



Factors affecting hemodialysis adequacy in patients undergoing hemodialysis: a cross-sectional study

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ABSTRACT

Hemodialysis is the most preferred renal replacement therapy for patients with chronic kidney failure worldwide. The indicator of the success of hemodialysis therapy is the fulfillment of the adequacy of the hemodialysis dose as measured by Kt/V. Many factors affect the adequacy of hemodialysis, including internal factors and external factors of the patient. This study aimed to analyze the factors that affect the adequacy of hemodialysis in patients undergoing hemodialysis at Indramayu Hospital. Research design using a cross-sectional approach. The sample in this study was 44 respondents who were taken based on purposive sampling. The result showed that the average Kt/V was 1.71 with the lowest Kt/V value being 0.76 and the highest Kt/V being 2.33. Of 44 respondents, 24 (54.5 %) found adequacy achieved, and 20 (45.5 %) respondents did not achieve adequacy. Factors related to hemodialysis adequacy are gender ($p=0.000$; OR=4.0), dry weight ($p=0.006$; OR=7.286), dialyzer reuse ($p=0.005$; OR=8.000), and quick of blood ($p=0.38$; OR=4.5). Suggestions for hemodialysis nurses to be able to evaluate, especially the use of dialyzer reuse no more than 4 times, and maintain a *quick blood speed* of at least 250 ml/minute to achieve adequacy.

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ABSTRAK

Hemodialisa merupakan terapi pengganti ginjal yang paling banyak dipilih untuk penderita gagal ginjal kronik di seluruh dunia. Indikator keberhasilan terapi hemodialisa adalah terpenuhinya kecukupan dosis hemodialisa yang diukur dengan Kt/V. Ada banyak faktor yang mempengaruhi adekuasi hemodialisa, diantaranya faktor internal dan faktor eksternal pasien. Tujuan penelitian ini adalah untuk menganalisis faktor-faktor yang mempengaruhi adekuasi hemodialisa pada pasien yang menjalani hemodialisa di RSUD Indramayu. Desain penelitian menggunakan pendekatan cross-seksional. Sampel dalam penelitian ini berjumlah 44 responden yang dipilih berdasarkan purposive sampling. Hasil penelitian diketahui rata-rata Kt/V adalah 1,71 dengan nilai Kt/V terendah adalah 0,76 dan Kt/V tertinggi adalah 2,33. Dari 44 responden ditemukan sebanyak 24 (54,5 %) responden adekuasi tercapai, dan 20 (45,5 %) responden adekuasi tidak tercapai. Faktor yang berhubungan dengan adekuasi hemodialisa adalah faktor jenis kelamin ($p=0,000$; OR 4,0), berat badan kering ($p=0,006$; OR 7,286), dialyzer reuse ($p=0,005$; OR=8.000), dan quick of blood ($p=0,38$; OR=4.5). saran ditujukan untuk perawat hemodialisa agar dapat melakukan evaluasi terutama penggunaan dialyzer reuse tidak lebih dari 4 kali, serta mempertahankan kecepatan quick of blood minimal 250 ml/menit agar adekuasi tercapai.

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INTRODUCTION

Hemodialysis is one of the renal replacement therapies that are utilized in the management of end-stage renal disease (ESRD) which is also known as stage 5 Chronic Kidney Disease (CKD) (Mahon, Jenkins, & Burnapp, 2013). Hemodialysis is a method option when the toxic substance needs to be removed from the body quickly through the semipermeable membrane through diffusion, osmosis, and ultrafiltration using a tool that is called a dialyzer (Black & Hawk, 2014; Smeltzer & Bare, 2015). When hemodialysis is not administered, there is a risk of intradialytic complications such as hypotension, hypertension, muscle cramps, nausea and vomiting, itching, headache, fever, chills, and chest pain so compliance in hemodialysis therapy is required (Levy, Brown & Lawrence, 2016).

