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Research Article

Impact of Haemodialysis: Analysis of Haemoglobin Levels and Blood Pressure Control in Patients with End-Stage Renal Disease

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Abstract

Aims: To analyze the effect of hemodialysis on hemoglobin levels and blood pressure in patients with End Stage Renal Disease (ESRD).
Method: The study used a one-group pretest-posttest design with 17 respondents. Data were collected using EDTA tubes, sphygmomanometers, and stethoscopes. A paired t-test and Wilcoxon signed-rank test were applied to analyze the significance of changes between pretest and posttest results
Results: The mean hemoglobin level before hemodialysis was 7.92 g/dL and increased to 8.50 g/dL after hemodialysis (p = 0.001). The mean systolic blood pressure decreased from 136.6 mmHg before to 124.0 mmHg after hemodialysis (p = 0.003). However, there was no significant difference in diastolic blood pressure, with an average of 80.6 mmHg before and 78.6 mmHg after hemodialysis (p = 0.180).
Conclusion: It can be concluded that hemodialysis significantly increases hemoglobin levels and reduces systolic blood pressure in ESRD patients, while diastolic blood pressure remains unchanged. Regular monitoring of hemoglobin and systolic blood pressure is crucial for managing patient health. Hemodialysis effectively raises hemoglobin levels and reduces systolic blood pressure in ESRD patients. Regular monitoring of both parameters is essential for effective patient management. While the findings highlight the benefits of hemodialysis, the limited sample size may restrict the generalizability of the results. Further studies with larger sample sizes are needed to confirm these findings and explore the long-term implications.

Keywords:
Blood pressure, End Stage Renal Disease (ESRD), Hemodialysis, Hemoglobin, Patients

INTRODUCTION

Chronic kidney disease (CKD) is now the 11th leading cause of death, while kidney dysfunction ranks as the 8th leading cause of disability-adjusted life years (DALYs). Over the span of more than three decades, from 1990 to 2021, the burden of CKD per 100,000 people has risen by about 45%(1). If left untreated, CKD can progress to end-stage renal disease (ESRD), synonymous with CKD Stage 5, which requires dialysis or a kidney transplant for survival. This progression significantly increases healthcare costs and negatively impacts patients' quality of life

In Indonesia, in 2020, the highest number of kidney disorder patients was CKD Stage 5, with a total of 61,786 cases, followed by acute kidney injury with 4,625 cases. Among CKD Stage 5 patients, the leading

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cause was hypertension, accounting for 35%, followed by diabetic nephropathy at 29% (2)Given the prevalence of CKD Stage 5 and its complications, hemodialysis becomes a vital treatment for these patients, as it eliminates waste and excess fluids from the blood while helping to manage blood pressure.

However, in ESRD patients, decreased kidney function also leads in insufficient production of erythropoietin, a hormone that stimulates the formation of red blood cells. Consequently, many of these patients experience anemia characterized by low hemoglobin levels, resulting in fatigue, decreased quality of life, and an increased risk of cardiovascular complications. Low hemoglobin levels in hemodialysis patients often necessitate medical interventions, including the administration of erythropoiesis-stimulating agents (ESAs) or blood transfusions(3).

Additionally, blood pressure changes during hemodialysis, particularly intradialytic hypotension, are a common complication affecting 20-30% of patients. This condition can lead to dizziness, nausea, and an increased risk of organ damage. Furthermore, uncontrolled blood pressure in hemodialysis patients can exacerbate the risk of cardiovascular disease and premature death, highlighting the critical importance of regular blood pressure monitoring during treatment (4).

Despite the known complications, there is a limited understanding of how hemodialysis specifically affects hemoglobin and blood pressure control in Indonesian ESRD patients. This study seeks to address this research gap by analyzing hemoglobin levels and blood pressure before and after hemodialysis, which is crucial for gaining a comprehensive understanding of the impact of this therapy on patient conditions. By systematically examining these parameters, we can identify trends and variations that reflect the physiological responses of patients undergoing hemodialysis. Changes in hemoglobin concentrations and blood pressure readings serve as vital indicators of treatment efficacy, allowing healthcare providers to assess whether the therapy is achieving its intended goals. Moreover, this information can aid in developing more effective management strategies tailored to individual patient needs, ultimately enhancing the overall quality of care provided.

The primary objective of this research is to evaluate how hemodialysis affects hemoglobin concentrations and blood pressure control in individuals with ESRD. This evaluation will involve a detailed comparison of pre-treatment and post-treatment values to ascertain the direct effects of hemodialysis on these critical health metrics. Understanding these effects is essential not only for improving clinical outcomes but also for informing future treatment protocols and interventions designed to optimize patient management in this vulnerable population.

