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FACTORS AFFECTING INTRADIALYTIC HYPERTENSION

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ABSTRACT
Intradialytic hypertension, defined as an increase in blood pressure during or immediately after hemodialysis which results in postdialysis hypertension, has long been recognized to complicate the hemodialysis procedure, yet it is often largely ignored. Intradialytic hypertension affects the quality of life of patients undergoing hemodialysis and reduces their survival and increases mortality in CKD patients on hemodialysis. Objective to identify other factors that influence the occurrence of intradialytic hypertension. We conducted a literature search through the ScienceDirect, Scopus, and PubMed databases. The keywords used are "blood pressure" AND "hypertension" AND "dialysis" AND "intradialytic hypertension" AND "factor." The method used to compile information in this article is a scoping review, covering the period from 2020 to 2025, with article screening guided by the PRISMA flow. The article search selection results from ScienceDirect (n=45), PubMed Database (n=74), and Scopus Database (n=50) show that 9 articles can be selected according to the criteria. Articles were selected that correlate with the theme, specifically those discussing factors influencing intradialytic hypertension. Sodium dialysate, intradialytic weigh gian, diabetes mellitus, malnutrition, endothelial dysfunction, duration of hemodialysis, injection of erythropoietin hormone, blood phosphorus, and zinc level, are some factor all affect intradialytic hypertension.

Keywords: chronic kidney disease; hemodialysis; intradialytic hypertension

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INTRODUCTION

Intradialytic hypertension is a symptom that often appears in patients with chronic kidney disease (CKD). Intradialytic hypertension is defined as an increase in systolic blood pressure during hemodialysis (HD) of greater than or equal to 10 mmHg or diastolic blood pressure of greater than or equal to 15 mmHg. (Iatridi et al., 2022) An increase in blood pressure often occurs during the second or third hour of HD after the ultrafiltration process has significantly progressed. This increase in blood pressure is a sign that the HD patient is resistant to ultrafiltration. Long-standing hypertension that always occurs during HD may be related to the use of erythropoiesis-stimulating agents. The symptoms that arise from this hypertension are very varied and depend on the level of blood pressure (Clemmer et al., 2022). Intradialytic hypertension affects the quality of life of patients undergoing hemodialysis, reduces their survival, and increases mortality in CKD patients on hemodialysis. Research shows that the average survival rate for hemodialysis patients with intradialytic hypertension is below 2 years(Clemmer et al., 2022; Fallo et al., 2022)

Intradialytic hypertension is a condition that can worsen the prognosis of the disease, yet it is often overlooked and does not receive the appropriate immediate treatment. Intradialytic hypertension can lead to the emergence of more complex problems, including discomfort, increased stress, and affecting the quality of life of patients, worsening their condition, and even causing death (Davenport, 2023; Hamrahian et al., 2023).Some causes of intradialytic hypertension include excess volume or fluid in the body, excessive sympathetic nerve activity, disturbances in the renin-angiotensin system, endothelial cell dysfunction, and dialysis techniques that do not match the patient's response(Armiyati et al., 2021; Flythe et al., 2020). Factors causing an increase in intradialytic blood pressure include fluid overload. The increase in blood pressure during hemodialysis can occur due to the activation of the renin-angiotensin-aldosterone system (RAAS) as a result of hypovolemia when fluid removal is performed through ultrafiltration (Crowley et al., 2024). The objective of writing this scoping review is to identify factors that influence intradialytic hypertension

METHOD

This method uses the scoping review method. In this method, the steps in the scoping review use the framework developed by Arksey and O'Malley. The following are the work stages based on the Arksey and O'Malley framework: 1. Identifying the research question; 2. Identifying relevant studies; 3. Selecting research articles; 4. Charting data; 5. Subsequently compiling, summarizing, and reporting the results (Aromataris, Lockwood, Porritt, Pilla, 2025).

Eligibility Criteria

The articles used in the scoping review are studies related to intradialytic hypertension. The literature is in English. The selected article discusses the factors influencing intradialytic hypertension.

