



Original Research

High Ultrafiltration Increasing Intradialytic Blood Pressure on Hemodialysis Patients

Yunie Armiyati^{1,2}, Suharyo Hadisaputro³, Shofa Chasani^{4,5}, Untung Sujianto⁶

¹ Department of Nursing, Universitas Muhammadiyah Semarang, Indonesia

² Doctoral Program, Faculty of Medicine, Universitas Diponegoro, Indonesia

³ Postgraduate Program of Health Polytechnic of Semarang

⁴ Hemodialysis Center, Roemani Hospital, Indonesia

⁵ Faculty of Medicine, Universitas Muhammadiyah Semarang, Indonesia

⁶ Department of Nursing, Faculty of Medicine, Universitas Diponegoro, Indonesia

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Abstract

The increase in blood pressure when the patient is undergoing hemodialysis is experienced by patients with intradialytic hypertension. This condition can be very dangerous for the patient, must be prevented and needs to be controlled. Prevention can be done by controlling variables that can affect intradialytic blood pressure, including ultrafiltration during hemodialysis. This study aims to analyze the relationship between ultrafiltration (ultrafiltration goal, ultrafiltration rate) and intradialytic blood pressure. This research was a descriptive-analytic study with a cross-sectional design, with 112 samples at two centres of dialysis in Semarang. Data were analyzed using the Spearman Rho. The finding obtained showed that ultrafiltration goal (UFG) and ultrafiltration rate (UFR) correlated with intradialytic blood pressure (systolic, diastolic and mean arterial pressure). The magnitude of UFG an associated with increase in intradialytic systolic ($p=0,024$; $r=0,213$), increase in intradialytic diastolic ($p=0,007$; $r=0,252$) and increase in mean arterial pressure ($p=0,016$; $r=0,227$). High UFR is associated with with increase in intradialytic systolic ($p=0,037$; $r=0,211$), increase in intradialytic diastolic ($p=0,001$; $r=0,320$) and increase in mean arterial pressure ($p=0,034$; $r=0,200$). Determination of ultrafiltration during hemodialysis must be done carefully and precisely to prevent an increase in intradialytic blood pressure.

INTRODUCTION

Chronic Kidney Disease (CKD) is an irreversible decline in renal function so that the kidneys are unable to regulate body homeostasis.¹ CKD patients at the End Stage Kidney Disease stage require renal replacement therapy to maintain body functions.² Hemodialysis is a kidney

replacement therapy that is widely used by patients with end-stage kidney disease.

Hemodialysis is effective in removing fluids, electrolytes and metabolic waste and improves the quality of life for CKD patients. The main goal of hemodialysis in patients with End-Stage Kidney Disease is symptom relief, controlling uremia, fluid overload,

Corresponding author:

Yunie Armiyati

yunie@unimus.ac.id

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and electrolyte imbalance.³ However, various intradialytic complications can occur in patients undergoing hemodialysis. The complications experienced by many hemodialysis patients are an increase in intradialytic blood pressure or the occurrence of intradialytic hypertension. Intradialytic hypertension is a persistent increase in blood pressure during hemodialysis and at the end of hemodialysis is higher than blood pressure at the initiation of hemodialysis. It's marked by an increase in Mean Arterial Blood Pressure (MAP) > 15 mmHg on dialysis sessions.

Several studies in Indonesia show that the incidence of intradialytic hypertension is a common complication experienced by many patients. A retrospective cohort study of 22,955 hemodialysis treatments showed that the prevalence of intradialytic hypertension was 21.3 per 100 procedures.⁴ Research in Denpasar found that the incidence of IDH was 32.1%.⁵ Research on hemodialysis patients in Yogyakarta also concluded that the frequency of intradialytic hypertension was 54%.⁶ Another study on 198 hemodialysis patients in Palembang also showed that 58.6% of the patients had intradialytic hypertension. The increase in blood pressure can be severe even to the point of a hypertensive crisis that endangers the patient.⁷

High intradialytic blood pressure will affect hemodialysis adequacy, increasing the risk of heart failure and patient death. Previous studies in 151 routine hemodialysis patients showed that high interdialytic blood pressure was associated with an increased risk of stroke and death. A total of 13.91% of patients with high interdialytic blood pressure had a stroke and 16.56% of patients died.⁸ An increase in intradialytic blood pressure must be anticipated with proper control of the risk factors.

