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Blood Pressure and Pulse Rate Changes in Chronic Kidney Disease Patients Before and After Hemodialysis: An Observational Study

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ABSTRACT

Background: Chronic Kidney Disease (CKD) is a progressive decline in kidney function that leads to the accumulation of metabolic waste products and excess body fluids, causing most patients to require long-term hemodialysis therapy. Hemodialysis may trigger significant hemodynamic changes, including intradialytic hypertension and tachycardia, which can cause serious cardiovascular complications. **Objective:** This study aimed to analyze changes in blood pressure and pulse rate before and after hemodialysis in patients with CKD at Bhayangkara Tulungagung Hospital. **Methods:** This study used an observational design with a before-after approach involving 30 respondents selected using a purposive sampling technique. Data were collected using structured observation sheets 15 minutes before and after each hemodialysis session. Data analysis was performed using the Wilcoxon signed-rank test with a significance level of $\alpha = 0.05$. **Results:** Before hemodialysis, most respondents were categorized as prehypertensive (50%) with normal pulse rates (76.7%). After hemodialysis, the proportion of hypertension increased from 16.7% to 63.3%, and tachycardia increased from 16.7% to 63.3%. The Wilcoxon signed-rank test showed statistically significant changes in blood pressure and pulse rate before and after hemodialysis ($p < 0.001$). **Conclusion:** Hemodialysis was associated with significant hemodynamic changes in patients with CKD, characterized by increased proportions of hypertension and tachycardia. These findings emphasize the importance of systematic hemodynamic monitoring protocols by nurses during hemodialysis sessions to enable the early detection of cardiovascular complications and improve patient safety. Future researchers are encouraged to analyze the factors contributing to hemodynamic changes in patients with CKD.

Keywords: Chronic Kidney Disease, Hemodialysis, Blood Pressure, Pulse Rate, Hemodynamics.

Background

Chronic Kidney Disease (CKD) is a major health problem associated with high morbidity and mortality rates, particularly due to the increased risk of cardiovascular disease among patients, and it imposes a significant burden on healthcare systems worldwide (1). Globally, in 2023, approximately 788 million adults were estimated to have CKD, a substantial increase from 378 million cases in 1990, with an age-standardized prevalence of 14.2%. CKD is currently recognized as the ninth leading cause of death worldwide (2). Future projections indicate that CKD will become the fifth most common chronic condition by 2040, accompanied by a significant increase in the risk of cardiovascular disease, mortality, and hospitalization (3).

Indonesia, the burden of CKD is increasing significantly. Analysis of the 2018 National Basic Health Survey demonstrated an increasing prevalence of CKD, with hypertension (40.8%) identified as the primary independent risk factor. In addition, the risk of CKD was higher among male patients with hepatitis and diabetes mellitus (4). Indonesia has recorded the highest increase in the prevalence of end-stage kidney disease over the last decade, making the management of hemodialysis patients an urgent national health priority (5).

Hemodialysis is the primary renal replacement therapy for patients with end-stage renal disease

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(ESRD). However, this procedure is associated with high rates of hospitalization and mortality (6). Cardiovascular disease is the leading cause of death among patients undergoing hemodialysis, with cardiovascular mortality estimated to be 20 times higher than that in the general population (7). In addition, approximately 25% of all deaths among patients undergoing dialysis are attributed to sudden cardiac death, with arrhythmias and sudden cardiac arrest identified as major contributing factors (7).

One of the most significant hemodynamic manifestations during hemodialysis is a change in blood pressure. Hypertension is observed in more than 80% of patients undergoing routine hemodialysis, with a multifactorial pathophysiology involving volume overload, arterial stiffness, increased sympathetic nervous system activity, activation of the renin-angiotensin-aldosterone system, and endothelial dysfunction (8). In addition to blood pressure changes, alterations in the pulse rate also represent important hemodynamic manifestations during hemodialysis. Cardiac arrhythmias are highly prevalent in patients undergoing maintenance hemodialysis, with atrial fibrillation being the most common sustained arrhythmia (9). A prospective observational study demonstrated that sudden death in patients undergoing hemodialysis is closely associated with the hemodialysis schedule cycle, with the highest mortality occurring within 12 h before and after the first hemodialysis session of the week (10). Monitoring hemodynamic parameters, including blood pressure and pulse rate, during the 15 min before and after hemodialysis has been shown to be effective in detecting early hemodynamic changes and preventing potentially life-threatening complications during hemodialysis (11).

