complex pathophysiology of IDHE, along with individual variations in hemodynamic regulation and vascular reactivity, can significantly impact this critical complication (Sars et al., 2020). This suggests that each patient may respond differently to dialysis treatment and that these responses may affect DA. In some patients, vascular reactivity may cause sudden drops in blood pressure, which may subsequently result in IDHE. Numerous studies in the literature support this observation (Agarwal et al., 2009; Kanbay et al., 2020; Sars et al., 2020; Timofte et al., 2021; Yildiz et al., 2023). In this context, it is evident that preventing intradialytic hypotension requires consideration not only of Kt/V and URR but also of the individual's hemodynamic stability and fluid status (Timofte et al., 2021; Baeg et al., 2022). The effectiveness of dialysis treatment and the risk of IDHE can be significantly influenced by each patient's unique health status and existing comorbidities. Patients with additional health conditions such as diabetes or cardiovascular disease may be more susceptible to haemodynamic changes, which may increase the risk of IDHE. Indeed, numerous studies have reported the prevalence of cardiovascular comorbidities among HD patients (Luo et al., 2020; Pan et al., 2024).

5. Conclusion

To the best of our knowledge, this study is the first to examine the relationship between DA and the number of IDHEs. The findings of our study indicate that there is no statistically significant correlation between DA and either blood pressure or the number of IDHEs. Further research is required to ascertain whether these relationships will undergo a change in patient groups with disparate demographic and clinical characteristics.

Limitations

The limited demographic and clinical characteristics of our participants, coupled with the fact that a single-session relationship was analysed, may have rendered it challenging to discern potential associations between DA and blood pressure and IDHE. It would be beneficial to conduct long-term follow-up studies in the future, in which the demographic and clinical characteristics of the participants are questioned in more detail. This could include factors such as nutritional status and regular medication use.

Author Contributions

The percentage of the author(s) contributions is presented below. All authors reviewed and approved the final version of the manuscript.

	Ö.B.	S.O.
C	80	20
D	70	30
S		100
DCP	100	
DAI	100	
L	100	
W	70	30
CR	20	80
SR	20	80

C=Concept, D= design, S= supervision, DCP= data collection and/or processing, DAI= data analysis and/or interpretation, L= literature search, W= writing, CR= critical review, SR= submission and revision.

Conflict of Interest

The authors declared that there is no conflict of interest.

Ethical Approval/Informed Consent

The authors confirm that the ethical policies of the journal, as noted on the journal's author guidelines page, have been adhered to. This study was approved by the Scientific Research and Publication Ethics Committee of Muş Alparslan University (approval date: March 13, 2023, protocol code: 86766). Before participation, the purpose of the study was explained to all individuals, and their written consent was obtained. The process was conducted in accordance with the Helsinki Declaration.

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