Various factors cause an increase in intradialytic blood pressure including excess fluid (fluid overload). An increase in

blood pressure during hemodialysis can occur due to activation of the renin-angiotensin-aldosterone system (RAAS) due to hypovolemia when the fluid withdrawal is carried out through Ultrafiltration.⁷ The process of withdrawal of fluid during hemodialysis through Ultrafiltration involves the fluid withdrawal rate or ultrafiltration rate (UFR) and the amount of fluid withdrawn or ultrafiltration goal (UFG). The amount and speed of fluid withdrawal during hemodialysis can be seen from the ultrafiltration which is regulated in the form of UFG and UFR determination.

Determination of the UFG and UFR should be optimal to achieve normotensive conditions in hemodialysis patients. When hemodialysis is performed, the UFG determination is determined to draw excess fluid in the blood, the UFG size depends on the addition of the interdialytic body weight gain (IDWG) and the target patient's dry weight.⁹ The phenomenon in the field is often the determination of ultrafiltration based on the increase of IDWG which indicates the amount of fluid buildup in the body. Excess fluid occurs due to poor fluid intake regulation during the interdialytic period, which is characterized by a high IDWG value.¹⁰ If fluid intake is excessive, during the period between dialysis there will be a large weight gain.¹¹

Hypervolemia (fluid overload) is believed to play a role in the pathogenesis of intradialytic hypertension.¹² Often the ultrafiltration determination during hemodialysis exceeds the requirements. A decrease in relative blood volume and total blood volume due to a large ultrafiltration goal decreases blood flow to the kidneys, stimulates the release of renin and causes hypertension.¹³

This study aims to analyze the relationship between ultrafiltration during hemodialysis (ultrafiltration goal, ultrafiltration rate) and intradialytic blood pressure. This research is useful to anticipate and prevent

intradialytic hypertension by controlling these factors.

METHODS

The study design was a cross-sectional study. The aim of the studies to determine the relationship between ultrafiltration goal (UFG), ultrafiltration rate (UFR) and intradialytic blood pressure. The population were 188 patients who underwent hemodialysis in January 2019 in two hemodialysis units in Semarang Central Java, Indonesia. Sampling using purposive sampling according to the inclusion criteria. The inclusion criteria of this study were: patients undergoing regular hemodialysis for more than three months, scheduled hemodialysis with a frequency of 2 times a week with a duration of hemodialysis 4 hours, awareness of *compos mentis*, can communicate well verbally, aged 18-60 years and not using erythropoietin. The sample of this study were 112 patients.

The instrument used in this study as a tool for measuring blood pressure (BP) before, during and after the patient underwent hemodialysis using a digital sphygmomanometer. Measurement blood pressure using a standard digital sphygmomanometer that has been calibrated. Blood pressure measurements were taken before hemodialysis, at 2.5 hours hemodialysis (intradialytic) and after hemodialysis. Measurements were made on the arm that was not attached to the vascular access. The predialysis blood pressure was measured 5 minutes before the dialysis needle was inserted and the post-analysis blood pressure was measured 5 minutes after the dialysis needle was removed. UFG is the amount of fluid drawn by the hemodialysis machine during a hemodialysis session in litres, which can be seen from the hemodialysis machine monitor screen. Excess UFG is the amount of fluid drawn by the hemodialysis machine during one HD session in excess of 4.8% dry body weight. UFR is the amount of fluid drawn by the hemodialysis machine per

kilogram of body weight per hour (ml/kg/hour).

This research applies the principles of research ethics include the principles of confidentiality, benefits, the principles of respecting human dignity and the principles of justice. This study was conducted after obtaining approval from the ethics committee. The principles of research ethics in this research.