Nurses play a central role in monitoring the hemodynamic status of patients during hemodialysis. Dialysis nurses are responsible for systematically assessing each patient for the risk of hemodynamic instability from the beginning of the session, including monitoring blood pressure and body weight and implementing corrective actions when signs of risk are identified (12). Based on the description above, this study was conducted to analyze changes in blood pressure and pulse rate before and after hemodialysis in patients with CKD at Bhayangkara Tulungagung Hospital to provide evidence-based clinical data for the development of hemodynamic monitoring protocols in regional healthcare facilities.

Methods

This study used an observational design with a pre- and post-observational study approach. This design was selected because the researchers did not provide any additional intervention to the respondents but only observed the hemodynamic changes occurring before and after routine hemodialysis procedures. This approach was used to identify changes in blood pressure and pulse rate as patients' physiological responses to hemodialysis.

The study population consisted of all patients with CKD undergoing routine hemodialysis therapy at the Hemodialysis Unit of Bhayangkara Tulungagung Hospital. The sample consisted of 30 respondents selected using purposive sampling. The inclusion criteria were as follows: patients diagnosed with CKD undergoing routine hemodialysis, aged ≥18 years, willing to participate as respondents by signing informed consent, and conscious and cooperative during the data collection process.

The research instrument used in this study was a structured observation sheet to record blood pressure and pulse rate measurements before and after hemodialysis. The observation sheet included respondents' characteristics, such as initials, age, sex, medical diagnosis, and duration of hemodialysis. An observation sheet was used to document systolic blood pressure, diastolic blood pressure, and pulse rate measurements at two different times. Blood pressure measurements were performed using a calibrated digital sphygmomanometer with the respondent's arm positioned at heart level in either a sitting or lying position, according to the patient's condition. Pulse rate measurements were conducted using a pulse oximeter or by manual palpation of the radial artery for one full minute. All measuring instruments were calibrated to ensure the validity and accuracy of the measurements. Measurements were performed at two stages: pre-hemodialysis, 0–15 min before the hemodialysis procedure, and post-hemodialysis, 0–15 min after the completion of the hemodialysis procedure. The collected data were analyzed using the Wilcoxon signed-rank test to determine the differences in blood pressure and pulse rate before and after hemodialysis. The level of statistical significance was set at $\alpha = 0.05$.

Results

This study was conducted on 30 CKD patients undergoing hemodialysis at Bhayangkara Tulungagung Hospital from November 4 to 6, 2024. The results are presented in the form of respondents'

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characteristics, changes in blood pressure and pulse rate before and after hemodialysis, and the results of the statistical anal.

Table 1. Characteristics of Respondents

Characteristics	Frequency (f)	Percentage (%)
Gender		
Male	18	60,0
Female	12	40,0
Aged		
33–44 years	6	20,0
45–54 years	12	40,0
55–64 years	8	26,7
≥65 years	4	13,3

Based on Table 1, most respondents were male, accounting for 18 respondents (60.0%). Based on age, nearly half of the respondents were in the 45–54 years age group, totaling 12 respondents (40.0%).