The number of chronic kidney failure experienced an increase of 14.8% and is the 9th leading cause of death in the United States (USRDS, 2014). According to the World Health Organization (WHO, 2019) the number of deaths caused by chronic kidney failure experienced an increase from the 13th rank to the 10th rank. The death toll increased from 813.000 to 1.3 million in 2019. Indonesian Renal Registry (IRR) in 2018 found that the number of new chronic kidney failure increased twice compared to 2018, that is from 30.831 patients to 66.433 patients. People who suffered from chronic kidney failure going on hemodialysis until the end of 2017 were 77.892 people, while the new patients were 30.843 people. From the aforementioned data, not all of the chronic kidney failure patients underwent hemodialysis because the ones undergoing hemodialysis were 98%. The rest of the patients did not undergo hemodialysis service. The number of hemodialysis patients in Indonesia with stage 5 chronic kidney disease is 92% while chronic kidney failure is 2% (IRR, 2018).

Hemodialysis is not intended to cure patients with chronic kidney failure but it only serves as a temporary replacement of the kidney function before the patient undergoes kidney transplantation. Therefore, chronic kidney failure patients need to continuously undergo hemodialysis therapy for the rest of their life until they get kidney transplantation (Smeltzer & Bare, 2015). Steenkamp et al, 2016 in Thomas (2019) found that patients who underwent hemodialysis therapy still had a risk of death in comparison to those who do not undergo hemodialysis therapy at the same age. This is confirmed by Loud & Gallagher, 2013 in Thomas (2019) who stated that hemodialysis therapy is a challenging therapy due to the profound number of complications that will be encountered by the patients. These patients need to spend 12–15 hours in dialysis process each week as each therapy takes 3–4 hours and this will last for the rest of their life (Smeltzer & Bare, 2015).

The administration of hemodialysis doses according to patient needs can be assessed from the adequacy or the hemodialysis adequacy attained by hemodialysis patients. Adequacy refers to the attainment of the dose in the hemodialysis process that is expected to get adequate results in chronic kidney failure patients undergoing hemodialysis (NKF-KDOQI, 2015). Hemodialysis adequacy can be measured using Kt/V calculation or *urea reduction ratio* (URR) as the hemodialysis adequacy standard (IRR, 2018). Kt/V is the most accurate and tested measurement tool from the dialyzer effect that is related to hemodialysis patients' survival. The Kt/V measure is the most widely used in dialysis dose measurement. Based on the results of several observational studies and one controlled clinical trial, it has

shown a strong correlation between Kt/V urea and mortality (NKF-KDOQI, 2015).

According to the Indonesian Renal Registry/IRR (2017), the attainment of the target Kt/V of patients is generally between 1.2 and 1.8. Patients who undergo hemodialysis twice a week are said to have attained adequacy if the Kt/V target is reached at least 1.8, while in patients undergoing hemodialysis 3 times a week, the Kt/V target is attained at least 1.2. Several factors that are predicted to affect hemodialysis adequacy include the surface dimension of the dialyzer, the type of vascular access, hematocrit level, *Quick of blood* (Qb), ultrafiltration, body mass index (BMI), the number of times hemodialysis is performed, dialyzer factors, and the dose of heparinization (Daugirdas, Blake, & Ing, 2015).

The attainment of hemodialysis adequacy can also be influenced by internal factors and external factors. According to the research done by Rezadise, Shahgholian & Shahidi (2016) there is an individual and personal factor that influences the hemodialysis adequacy, both, either directly or indirectly. In this study, it was found that age, pre hemodialysis blood pressure, hemodialysis length in months, and gender were associated with hemodialysis adequacy.

The number of patients that underwent hemodialysis at Indramayu hospital in March 2022 was 142 patients. According to the survey result was 88 female patients and 54 male patients. Based on the access, 116 patients through AVF, 8 patients used CDL, and 18 patients used femoralis. The machine that was used was Fresenius, and dialyzer F8 HPS with the dimension of 1.8 m². The attainment of adequacy also varies which is estimated to be influenced by several conditions. Hemodialysis schedule set at Indramayu hospital is 2 times a week. Based on the survey results in 12 patients, 2 patients attained adequacy (Kt/V 1.8) and 10 patients did not attain (Kt/V < 1.8). No one has conducted research on the factors that affect adequacy in Indramayu hospital. The purpose of this study was to determine the factors associated with adequacy of hemodialysis in the hemodialysis unit of Indramayu Regency hospital.