METHODS

Study Design

This quasi-experimental study employed a one-group pretest-posttest design to evaluate the effects of an intervention on specific health outcomes. A total of 17 participants were selected through accidental sampling from outpatient care at the Integrated Kidney Unit of Dustira II Hospital between March and July 2024. While the small sample size of 17 was chosen for its feasibility and potential to provide preliminary insights, it is important to recognize that this limitation may impact the generalizability of the findings. To ensure the integrity of the results, patients who had previously received blood transfusions were excluded from the study, reducing the risk of confounding variables that could affect hemoglobin levels and blood pressure.

Data Collection

Data were collected using specific instruments: hemoglobin levels and blood pressure were measured with 3ml EDTA

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Vacutube vacutainers, OneMed sphygmomanometers, and ABN stethoscopes. The OneMed sphygmomanometers were calibrated to guarantee accuracy within ±3 mmHg, ensuring reliable blood pressure readings. Additionally, a 10-item questionnaire regarding medical history and medications was administered to gather relevant baseline information about the participants.

Data Analysis

Data analysis included univariate analysis to calculate means and bivariate analyses using paired T-tests and the Wilcoxon signed-rank test to assess changes in health outcomes before and after the intervention. Ethical approval for the study was obtained, documented under No. Etik.RSD/062/V/2024, ensuring that the research adhered to ethical standards throughout the process.

RESULTS

Table 1 Demographic Characteristics

Characteristics	Frequency (n=17)	Percentage (%)
Gender		
Female	11	64,7%
Male	6	35,3%
Age		
20-44 years	3	17,6%
45-59 years	10	58,9%
≥60 years	4	23,5%
Occupation		
Employed	3	17,6%
Unemployed	14	82,4%
Duration of Hemodyalisis		
≤24 months	9	52,9%
>24 months	8	47,1%
Medical History		
Hypertension	14	82,3%
Diabetes Mellitus	3	17,7%

Table 1 shows that the majority of respondents are female, with 11 individuals (64.7%). Most respondents are aged 45-59 years, comprising 10 people (58,9%). In terms of occupation, 14 respondents (82,4%) are unemployed. The duration of hemodialysis is predominantly recent (≤24 months), with 9 individuals (52,3%). Hypertension is the most common medical history, affecting 14 respondents (82,3%).

Table 2 Normality Test

		Saphiro-Wilk		
Variable	**N**	**Score**	**Statistic**	**Sig**
Hemoglobin	17	Pre test	0,968	0,788
		Post test	0,978	0,915
Systolic Blood Pressure		Pre test	0,905	0,082

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	Post test	0,872	0,024
Diastolic Blood Pressure	Pre test	0,385	0,000
	Post test	0,785	0,001

Table 2 highlights that hemoglobin and systolic blood pressure were normally distributed, with significance values greater than 0.05, allowing for the use of paired T-tests. In contrast, diastolic blood pressure did not meet the normality assumption, prompting the use of the Wilcoxon signed-rank test for analysis.

Table 3 Changes in Hemoglobin and Blood Pressure Before and After Hemodialysis in Patients with ESRD

Variable	Pre-HD Mean ± SD	Post-HD Mean ± SD	Pre-HD Mean Rank ± Sum of Ranks	Post-HD Mean Rank ± Sum of Ranks	p-Value
Hemoglobin (g/dL)	7.78 ± 1.25	8.65 ± 1.33	-	-	0.001
Systolic BP (mmHg)	136.4 ± 17.65	124.1 ± 10.0	-	-	0.002
Diastolic BP (mmHg)	-	-	3.00 ± 3	3.60 ± 18	0.096

Table 3 reflects that the average hemoglobin level in ESRD patients significantly increased from 7.78 ± 1.25 g/dL before hemodialysis to 8.65 ± 1.33 g/dL after (paired t-test: p = 0.001). Systolic blood pressure also significantly decreased from 136.4 ± 17.65 mmHg to 124.1 ± 10.0 mmHg (p = 0.002). In contrast, the Wilcoxon Signed-Rank Test indicated no statistically significant difference in diastolic blood pressure before and after the intervention, with a p-value of 0.096.

