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Factors Influencing Blood Pressure Variability in Hemodialysis Patients at RSUD Tgk Chik Ditiro Sigli

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Abstract

Background: Blood pressure changes during hemodialysis are a common complication and can profoundly impact patient safety and quality of life. Various factors such as individual characteristics, technical aspects of the dialysis procedure, and psychological conditions are suspected to contribute to these of blood pressure variability. Objective: This study aims to analyze the relationship between age, dialysis vintage, interdialytic weight gain (IDWG), blood flow rate (BFR), and stress levels with blood pressure variability in hemodialysis patients. Methods: This study uses a cross-sectional design with a quantitative approach. Fifty hemodialysis patients who met the inclusion criteria were selected as respondents at RSUD Tgk Chik di Tiro Sigli, Aceh Province. Data were collected through clinical dialysis observation sheets, pre-post dialysis blood pressure measurements, and stress level questionnaires. Data analysis was performed using the chi-square test. Data analysis was performed using the chi-square test. Results: The results showed that 54% of patients experienced changes in blood pressure after hemodialysis. There was a significant relationship between age ($p = 0.008$), IDWG ($p = 0.003$), BFR ($p = 0.027$), and stress levels ($p = 0.002$) with changes in blood pressure. Meanwhile, the dialysis vintage did not show a significant relationship ($p = 0.569$). Conclusion: Variability in blood pressure during hemodialysis are influenced by physiological, technical, and psychological factors. Managing hemodialysis patients requires a holistic and individual approach, including IDWG management, BFR adjustment, and stress management. Further research is recommended with a longitudinal design and a larger sample coverage.

Keyword: BFR; blood pressure; hemodialysis; IDWG; stress

Introduction

Chronic kidney disease (CKD) is a global public health issue affecting about 10% of the world's population or around 850 million people worldwide. The burden of CKD continues to rise globally and triggers prevalence, morbidity, mortality, and challenges of adequate treatment costs, particularly in low-income countries. CKD is characterized by a gradual decrease in kidney function that can adversely affect health, including increasing the risk of heart failure and various other cardiovascular problems (Bello et al., 2023; Bikbov et al., 2020; Jager et al., 2019; Kovesdy, 2022; Rovin et al., 2024). Indonesia Health Survey Data (Survei Kesehatan Indonesia [SKI]) (Badan Kebijakan Pembangunan Kesehatan Republik Indonesia, 2023) shows that the prevalence of CKD among the population aged ≥ 15 years in Indonesia reaches 0.18%, which is equivalent to approximately 1.15 million people suffering from CKD. Based on local observations at RSUD Tgk Chik di Tiro Sigli indicate that fluctuations in blood pressure are commonly found among hemodialysis patients. Several patients often experience intradialytic hypertension or hypotension episodes, which can interfere with the dialysis process and patient comfort. This situation highlights the importance of analyzing factors influencing blood pressure variability among hemodialysis patients in this setting.

CKD can progress to the final stage, known as end-stage renal disease (ESRD). At this stage, patients require renal replacement therapy to maintain survival, where kidney transplantation is the ideal treatment option. However, more than 80% of CKD patients worldwide rely on dialysis, particularly hemodialysis (HD), as the primary treatment. The number of patients undergoing dialysis continues to increase by about 6% each year, in line with the rising cases of CKD and improved access to healthcare services in various countries (Bello et al., 2023; Jha et al., 2013).

The HD process cleanses the body of metabolic waste and maintains fluid balance. This process removes toxic substances such as urea, creatinine, and nitrogen and helps reduce excess fluid in the body (Leung et al., 2017). HD procedures have the potential to cause various side effects, such as lethargy, fatigue, restless leg syndrome, muscle cramps, nausea, vomiting, dizziness, and persistent systemic inflammation (Rocco et al., 2015). In addition, one of the serious complications that often occur during hemodialysis procedures is hemodynamic instability related to renal replacement therapy (HIRRT), which can occur across various dialysis modalities with a prevalence ranging from 10–70% (Douvris et al., 2018).

Patients with chronic fluid volume expansion often show unstable blood pressure due to decreased vascular compensatory capacity when fluid is rapidly removed during dialysis sessions. Disorders of the autonomic nervous system, which are common in CKD patients due to uremic neuropathy, also hinder the reflex response to blood pressure drops, thereby increasing the risk of hypotension (Zoccali et al., 2017). Hypotension also causes organ hypoperfusion and persistent renal perfusion disorders, which ultimately increase the risk of hospital mortality and decrease the rate of recovery of kidney function (Wald et al., 2014). Not only hypotension but intradialytic hypertension can also occur, especially in patients with chronic sodium overload or uncontrolled activation of the renin-angiotensin-aldosterone system, which ultimately worsens target organ damage such as the heart and brain (Van Buren & Inrig, 2011).