Univariate analysis was used to describe the characteristic data of respondents in the form of age, gender, frequency of hemodialysis, length of undergoing hemodialysis, and ultrafiltration (UFG and UFR). Research data were analyzed univariately and using a personal computer program. Univariate analysis by presenting numeric and categorical data. Numerical data such as age, frequency of hemodialysis, length of undergoing hemodialysis, ultrafiltration (UFG and UFR) and blood pressure are described in the central tendency (mean, minimum, maximum and standard deviation). Data categorized by gender distributed in a frequency distribution. The data normality test was carried out before carrying out the bivariate test. The results of the normality test with Saphiro Will showed that ultrafiltration data and intradialytic blood pressure were not normally distributed ($p < 0.005$). Bivariate analysis was performed using statistical data processing software on the computer, used Spearman's rho test. Bivariate statistical test to determine the relationship and direction of the relationship between the ultrafiltration variable and intradialytic blood pressure.

RESULTS

Table 1 showed the mean patient age was 47,77 years with the youngest age being 20 years and the oldest being 70 years. The number of male and female respondents is equal, each 50%. The mean length of hemodialysis was 26,20 months. The mean frequency of hemodialysis was 184,95 times. The mean of ultrafiltration goal (UFG) was

2704,91 times and the mean of ultrafiltration goal (UFR) was 11,366 mL/h/kg.

The results in table 2 show that the mean pre-dialysis systolic blood pressure was 158.214 mmHg, the lowest was 107 mmHg and the highest was 195 mmHg. The mean pre-dialysis diastolic blood pressure was 86.652 mmHg, the lowest was 76 mmHg and the highest was 114 mmHg. The mean intra-dialysis systolic blood pressure was 168.839 mmHg, the lowest was 110 mmHg and the highest was 198 mmHg. The average intra-dialysis diastolic blood pressure was 95.161 mmHg, the lowest was 86 mmHg and the highest was 115 mmHg. The average post-dialysis systolic blood pressure was 169.920 mmHg, the lowest was 100 mmHg and the highest was 211 mmHg. The mean post-dialysis diastolic

blood pressure was 94.384 mmHg, the lowest was 74 mmHg and the highest was 121 mmHg.

The figure 1 shows an increase in intradialytic and post-dialysis blood pressure. This research showed that the mean systolic, diastolic and mean arterial pressures of intradialytic and post-dialysis were higher than before (pre) hemodialysis.

The results of statistical analysis with *Spearman Rho* test showed that there was a relationship between ultrafiltration (UFG and UFR) with intradialytic systolic blood pressure, intradialytic diastolic blood pressure (p -and mean intradialytic arterial pressure (p -value < 0,005). The greater the UFG and UFR the higher the intradialytic blood pressure (r 0,211-0,320).

Table 1
Characteristic of respondents (n=112)

Indicators	f	%	Mean \pm SD (min-max)
Age			47,77 \pm 11,66 (20-70)
Gender			
<i>Male</i>	56	50	
<i>Female</i>	56	50	
Frequency of hemodialysis			184,95 \pm 153,79 (24-807)
Length of hemodialysis (months)			26,20 \pm 39,012 (3-374)
Ultrafiltration Goal (ml)			2704,91 \pm 1000,359 (500-4000)
Ultrafiltration Rate (mL/h/kg)			11,366 \pm 4,020 (2-18)

Table 2
Description of Pre, Intra dan Post Hemodialysis Blood Pressure (n=112)

Indicators (Blood Pressure)	Mean \pm SD (min-max)
Pre dialytic blood pressure	
<i>Sistolic (mmHg)</i>	158,214 \pm 17,151 (107-195)
<i>Diastolic (mmHg)</i>	86,652 \pm 18,186 (76-114)
<i>Mean Arterial Pressure (mmHg)</i>	134,432 \pm 12,736 (92,7-164,3)
Intra dialytic blood pressure	
<i>Sistolic (mmHg)</i>	168,839 \pm 18,009 (110-198)
<i>Diastolic (mmHg)</i>	95,161 \pm 9,28 (86-115)
<i>Mean Arterial Pressure (mmHg)</i>	156,779 \pm 134,049 (96,7-155)
Post dialytic blood pressure	
<i>Sistolic (mmHg)</i>	169,920 \pm 21,461 (100-211)
<i>Diastolic (mmHg)</i>	94,384 \pm 13,052 (74-121)
<i>Mean Arterial Pressure (mmHg)</i>	144,763 \pm 17,362 (90-174)