METHOD

This research used a descriptive-analytic method with a cross-sectional approach. The study population was all patients undergoing hemodialysis in the hemodialysis unit of the Indramayu District Hospital as many as 133 patients. Determine the sample size using the Slovin Formula, is obtained 57 respondents. However, found 44 respondents were taken as the sample using purposive sampling, which was in accordance with the inclusion and the exclusion criteria. The inclusion criteria included patients undergoing routine hemodialysis 2 times a week, aged 65 years, using dialyzer reuse, and patients using AVF vascular access for 1 month.

The independent variables studied included age, gender, length of therapy in months, systolic blood pressure, IDWG degree, dry weight, *quick of blood*, and dialyzer reuse. While the dependent variable is the adequacy of hemodialysis with Kt/V. The time of study was carried out in June 2022. The data collection tool was in the form of observation sheets according to the variables studied. The author applies ethical principles as conveyed by (Nursalam, 2020) namely the right to self-determination, the right to privacy on dignity, the

right to anonymity and confidentiality, and the right to fair treatment. Data analysis technique using chi-square test.

RESULTS AND DISCUSSION

The total number of patients undergoing hemodialysis during the study was 133 patients. While the number of hemodialysis machines available is 32 machines, including machines that are infectious and spare machines. The number of samples is 44 respondents, where the number has been adjusted to the inclusion and exclusion criteria. One of the reasons for the small number of samples is that there are 11 hemodialysis machines that cannot be set to Kt/V, so that patients who use these machines, even though they are in

accordance with the inclusion criteria, cannot be taken as samples.

Based on the research results, it is known that the average Kt/V of respondents is 1.71 (SD 0.34) with the lowest Kt/V value being 0.76 and the highest Kt/V being 2.33. The average age of the respondents was 45.20 years (SD 10.8 years). The age of the respondents is in the range of 23 years to 65 years. A total of 32 (72.7%) respondents are female, as many as 24 (54.5%) respondents have secondary education (junior high school and high school), as many as 32 (72.7%) respondents do not work, the average use of dialyzer reuse is 3.8 (SD 2,305), the average respondent had undergone hemodialysis for 48 months (SD 31.76), and the average dry weight was 52.6 kg (SD 8.05 kg). Of the 44 respondents who underwent hemodialysis, it is known that 24 (54.5%) attained adequacy. The description can be seen in table 1 below:

Table 1 Distribution of Patient Characteristics

No	Variable	Category	Frequency	Percentage
1.	Age	≤ 42.5 years old	16	36.4
		> 42.5 years old	28	63.6
2.	Gender	Male	12	33.3
		Female	32	72.7
3.	Occupation	Employed	18	40.9
		Unemployed	26	59.1
4.	Education	Primary education	14	31.8
		Secondary education	24	54.6
		Tertiary education	6	13.6
5.	Hemodialysis length	≤ 48 months	21	47.7
		> 48 months	23	52.3
6.	Pre HD Systolic blood pressure	Normal	4	9.1
		High	40	90.9
7.	Dry weight	≤ 52.6 kg	22	50.0
		> 52.6 kg	22	50.0
8.	IDWG Degree	Average	13	29.5
		High	31	70.5
9.	Dialyzer reuse	≤ 3.8 times	20	45.5
		> 3.8 times	24	54.5
10.	<i>Quick of blood</i> (QB)	< 250 ml/minute	20	45.5
		≥ 250 ml/minute	25	54.5
11.	Adequacy attainment	Attained (Kt/V ≥ 1.8)	24	54.5
		Not attained (Kt/V < 1.8)	20	45.5

The results of the bivariate analysis of factors related to the attainment of adequacy using the chi square test can be seen in table 2 below:

Table 2. Results of Relationship Analysis of Factors Affecting Adequacy Attainment

Variable	Kategori	Adekuasi Hemodialisa				Total		OR	P-value
		Tercapai		Tidak Tercapai		F	%		
		F	%	F	%				
Age	≤ 45,2 y.o	11	68.8	5	31.2	16	100.0	2.538	0.265
	> 45,2 y.o	13	46.4	15	53.6	28	100.0		
Gender	Male	0	0.0	12	100.0	12	100.0	4.000*	0.000**
	Female	24	75.0	8	25.0	32	100.0		