Variability in blood pressure during hemodialysis, particularly in the form of intradialytic hypotension, not only decreases patient comfort during the procedure but can also worsen long-term prognosis. Various factors have been identified to contribute to these blood pressure fluctuations, including high interdialytic weight gain (IDWG), indicating excessive fluid and sodium intake between dialysis sessions. This relates to high blood pressure before dialysis and the need for aggressive ultrafiltration, which can lead to intradialytic hypotension (Lee et al., 2014). A blood flow rate that is too fast can trigger a sudden drop in blood pressure if not balanced with stable circulation volume (KDIGO, 2017). Psychological factors such as stress are also known to affect blood pressure regulation by activating the sympathetic nervous system, which can trigger excessive vasoconstriction or vasodilation (Morowatisharifabad et al., 2020). The factor of advanced age is also associated with decreased vascular elasticity and weak baroreceptor response, thereby increasing vulnerability to low blood pressure during dialysis. (Harvey et al., 2015) . The dialysis vintage also becomes a risk factor, as patients may experience cardiovascular structural changes that reduce their tolerance to changes in intravascular volume (Zoccali et al., 2017).

Various previous studies have examined blood pressure instability during dialysis. However, most research still focuses on general clinical aspects without comprehensively integrating the multifactorial factors that influence blood pressure changes, such as psychological factors (e.g., stress), dialysis vintage, old age, as well as technical factors like blood flow rate and interdialytic weight gain (IDWG). The prevalence CKD patients undergoing dialysis is relatively high, yet research on the specific factors affecting blood pressure changes during hemodialysis is still limited. This condition is very important to explore further, considering that hemodynamic instability is one of the main predictors of increased morbidity and mortality rates in patients.

Thus, this research aims to examine the relationship between blood pressure fluctuations during hemodialysis and various influencing factors, such as age, duration of hemodialysis, interdialytic weight gain (IDWG), blood flow rate, and psychological stress. The novelty of this study lies in its integration of physiological, technical, and psychosocial dimensions simultaneously, which are often overlooked in previous studies. This research is also expected to provide relevant data for developing more precise clinical interventions in addressing blood pressure instability in hemodialysis patients.

Methods

This study is a quantitative with a cross-sectional approach. The research was conducted at a Hemodialysis Unit of a Regional Hospital located in Sigli, Aceh Pidie. The duration of the study took place over two months (May-July 2024). The population in this study consists of all patients with chronic kidney disease who undergo routine hemodialysis at the Hemodialysis Unit of the Regional Hospital in Sigli. Samples were taken using a consecutive sampling technique, whereby samples were selected based on inclusion and exclusion criteria. The inclusion criteria include: (1) patients who have been undergoing hemodialysis for at least 3 months, (2) undergoing hemodialysis at least twice a week, and (3) willing to participate as respondents through informed consent. The exclusion criteria encompass patients with severe mental disorders or acute conditions that impair the ability to measure blood pressure accurately. The sample size was determined using the Slovin formula, which included 50 respondents.

Data were collected through questionnaire filling, direct observation, and blood pressure measurement before, during, and after hemodialysis. The observation sheet instrument used was self-compiled by the researcher which included name (initials), age, gender, dialysis vintage (year), Pre HD weight (kg), Post HD weight (kg), and blood pressure in one session. Blood pressure was measured using an aneroid sphygmomanometer. The level of stress was measured using the DASS-21 questionnaire (Depression, Anxiety, Stress Scale - 21), which can identify the mental health status and needs of patients. The DASS-21 questionnaire was developed by Lovibond & Lovibond (1996) using a Likert scale with four answer choices, then adapted by Kinanthi et al. (2020) into Indonesian and has passed readability tests and construct validity tests by Hakim & Aristawati (2023) and is stated to be usable for adult groups.

Data were analyzed using SPSS version 26 statistical software. Univariate analysis was used to describe the characteristics of the respondents including age and gender, HD duration, IDWG, BFR, HD duration, and stress levels. Bivariate analysis used chi-square tests and independent t-tests to examine the relationship between each variable and changes in blood pressure.