Literature search strategy

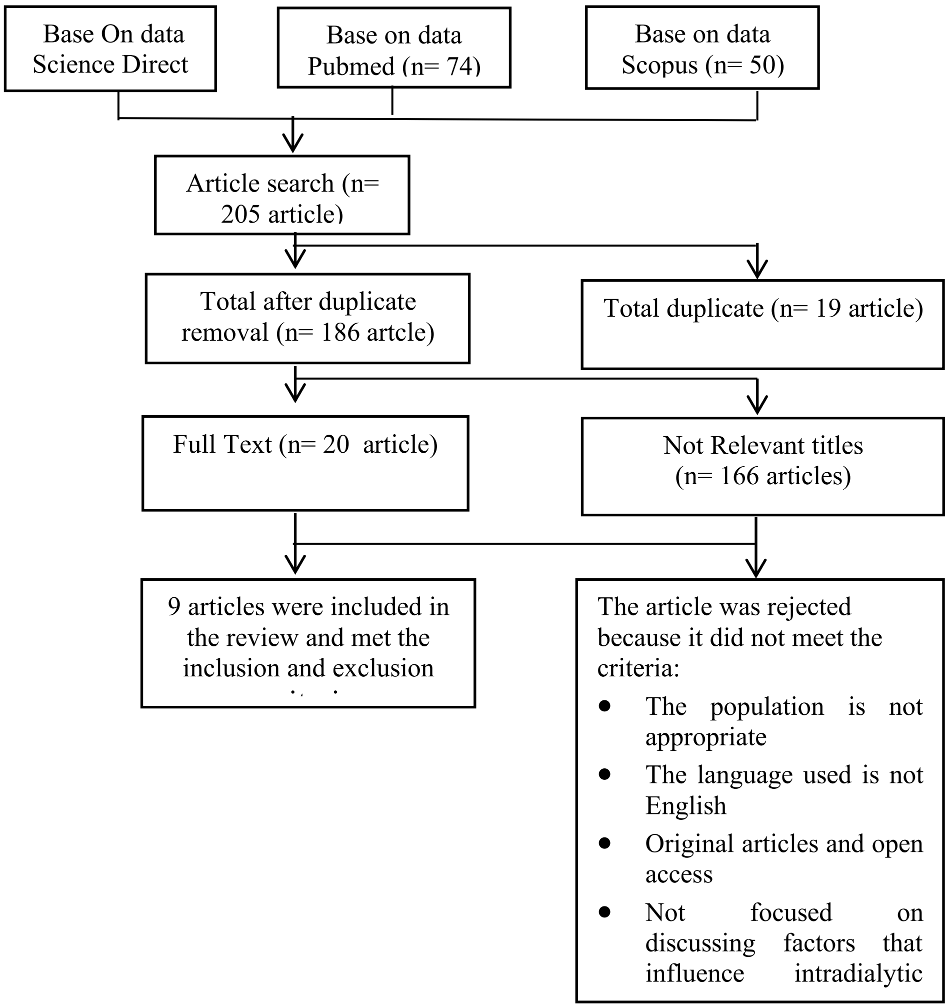
The literature search uses databases from Scopus, ScienceDirect, and PubMed with research time from 2020 to 2025. In this study, Boolean operators "OR/AND" are used. The keywords in the article search are "Blood pressure" AND "Hypertension" AND "Dialysis" AND "intradialytic hypertension" AND "factor."

Identification and selection of literature

This scoping review involved an independent literature search through trusted databases. The articles that have been obtained are analyzed, differentiated, and published. In Figure 1, the process of searching for articles and selecting literature articles using Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) is explained.

Data extraction

The synthesized articles were then subjected to data extraction in matrix form in Microsoft Word. The domains used in data extraction include the researcher's name, year, country, article title, respondents or participants, and findings as shown in Table 1. The data selection process is carried out through several stages, starting with selecting articles that align with the researcher's objectives based on the article title and abstract obtained from various search engines. The collected literature is then analyzed according to the inclusion and exclusion criteria determined by the researcher, followed by mapping the articles based on their characteristics.