Variable	Kategori	Adekuasi Hemodialisa				Total		OR	P-value
		Tercapai		Tidak Tercapai		F	%		
		F	%	F	%				
Hemodialysis length in months	≤ 48 month	9	42.9	12	57.1	21	100.0	0.400	0.236
	> 48 month	12	65.2	8	27.3	23	100.0		
Pre-HD systolic blood pressure	Normal	3	75.0	1	25.0	4	100.0	2.714	0.614
	High	21	52.5	19	47.5	40	100.0		
Dry weight	≤ 52.6 kg	17	77.3	5	22.7	22	100.0	7.286	0.006**
	> 52.6 kg	7	31.8	15	68.2	22	100.0		
IDWG degree	Avarege	6	46.2	7	53.8	13	100.0	0.619	0.695
	High	18	58.1	13	41.9	31	100.0		
Dialyzer reuse	≤ 3.8 times	18	80.0	4	20.0	20	100.0	8.000	0.005**
	> 3.8 times	8	33.3	16	66.7	24	100.0		
<i>Quick of blood</i> (QB)	> 250 ml/minute	17	70.8	7	29.2	24	100.0	4.510	0.038**
	≤ 250 ml/minute	7	35.0	13	65.0	20	100.0		

*adequation = is not achieved; **Significant

Based on the results of the analysis using the chi-square test, it is known that the factors associated with attaining adequacy of hemodialysis in patients with chronic kidney failure undergoing hemodialysis at Indramayu hospital are gender factors ($p = 0.000$; OR 4,000), where the male patients has a risk of 4 times the adequacy of hemodialysis was not attained compared to the female patients. The dry weight factor was shown to be significantly associated with the attainment of hemodialysis adequacy ($p=0.006$; OR 7.286), where patients who had an dry weight of 52.6 kg had a 7,286 times chance of attaining it compared to patients who had a dry weight of > 52.6 kg. The factor of using dialyzer reuse was also significantly related to the attainment of adequacy of hemodialysis ($p=0.005$; OR 8.000), where patients who used dialyzer reuse < 4 times had an 8 times chance that adequacy would be attained compared to those who used dialyzer reuse ≥ 4 . Finally, factors that are significantly related to the attainment of hemodialysis adequacy is *quick of blood* ($p = 0.038$, OR 4.510), meaning that patients with *quick of blood* > 250 ml/minute have a 4.5 times chance of attaining adequacy compared to patients whose quick of blood is 250 ml/minute.

One of the successes of hemodialysis is the attainment of adequacy, which is associated with the ability to clean toxins and waste from the body and has a major impact on the better condition of hemodialysis patients (Kallenbach, 2020). Hemodialysis adequacy can be measured using the calculation of Kt/V or urea reduction ratio (URR) as a standard for hemodialysis adequacy. The minimum target is Kt/V 1.8 for those undergoing HD 2 times a week while Kt/V 1.2 for those undergoing HD 3 times a week. The frequency of HD adequacy measurements should be carried out periodically (ideally once per month) at a maximum of every 6 months (IRR, 2018). Meanwhile, according to Levy et al. (2016), the dialysis dose should be assessed every 3 months in stable patients, and every 1 month in unstable patients.

The adequacy of hemodialysis is associated with the extent to which dialysis is able to remove toxins and metabolic waste from the patient's blood which has a major impact on the patient's health. This means that adequate dialysis will still maintain good health even though the patient is suffering from kidney disease.

Factors that affect hemodialysis adequacy are the length of time and interval of dialysis, dialysis surface dimension, dialysate flow rate (Qd), blood flow velocity (Qb), vascular access, body size, and patient weight (Daugirdas et al., 2015). In this study, it is known that the average attainment of patient adequacy is 1.71 ± 0.34 , with the lowest Kt/V being 0.76 and the highest Kt/V being 2.33. From 44 respondents, it is known that there are 24 (54.5%) attained adequacy.