DISCUSSION

Demographic Profile of the ESRD Patient

The results indicated that women aged 45 to 59, particularly those with hypertension, constitute a significant portion of ESRD patients. This demographic is at higher risk due to the combined effects of aging, hormonal changes, and the prevalence of chronic conditions such as high blood pressure. Research has shown that hormonal fluctuations during menopause can exacerbate cardiovascular risks, further impacting kidney health. These findings align with earlier studies suggesting that chronic kidney disease (CKD) is more prevalent among women than men in most countries worldwide (5). Both hypertension and diabetes play crucial roles in increasing the risk of CKD (6). Hypertension exerts excess pressure on the blood vessels within the kidneys, leading to structural damage that impairs their ability to filter blood effectively. Over time, this damage can progress to CKD and, ultimately, ESRD. Simultaneously, diabetes contributes to elevated blood sugar levels that harm the glomeruli, thereby reducing overall kidney function. The interaction between these two conditions compounds the risk of ESRD; uncontrolled hypertension can exacerbate kidney damage resulting from diabetes, while high blood sugar levels can lead to increased blood pressure, creating a vicious cycle of worsening health.

Furthermore, as individuals age, kidney function naturally declines, accompanied by

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structural changes within the kidneys (7). The decline in glomerular filtration rate (GFR) and the potential for the accumulation of fibrotic tissue further hinder renal function. These aging processes, when coupled with degenerative diseases like hypertension and diabetes, can accelerate kidney damage significantly. This underscores the importance of early detection and management of these conditions, particularly in middle-aged women, to mitigate the risk of developing CKD and ESRD. Comprehensive health strategies that focus on lifestyle modifications, regular monitoring, and appropriate medical interventions are essential in addressing this growing health concern.

Hemoglobin Response

The results presented in Table 3 show that hemodialysis has a significant positive effect on hemoglobin levels in ESRD patients, with hemoglobin levels rising markedly after the procedure ($p = 0.001$). This finding aligns with previous research on chronic kidney failure patients undergoing hemodialysis at Langsa City Hospital, Aceh, which also reported a significant increase in hemoglobin levels ($p = 0.000$) (8). This suggests that hemodialysis plays an important role in alleviating anemia, a common complication in ESRD patients.

Anemia in ESRD occurs primarily due to the kidneys' reduced capacity to produce erythropoietin, a hormone essential for red blood cell production in the bone marrow (9). With the progression of ESRD, the kidneys not only lose their ability to filter waste products effectively but also fail to produce sufficient erythropoietin, leading to reduced red blood cell formation and, consequently, anemia.

The impact of anemia extends beyond laboratory findings. It significantly affects the overall health and quality of life of ESRD patients, contributing to fatigue, weakness, and decreased tolerance for physical activity. This further complicates their clinical status, as studies have demonstrated a link between anemia and reduced quality of life in chronic kidney disease patients undergoing hemodialysis (10). To manage anemia in ESRD patients, treatment focuses on increasing hemoglobin levels, which helps reduce symptoms and improve overall well-being. Hemodialysis, although primarily used to remove fluid and waste, can also reduce the risk of cardiovascular complications commonly seen in these patients, especially when combined with erythropoiesis stimulating agent (ESA) therapy, such as erythropoietin (EPO) (11).

Previous studies have shown that monitoring hemoglobin levels after hemodialysis can guide doctors in adjusting EPO doses, preventing hemoconcentration which could exacerbate cardiac issues (12). By closely monitoring these levels, health care providers can reduce the EPO dosage needed, maintaining hemoglobin at healthy levels while minimizing the risk of side effects from excessive EPO use.

Maintaining adequate iron levels is imperative for achieving an optimal response to erythropoiesis-stimulating agents (ESA), given that iron is a fundamental component in the synthesis of hemoglobin. Therefore, the effective management of anemia in patients with ESRD necessitates a comprehensive treatment strategy. Such a strategy typically encompasses a combination of hemodialysis, ESA therapy, and iron management to ensure thorough control of anemia (13,14).

Nurses play a crucial role in this process by providing holistic care that includes regular monitoring of hemoglobin levels, educating patients about treatment adherence, and advocating for timely interventions. Nurses are instrumental in monitoring lab results and coordinating adjustments in treatment, such as altering EPO dosage or recommending iron supplements when needed, to ensure optimal outcomes. Their expertise ensures that patients receive appropriate EPO administration while

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minimizing potential complications. By fostering a collaborative environment and addressing the psychosocial aspects of care, nurses help patients navigate the challenges of ESRD, ultimately promoting better health outcomes and improving quality of life for those undergoing hemodialysis

Blood Pressure Control

The findings presented in Table 3 indicate a significant decrease in average systolic blood pressure among ESRD patients undergoing hemodialysis ($p = 0.002$). This reduction is particularly important given the strong association between hypertension and chronic kidney disease (CKD). Hypertension is not only a prevalent condition among individuals with CKD but also serves as a critical risk factor for its onset. Conversely, the physiological changes associated with CKD can lead to elevated blood pressure, creating a vicious cycle that can further compromise kidney function. A prior study found that 85.6% of patients undergoing dialysis experienced hypertension, highlighting the urgent need for effective management strategies in this population (15).