RESULT
Based on the article search results, 205 articles were found on Sciencedirect, 74 articles on Pubmed, and 50 articles on Scopus. From the analysis, 9 articles met the criteria. There are 19 duplicate articles in the database to be excluded, leaving 186 articles. From the 186 articles, 166 articles were excluded because they were not relevant, being theoretical, not full text, not original articles, and not aligned with the topic. The screening results yielded 20 articles, and after filtering for intradialytic hypertension patients, 9 related articles were obtained. From the 9 articles that were analyzed, all of them were quantitative studies. This article summarizes the factors that influence intradialytic hypertension.

Dialysate Sodium
Sodium levels can increase even with standard dialysate sodium (i.e., 140 mEq/L) when patients start dialysis with lower serum sodium concentrations (i.e., <140 mEq/L). In addition to increasing interdialytic weight gain and blood pressure, this positive sodium gradient may be very important in the pathogenesis of intradialytic hypertension. In patients with intradialytic hypertension, low dialysate sodium settings significantly reduce post-HD blood pressure and episodes of intradialytic hypertension, compared to standard dialysate sodium (Nair et al., 2021).

Weight Gain Between Hemodialysis Sessions
Weight gain of more than 3 kg between hemodialysis sessions is one of the factors that trigger intradialytic hypertension. (Prabhu et al., 2022) The decline in kidney function leading to fluid accumulation in the body has a significant relationship with intradialytic hypertension (Sanz et al., 2024).

Diabetes Mellitus
Patients with comorbid diabetes mellitus will affect the occurrence of intradialytic hypertension. Intradialytic hypertension is a condition that occurs when blood pressure increases during or after hemodialysis. This can be associated with diabetes mellitus because diabetes can damage the kidneys, which can lead to salt and water retention as well as high blood pressure (Prabhu et al., 2022).

Malnutrition
Nutrition can play an important role in controlling intradialytic hypertension. Proper nutritional intake can help lower blood pressure and reduce the risk of complications. (Prabhu et al., 2022)

Endothelial Dysfunction
The increase in Endothelin-1 concentration in patients undergoing hemodialysis raises blood pressure and the incidence of intradialytic hypertension (Singh et al., 2021).

Duration of undergoing Hemodialysis
Patients undergoing HD for more than 3 years tend to have complications of intradialytic hypertension (Flythe et al., 2020).

Erythropoietin hormone
The administration of erythropoietin hormone affects the increase in blood pressure in the occurrence of intradialytic hypertension. The administration of erythropoietin hormone affects the blood, making it thicker, which in turn increases vascular pressure (Uduagbamen & Kadiri, 2021).

Phosphorus
High phosphorus levels affect blood pressure in the occurrence of intradialytic hypertension. Higher phosphorus intake combined with higher dietary calcium intake is associated with calcium deposition and vascular stiffness in patients with intradialytic hypertension and is an independent risk factor for resistant hypertension during hemodialysis, linked to increased mortality (Kale et al., 2020; Mahmoudi et al., 2024).

Zinc
This study shows that lower blood zinc levels are independently associated with intradialytic hypertension in patients undergoing hemodialysis (Liu et al., 2021).

DISCUSSION
The scoping review process is a type of research that gathers evidence from previous studies to conduct a literature review in order to map the available evidence. (Aromataris, Lockwood, Porritt, Pilla, 2025) This scoping review discusses the factors influencing the occurrence of intradialytic hypertension. Intradialytic hypertension is a complication that often occurs in CKD patients undergoing hemodialysis. Some symptoms that occur when intradialytic hypertension happens are dizziness, nausea, vomiting, blurred vision, and restlessness (Theofilis et al., 2023). The causes of intradialytic hypertension are very complex, but there are three main factors that lead to this condition: impaired heart function, arterial stiffness, and hormonal disturbances. The pathophysiological mechanism of intradialytic hypertension is caused by excess volume or fluid in the body, excessive sympathetic nerve activity, disturbances in the renin-angiotensin system, endothelial cell dysfunction, and dialysis techniques that do not match the patient's response (Bagha & Odhiambo, 2022; Flythe et al., 2020). The average sodium concentration of dialysate over time during hemodialysis with a