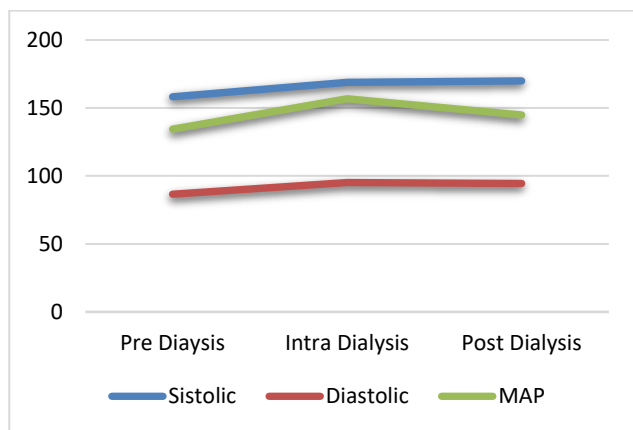


Figure 1

Pre, Intra and Post Hemodialysis Blood Pressure (n=112)

Table 3

Statistical analysis of the relationship between ultrafiltration and intradialytic blood pressure in hemodialysis patients (n=112)

Indicators	p	r
UFG – Intradialytic Systolic Blood Pressure	0,024*	0,213
UFG – Intradialytic Diastolic Blood Pressure	0,007*	0,252
UFG – Intradialytic Mean Arterial Pressure	0,016*	0,227
UFR – Intradialytic Systolic Blood Pressure	0,037*	0,211
UFR – Intradialytic Diastolic Blood Pressure	0,001*	0,320
UFR – Intradialytic Mean Arterial Pressure (MAP)	0,034*	0,200

*Spearman Rho

DISCUSSION

Blood pressure is one hemodynamic indicator that needs to be considered in patients undergoing hemodialysis. An increase in blood pressure or a decrease in blood pressure during the hemodialysis process can endanger the patient's condition. Research on hemodialysis patients in Indonesia shows that the increase in blood pressure during hemodialysis is more experienced by patients undergoing hemodialysis. This research showed that the mean systolic, diastolic and mean arterial pressures of intradialytic and post-dialysis were higher than before (pre) hemodialysis.

The increase in blood pressure during hemodialysis is also referred to as

intradialytic hypertension have an increased mortality risk compared to patients with modest decreases in blood pressure during dialysis. Intradialytic hypertension is associated with extracellular volume overload in addition to acute increases in vascular resistance during dialysis. Management strategies should include reevaluation of fluid overload and high ultrafiltration during hemodialysis.¹⁴ Hemodialysis patients have to control fluid overload by controlling interdialytic weight gain (IDWG).

Control of IDWG is needed to prevent an increase in the incidence of increasing blood pressure during hemodialysis. A study in China showed that reducing fluid overload in intradialytic hypertension patients with high predialytic blood pressure can effectively improve their blood pressure, but did not affect blood pressure in normal predialytic blood pressure intradialytic hypertension cases.¹⁵

An important factor causing an increase in intradialytic blood pressure, among others, is excess fluid. Hypervolemia condition will have implications for the many intradialytic fluid withdrawals determined by ultrafiltration. Increased blood pressure during hemodialysis can occur due to activation of the renin-angiotensin-aldosterone system due to hypovolemia when fluid withdrawal occurs intradialytic through ultrafiltration.

The findings of this study showed that increased ultrafiltration during hemodialysis increases the risk of intradialytic hypertension. This research showed there was a relationship between ultrafiltration (UFG and UFR) with intradialytic systolic blood pressure, intradialytic diastolic blood pressure and intradialytic mean arterial pressure. The greater the UFG and UFR the higher the intradialytic blood pressure.