Hemodialysis serves as a key intervention by effectively removing the excess fluid that accumulates in ESRD patients due to impaired kidney function, a primary contributor to hypertension. By alleviating this fluid overload during dialysis sessions, significant reductions in blood pressure can be achieved, enhancing patient stability and overall health. Moreover, hemodialysis plays a crucial role in correcting electrolyte imbalances, particularly concerning sodium and potassium levels, which can have a direct and profound effect on blood pressure regulation. Elevated levels of sodium can lead to fluid retention, increasing blood volume and subsequently raising blood pressure(16). By systematically removing excess sodium and adjusting potassium levels during dialysis, the procedure helps restore a more balanced state of electrolytes in the body. This balance reduces fluid overload, decreases vascular pressure, and prevents the stiffening of blood vessels, thereby allowing them to maintain their elasticity and function more effectively.

In summary, the effective management of fluid and electrolyte balance through regular hemodialysis not only significantly lowers blood pressure in ESRD patients but also supports overall cardiovascular health by enhancing the elasticity and functionality of blood vessels. Nurses play a critical role in this multifaceted process by closely monitoring patients' fluid and electrolyte levels, providing education on dietary restrictions and adherence to treatment regimens, and facilitating open communication between patients and the healthcare team. This holistic treatment strategy is essential for enhancing patient outcomes and quality of life, underscoring the significance of hemodialysis in the continuous management of individuals with chronic kidney disease. The collaborative efforts of healthcare providers, particularly nursing staff, are vital in ensuring that patients receive comprehensive care that addresses both their physiological needs and their educational requirements, ultimately leading to better health outcomes (17,18).

On the other hand, the Wilcoxon Signed-Rank Test revealed no significant difference in diastolic blood pressure among ESRD patients before and after hemodialysis ($Z = -1.67$, $p = .096$), indicating that hemodialysis does not meaningfully alter diastolic pressure. In this study, the 17 patients were already receiving antihypertensive medications, which are crucial for stabilizing blood pressure. Effective management of hypertension prior to dialysis may limit the potential impact of hemodialysis on diastolic blood pressure, as supported by previous research demonstrating that optimal blood pressure control can significantly influence outcomes in this patient population(19).

While hemodialysis effectively removes excess fluid and controls systolic blood

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pressure, the reduction in diastolic pressure is less pronounced. Diastolic pressure, which represents the pressure in the arteries when the heart rests between beats, is primarily influenced by vascular resistance and arterial stiffness (20). Therefore, managing diastolic pressure may require a targeted approach involving medications that specifically reduce vascular resistance and enhance arterial flexibility.

Given these findings, it is essential to maintain continued antihypertensive therapy and monitor blood pressure closely in ESRD patients. Nurses play a vital role in this process by regularly assessing blood pressure before, during, and after dialysis, ensuring adherence to prescribed antihypertensive medications, and educating patients on the importance of blood pressure management. By facilitating communication among patients, physicians, and the healthcare team, nurses help optimize the effectiveness of hemodialysis and improve overall patient outcomes

LIMITATION

This study is subject to several limitations that may affect the generalizability and robustness of the findings. First, the small sample size of 17 ESRD patients limits the ability to draw broader conclusions about hemodialysis effects on blood pressure management. Additionally, potential selection bias due to accidental sampling may result in a non-representative sample, further limiting applicability. The absence of a control group also restricts the ability to attribute observed changes in blood pressure solely to hemodialysis, complicating the assessment of confounding factors. These limitations suggest caution in interpreting the results and indicate the need for future research with larger, randomized samples and control groups.

CONCLUSION

Hemodialysis has a significant positive effect on hemoglobin levels in ESRD patients, effectively managing anemia and improving overall health and quality of life. It also significantly reduces systolic blood pressure by managing fluid and electrolyte balance, which enhances cardiovascular health by improving vascular elasticity. However, hemodialysis does not have a notable impact on diastolic blood pressure, indicating the need for continued antihypertensive management to address diastolic control. Healthcare providers should prioritize tailored antihypertensive regimens to manage diastolic pressure in ESRD patients, alongside monitoring hemoglobin and systolic blood pressure. Regular assessments of blood pressure before, during, and after dialysis are crucial for identifying fluctuations. Additionally, patient education on adherence to prescribed antihypertensive medications and dietary restrictions is vital for optimizing blood pressure management. Collaborative efforts among nurses, physicians, and patients are essential to ensure comprehensive care and improve health outcomes in this vulnerable population.

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