sodium profile will affect positive sodium balance and higher interdialytic weight gain. Sodium increases can occur even with standard dialysate sodium (i.e., 140 mEq/L) when patients start dialysis with lower serum sodium concentrations (i.e., <140 mEq/L). In addition to increasing interdialytic weight gain and blood pressure, this positive sodium gradient may be very important in the pathogenesis of intradialytic hypertension (Nair et al., 2021). Excess sodium increases intracellular sodium and calcium concentrations, leading to increased vascular smooth muscle tone. Conversely, sodium reduction can reverse this action, resulting in a decrease in blood pressure (Davenport, 2022).

Reducing salt intake for four weeks or more leads to a significant decrease in blood pressure in both hypertensive and normotensive individuals, regardless of gender and ethnic group. A greater reduction in salt intake also leads to a larger decrease in systolic blood pressure (Kopp et al., 2024). Hypertension can occur when the kidneys' ability to excrete sodium is impaired. The blood pressure response to changes in dietary salt intake varies among individuals. This condition leads to a different sensitivity to salt in individuals (Drawz et al., 2022; Kopp et al., 2024)An increase in blood pressure during hemodialysis raises the risk of death compared to patients who experience a decrease in blood pressure during dialysis. Patients with extracellular volume overload are more prone to intradialytic hypertension and increased acute vascular resistance during dialysis. Management strategies should include reevaluation of fluid overload and high ultrafiltration during hemodialysis. (Loutradis, Sarafidis, Ferro, et al., 2021). From the perspective of fluid overload, improper ultrafiltration may be the most significant factor contributing to arterial blood (Flythe et al., 2020; Günen Yılmaz & Yılmaz, 2022) The addition of ultrafiltration targets will result in increased blood pressure among hypertensive patients after hemodialysis, even though these patients have well-controlled dry weight. Improper ultrafiltration can also lead to the activation of the renin-angiotensin-aldosterone system and endothelial cell dysfunction (Laffer et al., 2020).

In general, a decrease in circulating blood volume causes blood pressure to drop. This condition triggers the kidneys to release renin. Mediated by angiotensin-converting enzyme, renin converts angiotensinogen into angiotensin II. Angiotensin II acts on several target organs throughout the body, including the brain, promoting the formation of reactive oxygen species, vasoconstriction, aldosterone release by the adrenal glands, and activation of sympathetic nerve release, which ultimately increases circulating volume and blood pressure. (Alshahrani, 2023) Therefore, the levels of renin, angiotensin-converting enzyme, and aldosterone in the blood serve as indices of renin-angiotensin-aldosterone system activation. (Crowley et al., 2024) The excess extracellular volume after HD is a greater contributor to the mean blood pressure in HD patients than the intradialytic changes in total arterial resistance or interdialytic weight gain. This effect is particularly observed in individuals with recurrent intradialytic hypertension. In patients without recurrent intradialytic hypertension, excess extracellular volume does not linearly affect the occurrence of intradialytic hypertension. Better fluid management should be implemented to reduce blood pressure increases and suppress the occurrence of intradialytic hypertension (McAdams et al., 2021).