Results

Demographic Characteristics of Respondents

The research results show the distribution of the demographic characteristics of respondents including age, gender, degree of IDWG, BFR rate, duration of undergoing HD, stress levels, and changes in blood pressure during dialysis, with the following results:

Table 1. Demographic Characteristics of Respondents (n=50)

Characteristics	f	%
Gender		
Male	27	54
Female	23	46
Age		
Early Adulthood (< 65 year)	14	28
Late Adulthood (≥ 65 year)	36	72
IDWG Level		
Low (< 4 % dry weight)	29	58
High (≥ 4% dry weight)	21	42
BFR		
Inadequate (< 250 ml/min)	21	42
Adequate (≥ 250 ml/min)	29	58
Dialysis vintage		
≤ 2 years	9	18
> 2 years	41	82
Stress Level		
Normal	13	26
Mild	9	18
Moderate	18	36
Severe	6	12
Extremely Severe	4	8
Blood Pressure Change		
Decreased	11	22
Unchanged	23	46
Increased	16	32

Based on the data above, it is known that 36 (72%) of the respondents fall into the category of late adulthood, 27 (54%) of the respondents are male, 29 (58%) of the respondents have a low IDWG level (< 4% dry weight), 29 (58%) of the respondents have an adequate BFR rate (≥ 250 ml/min), and 41 (82%) of the respondents have undergone hemodialysis for more than 2 years. Based on the changes in blood pressure after hemodialysis, it is noted that 23 (46%) of the respondents have stable blood pressure, 11 (22%) of the respondents experienced a decrease in blood pressure, and 16 (32%) of the respondents experienced an increase in blood pressure after undergoing the dialysis procedure.

Factors Related to Changes in Respondents' Blood Pressure

The correlation test in this study uses the Pearson Chi-square test. The factors analyzed include age, IDWG, QoB, duration of hemodialysis, and stress levels. As can be seen in the following table.

Table 2. Analysis of factors related to post-hemodialysis blood pressure changes (n=50)

Variable	Category	Blood Pressure						Total		*p value*
		Decreased		Unchanged		Increased				
		f	%	f	%	f	%	f	%	
Age	Early Adulthood (< 65 year)	1	7,1	4	28,6	9	64,3	14	28	
	Late Adulthood (≥ 65 year)	10	27,8	19	52,8	7	19,4	36	72	0,008
	Total	11	22	23	46	16	32	50	100	
IDWG Level	Low (< 4 % dry weight)	11	37,9	10	34,5	8	27,6	29	58	
	High (≥ 4% dry weight)	0	0	13	61,9	8	38,1	21	42	0,003
	Total	11	22	23	46	16	32	50	100	
BFR	Inadequate (<250 ml/min)	7	24,1	17	58,6	5	17,2	21	42	
	Adequate (≥ 250 ml/min)	4	19	6	28,6	11	52,4	29	58	0,027
	Total	11	22	23	46	16	32	50	100	

Variable	Category	Blood Pressure						Total		*p value*
		Decreased		Unchanged		Increased				
		f	%	f	%	f	%	f	%	
Dyalisis vintage	≤ 2 years	1	11,2	4	44,4	4	44,4	9	18	0,569
	> 2 years	10	24,4	19	46,3	12	29,3	42	82	
	Total	11	22	23	46	16	23	50	100	
Stress Level	Normal	8	61,5	5	38,5	0	0	13	26	0,002
	Mild	2	22,2	4	44,4	3	33,3	9	18	
	Moderate	1	5,6	8	44,4	9	50	18	36	
	Severe	0	0	5	83,3	1	16,7	6	12	
	Extremely Severe	0	0	1	25	3	75	4	8	
	Total	11	22	23	46	16	32	50	100	

Based on the table above, it can be seen that out of 50 respondents with chronic kidney disease undergoing hemodialysis, 27 respondents (54%) experienced changes in blood pressure post-hemodialysis, either in the form of a decrease or an increase. Based on the data analysis, it was found that the dialysis vintage was not significantly related to changes in blood pressure post-hemodialysis (p value > 0.05). However, factors such as age (p = 0.008), IDWG (p = 0.003), BFR rate (p = 0.027), and stress level (p = 0.002) showed a significant relationship to changes in blood pressure after hemodialysis.