Table 2. Distribution of Blood Pressure and Pulse Rate Before and After Hemodialysis

Variable	Pre Hemodialysis f (%)	Post Hemodialysis f (%)
Blood pressure		
Hypotension	2 (6,7)	0 (0)
Normal	8 (26,7)	4 (13,3)
Prehypertension	15 (50,0)	7 (23,3)
Hypertension	5 (16,7)	19 (63,3)
Pulse Rates		
Bradycardia	2 (6,7)	0 (0)
Normal	23 (76,7)	11 (36,7)
Tachycardia	5 (16,7)	19 (63,3)

Based on Table 2, before hemodialysis, most respondents were categorized as prehypertensive, totaling 15 respondents (50.0%), whereas after hemodialysis, most respondents were categorized as hypertensive, totaling 19 respondents (63.3%). Regarding pulse rate, before hemodialysis, most respondents had normal pulse rates, accounting for 23 respondents (76.7%), while after hemodialysis, most respondents experienced tachycardia, totaling 19 respondents (63.3%).

Table 3. Results of the Wilcoxon Signed Rank Test

Variable	p-value	α	Explanation
Pre-post hemodialysis blood pressure	<0,001	0,05	Significant
Pre-post hemodialysis pulse rate	<0,001	0,05	Significant

The results of the analysis using the Wilcoxon Signed Rank Test showed p-values of <0.001 for both blood pressure and pulse rate variables. These findings indicate significant changes in blood pressure and pulse rate before and after hemodialysis.

Discussions

The results of this study showed that most respondents were male, accounting for 18 respondents (60.0%). This finding is consistent with a study conducted in Brazil, France, Germany, and the United States involving 8,237 individuals with stage 3 to 5 CKD, which demonstrated that although CKD is more commonly found among women in the general population, the proportion of man was consistently higher among patients undergoing renal replacement therapy, including hemodialysis, with a male-to-female ratio exceeding 58% to 42% (13). This gender disparity was also identified in several hemodialysis centers in developing countries, including India, where males (72.7%) dominated the hemodialysis patient

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population, which was associated with sociocultural factors, lack of education, and limited financial resources for healthcare services (14). Based on age, nearly half of the respondents were in the 45–54 years age group, totaling 12 respondents (40.0%). This finding is consistent with the epidemiological profile of hemodialysis patients, which is generally dominated by middle-aged to older adults due to the accumulation of risk factors such as diabetes mellitus, hypertension, and a progressive decline in kidney function accelerated by vascular aging (15).

The results of this study showed that before hemodialysis, most respondents were categorized as prehypertensive, totaling 15 respondents (50.0%), whereas after hemodialysis, most respondents were categorized as hypertensive, totaling 19 respondents (63.3%). There was a marked increase in the proportion of hypertension from 16.7% before hemodialysis to 63.3% after hemodialysis, indicating that the hemodialysis procedure is closely associated with increased blood pressure in patients with CKD. The results of the Wilcoxon signed-rank test showed a p-value of <0.001, indicating statistically significant changes in blood pressure before and after hemodialysis. Intradialytic hypertension (IDH) is defined as an increase in systolic blood pressure of more than 10 mmHg during the hemodialysis procedure and is considered a paradoxical hemodynamic complication in which blood pressure increases despite fluid removal through ultrafiltration (16). The pathophysiology of IDH is multifactorial and not yet fully understood: pre-dialysis systolic blood pressure, ultrafiltration volume, inter-dialysis weight gain, inflammation score, high-sensitivity C-reactive protein, brain natriuretic peptide, phase angle, overhydration, extracellular water/total body water, and body cell mass were associated with IDH (17,18). Excessive activation of the renin-angiotensin-aldosterone system is a key mechanism in the pathogenesis of hypertension among patients with CKD, in which inappropriate activation of this system causes arterial vasoconstriction, sodium and water retention, and increased blood pressure that remains difficult to control despite adequate ultrafiltration (19). Continuous hemodynamic monitoring, including blood pressure measurement using wearable devices, has been shown to detect hemodynamic changes earlier, in which alterations in blood pressure, stroke volume, cardiac output, and systemic vascular resistance can be identified before clinical symptoms appear during hemodialysis sessions (11).