According to Levy et al. (2016), the assessment of the attainment of includes patient welfare (physical, mental and social); nutritional status (malnutrition); ureum kinetic modeling (UKM); the adequacy of ultrafiltration; controlled blood pressure; protein catabolic rate (PCR); control anemia, acidosis and bone disease. The characteristics of patients with good dialysis according to Mahon, Jenkins & Burnapp (2013) are adequate Hb, free of infection, good quality of life, limited access recirculation <10%, decreased morbidity, decreased mortality, reasonable activity tolerance, and adequate nutritional status. Meanwhile, other markers of attaining adequacy are controlled acidosis, sufficient ultrafiltration, and the absence of malnutrition.

The results of this study found that there were four factors that were shown to be significantly associated with hemodialysis adequacy, namely gender ($p=0.000$), dry weight (0.006), dialyzer reuse $p=0.005$, and *quick of blood* ($p=0.038$). Meanwhile, age, length of hemodialysis, pre-hemodialysis systolic blood pressure, and IDWG degree were not related to the attainment of hemodialysis adequacy. ($p>0.05$).

Gender was shown to be significantly associated with the attainment of hemodialysis adequacy ($p=0.000$). However, the results showed that hemodialysis adequacy had an inverse relationship with gender. Where male patients have 4 times the chance of not achieving adequacy compared to female patients. These results are in line with the research conducted by Rezadiee et al. (2016) and the research conducted by Somji et al. (2020) which concluded that male patients have a tendency to not attain adequacy compared to female patients. According to NKF-KDOQI (2015), giving high doses of dialysis to women is more beneficial because naturally, they have a lower V value than men. This may also be related to the dry body weight, where in this study it was known that the average dry weight of the respondents was 56.2 kg, and the results of the analysis proved that there was a significant relationship between the dry weight and hemodialysis adequacy ($p = 0.006$; OR = 7.286).

In this study, it was found that patients with a dry body weight of 56.2 kg compared to those with a dry body weight 7.286 times achieving adequacy, achieving adequacy > 56.2 kg. This can be proven by a study conducted by Chayati et al. (2015) which found that the strongest predictor of hemodialysis adequacy, namely body weight (Body Mass Index / BMI), which reflects the amount of fluid remaining in the patient's body. Obese patients usually have 10% less water content, and it is also determined by gender, where males have a higher fluid composition than (60% of males, and 55% of females). According to Levy et al., (2016) stated that malnutrition is considered a major marker of

inadequate hemodialysis (adequacy is not attained). Weight loss is often accompanied by decreased fluid retention when the dry weight does not decrease as muscle mass decreases.

Another factor that affects the adequacy of hemodialysis is the dialysis factor. According to Mahon et al. (2013), the determination of the dialyzer is determined by the size of the patient and tolerance for hemodialysis. Dialyzer reuse or dialyzer reprocessing is dialyzer reuse on the same patient. "Reuse" refers to the clinical use of the reprocessed dialyzer (Kallenbach, 2020). Dialyzer reuse can be used up to 7/8 times (Himmelfarb & Sayegh, 2010 in Asman et al., D., Bayhakki & Amir, 2021) Asman, Bayhakki & Amir, 2021). The Indonesian Renal Registry (2018) states that the average number of dialyzer reuse in HD measures in Indonesia is 1- >16.

The results of this study found that there was a significant relationship between the use of dialyzer reuse and the attainment of hemodialysis adequacy ($p=0.005$; OR 8.000). The average use of dialyzer reuse is 3.8 times or < 4 times, where patients who use dialyzer reuse < 4 times have an 8 times chance of achieving adequacy compared to those using dialyzer reuse 4. In line with the results of Georgianos & Agarwal (2017) in India who concluded that dialyzer reuse up to 3 times has proven to be effective and safe for patients, and can save costs without endangering patients.

However, the results of this study are not in line with the research conducted by Purnama, Kandarini & Sudhana (2015) which concluded that dialyzer reuse up to 7 times did not affect the URR and Kt/V values in chronic hemodialysis patients. This is not in line with the concept found by Nissenson & Fine (2017) which stated that the performance of a membrane dialyzer is determined by solute cleaning and biocompatibility. Membrane dialysis greatly affects the attainment of the best blood purification. The use of dialyzer reuse will reduce the performance of the dialyzer related to the clearance capacity.