Discussion

Hemodialysis is one form of kidney replacement therapy used to replace part of the kidney function in patients with chronic kidney failure. Although effective in sustaining life, this therapy has various complications risks, including changes in blood pressure during and after the dialysis procedure. The hemodialysis process, which involves the removal of fluid and toxins from the body, can cause imbalances in volume and electrolytes, ultimately disrupting the hemodynamics and cardiovascular system of the patient (Timofte et al., 2021).

Based on the results of this study involving 50 respondents, it was found that 54% of patients experienced changes in blood pressure post-hemodialysis, either in the form of an increase or decrease. 22% of respondents experienced a decrease in blood pressure, 32% experienced an increase, and 46% did not experience any changes in blood pressure. These results align with the research by Flythe et al. (2015) among 11,801 hemodialysis respondents who reported that fluctuations in blood pressure are a common occurrence in dialysis patients and impact long-term mortality and morbidity.

The decrease in blood pressure after hemodialysis is generally caused by a reduction in intravascular fluid volume through ultrafiltration. This condition leads to a decrease in cardiac preload, a reduction in systemic vascular resistance, and ultimately results in hypotension (Flythe et al., 2015). On the other hand, the increase in blood pressure after dialysis may be due to the activation of the renin-angiotensin-aldosterone system (RAAS) as compensation for relative hypovolemia, which leads to vasoconstriction and sodium retention (Assimon et al., 2018). Van Buren & Inrig (2017) explained the paradox where low blood pressure after dialysis is associated with increased mortality, while an increase in moderate blood pressure may indicate adequate compensation for changes in fluid volume. This phenomenon demonstrates that low blood pressure is not always an indicator of improvement in patients' hemodynamic status. In dialysis patients, excessively low blood pressure after dialysis can reflect severe hypovolemia or autonomic dysfunction, ultimately increasing the risk of ischemia in vital organs such as the heart and brain. Conversely, an increase in blood pressure within the moderate range can be considered an adaptive physiological response that reflects the body's ability to maintain organ perfusion effectively. The target blood pressure in hemodialysis patients cannot be equated with the general population, but must be adjusted according to the individual's tolerance to volume changes and the patient's vascular response. Zhao et al., (2020) in a systematic review and meta-analysis of 14 cohort studies involving 37,976 HD patients, found that the variation in systolic blood pressure during the interdialytic period is significantly associated with an increased risk of mortality.

Age and Blood Pressure Variability

The results of this study show that age is significantly related to changes in blood pressure post hemodialysis (p = 0.008), which is consistent with the research by Diakité et al. (2020) which was conducted over three months involving 131 respondents undergoing HD, where it showed a positive relationship between certain age groups and increased blood pressure during hemodialysis. Ages 40-50 years are a significant risk factor for an increase in blood pressure during dialysis. The study by Halle et al. (2020) involving 104 adult patients undergoing HD for more than 3 months indicated that age is associated with an increased risk of hypotension during HD, where each year of age increases the risk of hypotension by 2.7% (p = 0.006).

As age increases, significant structural and functional changes occur in the vascular system. One of the main changes is the increased stiffness of arteries due to the loss of elasticity in blood vessel walls, which raises systolic blood pressure and the workload of the heart. Additionally, the aging process impacts the sensitivity of the baroreceptor system, resulting in less effective reflex responses to fluctuations in blood pressure. The combination of increased arterial stiffness and decreased baroreceptor response contributes to hemodynamic instability in elderly individuals (Maier et al., 2023) A retrospective observational study conducted by Rohrscheib et al. (2008) involving 9,849 HD patients showed that the relationship between age and blood pressure is complex, where systolic blood pressure tends to decrease in the elderly age group, while pulse pressure increases due to a more significant drop in diastolic pressure. In addition, the variability of blood pressure between hemodialysis sessions is quite high, indicating that blood pressure measurements in the HD unit have limitations in predicting clinical outcomes. This necessitates an individual approach in managing blood pressure in patients undergoing HD therapy, especially in older age groups.

Interdialytic Weight Gain (IDWG) and Blood Pressure Variability

The research results indicate that IDWG has a significant relationship with changes in blood pressure (p = 0.003), suggesting that the greater the increase in body weight between dialysis sessions, the higher the likelihood of blood pressure instability during the hemodialysis procedure. These results are in line with the study by Ramadhan et al., (2023) on 90 hemodialysis patients, which showed a significant relationship between IDWG and changes in blood pressure during the first hour of fluid removal (p = 0.05). This study also supports the findings of Inrig et al., (2007) which indicated that every 1% increase in IDWG is associated with a 1.66 mmHg increase in systolic blood pressure during dialysis. hese findings also support the research by Nongnuch et al., (2015) on 531 dialysis patients, where patients with higher IDWG had a greater risk of experiencing increased blood pressure during hemodialysis.