The results of this study showed that before hemodialysis, most respondents had normal pulse rates, totaling 23 respondents (76.7%), whereas after hemodialysis, most respondents experienced tachycardia, totaling 19 respondents (63.3%). There was a marked increase in the proportion of tachycardia from 16.7% before hemodialysis to 63.3% after hemodialysis. The results of the Wilcoxon signed-rank test showed a p-value of <0.001, indicating statistically significant changes in the pulse rate before and after hemodialysis. Cardiac arrhythmias are a major cause of morbidity and mortality among patients with CKD undergoing hemodialysis, with a reported prevalence of 62.2% (9). Sudden increases in heart rate during or after hemodialysis are associated with the occurrence of non-sustained ventricular tachycardia, with mechanisms involving autonomic imbalance triggered by the hemodialysis procedure itself (20). In patients undergoing hemodialysis, hypervolemia plays an important role in pulse pressure changes. Fluid overload has been associated with left ventricular hypertrophy and increased mortality risk among patients receiving hemodialysis therapy (21). Sudden death in patients undergoing hemodialysis is associated with the hemodialysis schedule cycle, with the highest mortality occurring within 12 h before and after the first hemodialysis session of the week. Non-sustained ventricular tachycardia occurs more frequently during or within six hours after hemodialysis than before or between hemodialysis sessions (10).

The reduction in intravascular volume caused by ultrafiltration during hemodialysis triggers activation of the sympathetic nervous system as a compensatory mechanism to maintain blood pressure and cardiac output, in which cardiopulmonary receptors in the atria and baroreceptors in the aortic arch and carotid sinus detect decreased filling pressure and activate sympathetic responses that increase heart rate (22). Simultaneously, reduced renal blood flow decreases stretch receptor stimulation in the afferent arteriolar wall, which is transmitted to juxtaglomerular cells and triggers increased renin secretion (23). The released renin subsequently activates the renin-angiotensin-aldosterone cascade, in which the resulting angiotensin II potentiates norepinephrine release from sympathetic nerve terminals and increases sympathetic outflow from the brainstem, collectively enhancing sympathetic tone and contributing to increased heart rate after hemodialysis (24).

Systematic hemodynamic monitoring during hemodialysis, including blood pressure and pulse rate measurements, has been shown to identify significant hemodynamic changes long before life-

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threatening clinical manifestations occur, thereby providing healthcare professionals with opportunities to perform preventive interventions. The development and implementation of evidence-based hemodynamic monitoring protocols in hemodialysis units, including nurse training in the use of IDH prevention checklists and blood pressure monitoring according to facility policies, have been proven to improve patients' cardiovascular safety during hemodialysis. Regular monitoring of blood pressure and pulse rate beginning 15 minutes before hemodialysis and continuing until 15 minutes after the completion of the session is a recommended standard practice for comprehensively detecting hemodynamic changes in patients undergoing hemodialysis. The findings of this study emphasize the need to strengthen nurses' competencies in hemodynamic monitoring in hemodialysis units, particularly in regional healthcare facilities, to improve the safety and quality of care for patients with CKD. The relatively small sample size and data collection conducted in only one hemodialysis center limit the generalizability of the findings, considering that factors associated with hemodynamic fluctuations may vary across different facilities and populations. This study did not analyze factors known to be associated with intradialytic blood pressure changes, such as post-dialysis blood pressure, number of antihypertensive medications, and duration of hemodialysis, which are important variables for understanding hemodynamic patterns in patients with CKD. Future studies should use analytical designs with larger sample sizes, control for confounding variables, and explore factors associated with intradialytic hemodynamic changes to support the development of evidence-based nursing interventions.

Conclusion and Recommendations

Hemodialysis causes changes in blood pressure and pulse rate among patients with CKD, characterized by an increased incidence of hypertension and tachycardia after hemodialysis. Therefore, regular hemodynamic monitoring is necessary to prevent cardiovascular complications in these patients. Future studies should involve larger sample sizes and analyze other factors influencing hemodynamic changes during hemodialysis.

Ethical Consideration and Competing Interest

This study was approved by the Health Research Ethics Committee of STIKes Hutama Abdi Husada Tulungagung (ethical certificate number: No./KEPK-STIKesHAH/EC/I.S1/1970. There is no conflict of interest in the process of data collection and writing this article.

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