Quick of blood (Q_b) is the amount of blood flow that flows through the vascular access in minutes (ml/minute) (Daugirdas et al., 2015). Q_b is usually regulated at a rate of 250-300 mL/min (Nissenson & Fine, 2017). The dose of *quick of blood* (Q_b) in each patient varies according to each treatment. The standard *quick of blood* (Q_b) is 300 mL/min while the *quick of blood* (Q_b) is low 300 mL/min (NKF-KDOQI, 2015).

Q_b is one of the important factors affecting clearance, where the higher the blood flow velocity, the more blood will be processed in hemodialysis treatment (Thomas, 2019). Based on the results of the study, it was found that there was a significant relationship between *quick of blood* and adequacy of hemodialysis ($p = 0.038$, OR 4.510). The recommended *quick of blood* value is > 250 mmHg. This is in line with the research conducted by Tola'ba (2017) which concluded that there was a significant relationship between *quick of blood* and adequacy of hemodialysis ($p = 0.000$), where the researcher recommended setting the *quick of blood* between 240 ml/minute to 295 ml/minute for the attainment of optimal hemodialysis adequacy while taking into account the patient's tolerance for Q_b regulation. Physiologically, the results of this study are in line with the theory that the higher the dose of Q_b , the more adequacy is attained. This means that the process of filtering metabolic waste in the body is faster, the volume of fluid lost in the body will also be faster, and vice versa, the lower the Q_b dose, the adequacy is not attained (Thomas, 2019). Meanwhile the factors that were not related to hemodialysis adequacy obtained in this study were age ($p=0.265$), duration

of hemodialysis ($p=0.236$), pre-hemodialysis systolic blood pressure ($p=0.614$) and IDWG degree ($p=0.695$).

Patients aged 45.2 years attained more adequacy (68.8%) than those aged > 45.2 years (46.4 %). There is no relationship between age and the attainment of hemodialysis adequacy, meaning that the age factor is not a determinant of hemodialysis adequacy. These results are in line with the research conducted by Somji et al. (2020) where age is not associated with hemodialysis adequacy ($p=0.435$). However, it is different from the results of the research conducted by Rezadiei et al. (2016) which found that there was a significant relationship between age and hemodialysis adequacy ($p = 0.05$). However, based on this study, it is known that hemodialysis adequacy has an inverse relationship, where elderly patients tend to have less hemodialysis adequacy. This means that the adequacy of hemodialysis decreases with increasing age. This condition may be caused by increasing age. The physical condition will decrease, including decreased nutritional intake, so this condition can hinder the attainment of hemodialysis adequacy.

With regard to pre-hemodialysis systolic blood pressure factors and duration of hemodialysis in months, the results are different from the research conducted by Rezadiei et al. (2016) which found that there was a significant relationship between pre-hemodialysis blood pressure factors ($p=0.02$), and duration of hemodialysis in months ($p=0.02$) with the adequacy of hemodialysis. However, the IDWG factor is the same as the research results, namely, there is no relationship ($p = 0.04$)

LIMITATION OF THE STUDY

Based on the sample according to the calculation of the Slovin formula, it was found that sample size was 57 samples had to be achieved, but due to limitations of the HD engine, some of which could not be set Kt/V, the sample size that could be taken according to the exclusion inclusion criteria was only 44 respondents, 11 respondents occupy a bed where the machine cannot be set and 2 patients refuse to be respondent.

CONCLUSIONS AND SUGGESTIONS

The results showed that there was a significant relationship between gender, dry weight, dialyzer reuse, and *quick of blood* with the adequacy of hemodialysis, while the factors of age, pre-hemodialysis systolic blood pressure, duration of hemodialysis in months, and the degree of IDWG were not associated with hemodialysis adequacy. It is suggested that hemodialysis nurses are able to evaluate especially the use of dialyzer reuse and consider that the use of dialyzer reuse is not more than 4 times, and maintain a *quick of blood* speed of at least 250 ml/minute so that hemodialysis adequacy can be attained.

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