The amount of fluid removed during hemodialysis depends on the dry weight that needs to be achieved, and this is closely related to the Interdialytic Weight Gain level. IDWG is the increase in a patient's weight between two hemodialysis sessions that reflects fluid and salt accumulation and becomes a key indicator in fluid volume management and patient hemodynamic stability (Daugirdas et al., 2015). High IDWG is an indicator of fluid overload in hemodialysis patients. High IDWG also indicates an imbalance between fluid intake and compliance with dietary restrictions, where uncontrolled consumption of fluids and sodium contributes to greater fluid accumulation between dialysis sessions (Hecking et al., 2018). This excess volume complicates blood pressure management and increases the risk of significant blood pressure fluctuations, both intradialytic hypertension and hypotension during dialysis sessions, due to changes in intravascular volume (Lee et al., 2014b).

Bowman & Rosner (2018) state that patients with high IDWG require more fluid withdrawal. The withdrawal of a certain amount of fluid during hemodialysis will cause a decrease in intravascular volume and trigger the activation of the RAAS, which occurs as a compensatory mechanism of the body. RAAS activation leads to increased secretion of renin and angiotensin II, which can cause increased systemic vascular resistance and sudden blood pressure during the fluid withdrawal process in hemodialysis (Inrig et al., 2007; Mehmood et al., 2019). Routine monitoring of IDWG becomes an integral part of evaluating the volume status of hemodialysis patients. Multidisciplinary interventions involving patient education, adjustment of therapeutic regimens, and strict medical supervision are necessary to minimize complications related to blood pressure. Optimal control of IDWG is not only a target in fluid management but also a key component in preventing long-term cardiovascular complications (Hamrahian et al., 2023).

Blood Flow Rate (BFR) and Blood Pressure Variability

The results of this study indicate that 58% of respondents have an adequate blood flow rate (BFR) (≥ 250 ml/min) and that the BFR rate in this study is significantly related to changes in blood pressure ($p = 0.027$). This is in line with the study by Dugilo et al., (2025) which prospectively involved 215 dialysis patients and showed that BFR is significantly associated with blood pressure stability, where appropriate BFR was proven to reduce the risk of hypotension ($p < 0.001$) and hypertension ($p < 0.05$) during hemodialysis. Furthermore, a randomized crossover trial by Schytz et al., (2015) on 22 hemodialysis patients showed that a reduction in BFR from 300 to 200 mL/min led to a significant increase in systolic blood pressure from 128 ± 24 mmHg to 133 ± 23 mmHg ($p < 0.05$). The research by Fadlilah et al., (2020) shows that the higher the BFR, the faster the blood pressure of patients tends to drop, where in their study it was found that patients with BFR 150–170 mL/min mostly experienced an increase in blood pressure, while those with BFR 171–190 and 191–220 mL/min mostly experienced a decrease in blood pressure.

Blood Flow Rate (BFR) is the speed of blood flow drawn from the patient's body through an arterial needle to the dialyzer and then returned through a venous needle. BFR is an important parameter in hemodialysis therapy because it determines how quickly the patient's blood passes through the dialyzer for the processes of diffusion and ultrafiltration (Daugirdas et al., 2015) The higher the BFR, the greater the volume of blood cleaned per unit of time, thus increasing the efficiency of toxin removal and excess fluid. The common BFR rates used range from 200–450 mL/min, depending on the patient's vascular condition, catheter lumen size, and the patient's tolerance to the hemodialysis process. A BFR that is too low (<200 mL/min) can potentially decrease dialysis efficiency (urea clearance), while a BFR that is too high can increase the risk of complications such as intradialysis hypotension, muscle cramps, or hemolysis if not adjusted to the capacity of the dialyzer and hemodynamic status. The selection of BFR is also influenced by the type of vascular access. Central venous catheters (CVC) are generally able to support flows of up to 300–400 mL/min, while arteriovenous fistulas allow for higher BFR due to more stable and durable blood flow (Fiore & Ronco, 2007; Kidney Disease Improving Global Outcome/ KDIGO, 2017).