Control of intradialytic weight gain (IDWG) is necessary to prevent an increase in blood pressure during hemodialysis. A study in China showed that reducing fluid overload in intradialytic hypertensive patients with high predialytic blood pressure can effectively lower their blood pressure, but does not affect blood pressure in cases of intradialytic hypertension with normal predialytic blood pressure (Mohamed et al., 2022). Based on fluid removal/ultrafiltration during hemodialysis, 13 (24.5%) patients (Jia & Sowers, 2021)95% confidence level indicate that there is a statistically significant relationship between hemodialysis ultrafiltration and the occurrence of intradialytic hypertension (p-value: 0.04). In addition, a Prevalence Ratio (PR) of 1.25 with a 95% confidence interval (0.406-0.832) was obtained, which can be concluded that ultrafiltration is one of the factors with a 1.25 chance of experiencing intradialytic hypertension (Nugroho & Lazuardi, 2021).The determination of dry body weight that corresponds to the condition of patients undergoing hemodialysis affects changes in blood pressure. In the study conducted a decrease in systolic and diastolic blood pressure was observed. (Loutradis, Sarafidis, Ekart, et al., 2021; Loutradis, Sarafidis, Ferro, et al., 2021)

Hypertension causes changes in the vasculature and can lead to arterial stiffness. On the other hand, insulin resistance and diabetes mellitus can also cause arterial stiffness and hypertension as well as cardiovascular diseases. Increased arterial stiffness independently affects cardiovascular function and increases mortality in patients with type 1 diabetes mellitus (Tynjälä et al., 2020). Patients with abnormal glucose intolerance or type 2 diabetes have stiffer arteries compared to patients with normal glucose tolerance in type 1 diabetes (Jayaraman et al., 2021). Diabetic nephropathy is a major driving factor of hypertension in type 1 diabetes, with improper activation of the renin-angiotensin-aldosterone system (RAAS) and the sympathetic nervous system, mitochondrial dysfunction, oxidative stress, inflammation, abnormal release of extracellular vesicles, and microRNA, as well as dysregulation of gut microbiota emerging as underlying mechanisms in the development of insulin resistance and hypertension induced in type 2 diabetes (Jia & Sowers, 2021) Hypertension and malnutrition are closely related to inflammation. Malnutrition causes chronic inflammation, which in turn promotes the occurrence of arteriosclerosis, including intravascular disorders and calcification. Therefore, malnutrition is considered to potentially cause further acceleration of arteriosclerosis, which in turn accelerates the decline in kidney function in hypertensive patients (Kanda & Ohishi, 2024).

Endothelial cells regulate vascular tone through the synthesis of nitric oxide, prostaglandins, and other relaxation factors. In addition, healthy endothelium provides antioxidant, anti-inflammatory, and antithrombotic functions and contributes to the maintenance of vascular tone, acting as a guardian of organ/tissue homeostasis and blood pressure control (Gallo et al., 2022). Vascular endothelial cells play a crucial role in blood pressure regulation because they release variable vasoactive substances involved in the regulation of vasomotor activity. Endothelin-1 (ET-1) is a vasoactive peptide believed to play a role in vascular disorders, such as hypertension, atherosclerosis, hypertrophy, and stenosis (ElSharkawy et al., 2020). Endothelial dysfunction is characterized by a shift in the endothelium towards reduced vasodilation, cell proliferation, platelet adhesion and activation, as well as pro-inflammatory reactions and a prothrombotic state. Endothelial dysfunction occurs concurrently with several cardiovascular risk factors, including hypertension, hypercholesterolemia, and insulin resistance, which contribute to inflammation in the blood vessel walls, resistant arteries, as well as increased lipoprotein oxidation, smooth muscle cell proliferation, extracellular matrix deposition, cell adhesion, and thrombus formation in the arteries (Gallo et al., 2022) It should be noted that the manifestation of endothelial dysfunction may precede the development of hypertension. Essential hypertension is characterized by functional and structural changes in arterial resistance that lead to increased peripheral vascular resistance (Yu et al., 2020). Endothelial dysfunction can contribute to increased peripheral resistance through several mechanisms leading to enhanced constriction and vascular remodeling (i.e., structural, mechanical, and functional changes) of arterial resistance, which are associated with the development and complications of hypertension (Kim, 2023; Masenga & Kirabo, 2023). Endothelial dysfunction can play a role in increasing arterial resistance tone through the activation of the renin-angiotensin system (RAS), endothelin-1, catecholamines, and the production of growth factors, which leads to vasoconstriction, vascular remodeling, increased resistance to blood flow, and ultimately increased peripheral blood pressure (Kanugula et al., 2023; Singh et al., 2021)