The results of this study corroborate the findings of previous studies. The findings of

this study reinforce the results of research on hemodialysis patients in Surakarta, that the amount of ultrafiltration during hemodialysis has a positive correlation with the incidence of increased intradialytic blood pressure with $p = 0.003$ and $r = 0.421$.¹⁶ Previous studies have examined ultrafiltration rates for mortality and cardiovascular disease (CVD). Ultrafiltration speed is divided into 3 categories: <10 ml/hour/kg, $10-13$ ml/hour/kg, and > 13 ml/hour/kg. Faster ultrafiltration in hemodialysis patients is associated with a greater risk of multiple causes of CVD morbidity and mortality.¹⁷ A study of 64 hemodialysis patients showed that there was a linear correlation between high UFR and all cardiovascular disease morbidity and mortality where UFR was ≥ 10 ml/hour/kg body weight has the highest risk.¹⁸

Excessive ultrafiltration during hemodialysis due to high IDWG will lead to activation of the sympathetic nervous system, activation of RAAS, increased cardiac output. The process with intradialytic ultrafiltration risks reducing the Relative Blood Volume (RBV) and Total Blood Volume (TBV). The decrease in RBV and TBV will decrease blood flow to the kidneys and stimulate renin release. Renin stimulates angiotensin I to angiotensin II causing vasoconstriction and aldosterone secretion.² Then vasoconstriction and aldosterone secretion will trigger an increase in intradialytic blood pressure.

Determination of the amount of ultrafiltration must be optimal to achieve normotensive conditions in hemodialysis patients. When hemodialysis UFG determination is determined to attract excess, the magnitude of the UFG may depend on the addition of the IDWG and the target dry weight of the patient⁹. High UFG can lead to intradialytic vascular resistance. Intradialytic vascular resistance surges remain implicated as the driving force for blood pressure increases.¹⁹

Previous studies on patients who had hypertension during hemodialysis showed dilatation of the heart. The patient had an increase in blood pressure on ultrafiltration. A study by Cirit et al concluded that paradoxical blood pressure increases with ultrafiltration usually due to overhydration and heart dilation.²⁰ Another study also by Chou et al proved that aggressive ultrafiltration can decrease the heart index and mean arterial pressure (MAP), these results support volume overload as the cause of the initial increase in MAP during ultrafiltration.²¹ This study also showed there was a correlation between ultrafiltration (UFG and UFR) with Intradialytic Mean Arterial Pressure ($p=0,016$ & $p=0,034$). The greater the UFG and UFR the higher the Intradialytic Mean Arterial Pressure ($r=0,227$ & $r=0,200$).

Previous research on seven patient undergoing hemodialysis showed that after the fluid was withdrawn a total of 2520 ± 1698 cc then $4.5 \pm 2.3\%$ of the body fluid was withdrawn, the systolic heart function parameters were significantly increased to the maximum, arterial pressure increased from 107 ± 5 to 118 ± 6 mmHg with $p < 0.027$. This increase in blood pressure was accompanied by an increase in the cardiac index (from 3.8 ± 0.6 to 4.8 ± 1.1 L / min / m², $p < 0.027$). This study also concluded that the increased blood pressure during ultrafiltration is due to an increase in cardiac output, mediated by volume overload.²² Fluid excess (overload) can also be associated with adherence to fluid intake. The findings of this study indicate that poor fluid adherence correlated with the incident of increasing intradialytic blood pressure. Hemodialysis patients should comply with the restriction of fluid intake. If the patient is not adherent, there is a higher risk of fluid overload and a higher risk of intradialytic hypertension.

Care must be taken to determine the amount of ultrafiltration during hemodialysis to keep blood pressure stable and the patient's condition safe.

Determination of ultrafiltration that is not excessive and within the normal range will reduce the risk of an increase in intradialytic blood pressure. Determination of ultrafiltration during hemodialysis must be done carefully and precisely to prevent an increase in intradialytic blood pressure.

CONCLUSION

There is a relationship between ultrafiltrate and intradialytic blood pressure. The greater the ultrafiltration, the more the intradialytic blood pressure increases.

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CONFLICTS OF INTEREST

Neither of the authors has any conflicts of interest that would bias the findings presented here.

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