Dyalisis Vintage and Blood Pressure Variability

Dialysis vintage is defined as the length of time since one first underwent dialysis therapy. The Dialysis vintage is not significantly related to changes in blood pressure during hemodialysis ($p = 0.569$) in this study. These results are consistent with the retrospective study by Xu et al. (2024) which indicated that the dialysis vintage was not found to be a significant factor in influencing blood pressure changes during dialysis, although this factor is considered in clinical considerations; the duration of hemodialysis itself does not play a significant role in intradialytic blood pressure fluctuations. However, the observational cohort study by Flythe et al., (2012) which involved 2,422 dialysis sessions with a total of 19,170 systolic blood pressure measurements, showed that dialysis vintage has a significant relationship with increased blood pressure fluctuation along with the factor of older age, where the longer the duration of hemodialysis, the higher the blood pressure variability.

The differences in results between these two studies indicate that the relationship between hemodialysis duration and blood pressure changes is likely multifactorial and influenced by various interrelated clinical variables. In patients with longer hemodialysis durations, physiological changes such as increased arterial stiffness, autonomic dysfunction, and cardiac remodeling due to long-term volume overload may contribute to increased blood pressure variability during dialysis (Flythe et al., 2012). On the other hand, blood pressure stability in patients with shorter dialysis durations may be due to a sufficiently adaptive response to volume maneuvers during hemodialysis sessions. Xu et al., (2024) showed that other factors such as ultrafiltration rate, interdialytic volume, hydration status, and adherence to antihypertensive medication may be more dominant in affecting changes in blood pressure.

Stress Level dan and Blood Pressure Variability

This study shows that stress levels are significantly correlated with changes in blood pressure ($p = 0.002$). This is consistent with a case study of a 27-year-old male patient who experienced a consistent increase in blood pressure each time he underwent dialysis sessions, which was triggered by severe emotional stress felt before and during the procedure (Putu et al., 2025). However, quantitative evidence remains limited. A cross-sectional study by Bossola et al., (2025) involving 223 patients reported no statistically significant relationship between stress levels and changes in blood pressure during hemodialysis ($p > 0.05$). The differing study results indicate that while indications of a relationship exist at the individual case level, the population-level relationship between stress and blood pressure fluctuations still requires further research.

Stress is known to trigger the activation of the sympathetic nervous system, which directly impacts physiological changes, including an increase in blood pressure. Hering et al., (2015) state that when a person experiences stress, the sympathetic system is significantly activated, releasing catecholamines (adrenaline, noradrenaline) that cause an increase in heart rate, constriction of peripheral blood vessels, and an increase in blood pressure. In vulnerable hemodialysis patients, conditions such as anxiety and stress during dialysis sessions—such as fear of complications or emotional pressure—can add to this sympathetic burden. The impact can manifest as fluctuations in intradialytic blood pressure, even without intensive fluid removal. Although there are not many studies finding significant statistical relationships between stress and blood pressure during hemodialysis, the subjective impact of stress on the comfort and physiological stability of patients cannot be overlooked.

Conclusion

Based on the results of this study, it can be concluded that 54% of hemodialysis patients experience changes in blood pressure after the dialysis procedure, either as an increase or decrease in blood pressure. Age (p = 0.008), IDWG (p = 0.003), BFR (p = 0.027), and stress levels (p = 0.002) have a significant relationship with changes in blood pressure. Meanwhile, the duration of undergoing hemodialysis does not show a significant relationship with changes in blood pressure (p = 0.569). These findings emphasize that blood pressure instability in hemodialysis patients is a multifactorial condition influenced by physiological factors (age and IDWG), technical aspects (BFR), and psychological factors (stress), thus requiring a comprehensive management approach. A comprehensive management approach is necessary to stabilize blood pressure and minimize the risk of complications in hemodialysis patients.

This study has limitations related to the cross-sectional design that cannot illustrate causal relationships between variables and the limited scope of data collection in a single healthcare center. Further research with a longitudinal design and broader scope is needed to strengthen the generalization of the results and evaluate its impact on long-term clinical outcomes such as hospitalization and mortality. Healthcare institutions are expected to enhance patient education about fluid restrictions and sodium diet and provide psychological interventions such as counseling or relaxation therapy for patients experiencing stress.

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Author Contribution and Competing Interest

All authors contributed significantly to this research. IS was involved in the study design, data collection, and writing of the initial manuscript. RA was responsible for data analysis and interpretation of the results. AF contributed to the literature review, the development of the theoretical framework, and the revision of the manuscript content. MQ supervised the general research process and the final editing of the manuscript. All authors have read and approved the final version of this manuscript.The authors declare that there are no conflicts of interest that could influence the results or interpretation of this research.

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