Intradialytic hypertension is common among those who undergo dialysis for a longer duration. This condition occurs with the increase in arterial stiffness and unrecognized accelerated arteriosclerosis, leading to an increased risk of intradialytic hypertension. (Clemmer et al., 2022; Iatridi et al., 2022). The duration of years undergoing hemodialysis can also affect the incidence of blood pressure changes, as the longer patients undergo hemodialysis therapy, the endothelial cells will experience dysfunction. The HD procedure is known to have a dual effect on endothelial function. On one hand, HD therapy can improve endothelial function by removing uremic toxins, inflammatory factors, and inhibitors. The process of high blood turbulence at the needle site, lack of biocompatibility of the dialysis membrane, and dialysate issues, as well as hemodynamic changes. The HD process itself can directly or indirectly damage the vascular endothelium and thus weaken the beneficial effects on endothelial function, resulting in release abnormalities (Singh et al., 2021).

The administration of erythropoietin-stimulating agents (ESA) in patients with new or pre-existing hypertension undergoing hemodialysis can trigger acute vasoconstrictor effects mediated by endothelin-1 (Ohki et al., 2020). ESA can trigger acute vasoconstrictor effects mediated by endothelin-1. Intravenous recombinant erythropoietin causes an increase in mean arterial pressure of 20 mmHg after 30 minutes of injection, and such an increase lasts for 3 hours. On the other hand, the subcutaneous administration of ESA, particularly long-acting ones, does not increase blood pressure. Intravenous ESA is usually administered after dialysis and therefore they hardly contribute to the intradialysis blood pressure profile (Shahab & Saifullah Khan, 2020). Vitamin D has potential effects in blood pressure regulation in several ways; inhibiting the Renin-Angiotensin-Aldosterone System (RAAS), regulating vascular tone, reducing the impact of advanced glycation end products on the endothelium, affecting the nitric oxide system, and increasing prostacyclin production (Huang et al., 2023). Vitamin D deficiency is common among dialysis patients (Legarth et al., 2020). Vitamin D intake in patients with intradialytic hypertension is higher than in patients without intradialytic hypertension; however, serum vitamin D levels are lower in patients with intradialytic hypertension. Patients with intradialytic hypertension have lower vitamin D absorption, or reduced vitamin D production due to higher phosphorus intake (Latic & Erben, 2020). The average fat intake in patients with intradialytic hypertension is higher compared to patients without intradialytic hypertension. Several studies show that higher total fat intake, saturated fat, and cholesterol are risk factors for hypertension, and low-fat dairy products are associated with lower blood pressure. (Cicero et al., 2021; Latic & Erben, 2020).

Zinc exerts an inhibitory effect on the ATP-dependent calcium pump that catalyzes the efflux of calcium ions from the cell. Excess zinc within cells can lead to an increase in free calcium in the smooth muscle layer of blood vessels, resulting in increased arterial wall tension. (Kerkadi et al., 2021; Tamura, 2021) Zinc is involved in blood pressure regulation in the development of hypertension; low zinc intake leads to atherosclerosis, the onset of arterial hypertension, and diabetes (Huang et al., 2023; Latic & Erben, 2020)

CONCLUSION

Research results show that intradialytic hypertension is a common complication. Intradialytic hypertension affects the quality of life of patients undergoing hemodialysis and reduces their survival rate, increasing mortality among CKD patients on hemodialysis. Factors that influence intradialytic hypertension include the sodium concentration in the dialysate, weight gain between hemodialysis sessions, diabetes mellitus, malnutrition, endothelial dysfunction, duration of hemodialysis, administration of erythropoietin hormone, phosphorus content, and zinc content in the blood.

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