


Hypertension In Pregnancy With Serum Electrolyte Disorders At The End Of Pregnancy

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Article Info	ABSTRACT
<p>Keywords: Hypertension, Electrolyte, Pregnancy</p>	<p>Electrolyte disorders such as sodium, potassium, and calcium are often associated with hypertension in pregnancy, especially in the late trimester. This study aims to evaluate the relationship between electrolyte levels that deviate from normal and pregnancy hypertension. Using a hospital-based cross-sectional design, the study involved 42 pregnant women with a minimum gestational age of 37 weeks who underwent antenatal care at the hospital. Blood pressure measurements and serum electrolyte analysis were performed at the same visit. The data showed that 59.5% of respondents experienced gestational hypertension, with an abnormal prevalence of sodium and potassium levels associated with hypertension. The analysis showed no ions showed a statistically significant association with hypertension in pregnancy. In retrospect, women with hypokalaemia had a 1.921 times higher chance of developing hypertension in pregnancy compared to women with normocalium (OR = 1.921[0.441-8.365], p value = 0.385), while women with hyperchloride had a 2.515 times lower chance of developing hypertension in pregnancy compared to women with normocchloride (OR = 2.515 [0.544-11.632], p value = 0.238). These findings emphasize the importance of close monitoring of electrolytes in pregnant women at risk of hypertension to prevent complications.</p>
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INTRODUCTION

Hypertension is one of the health problems that cause high pain and maternal death. The initial causes of postpartum hypertension that 50% of the incidence of hypertension during pregnancy persists in the puerperium (Marco, Catherine A; Thomas, Kelli; Rzecznik, 2019). 61.3% of deaths occur during the puerperium Hypertension causes 26.6% of pregnancy, 12.1% of labor, and 25.5% of pregnancy (Chambali, Meylina and Rusli, 2019). Indonesia's health profile report in 2019 stated the three highest causes of maternal death, namely bleeding (1,280 cases), hypertension in pregnancy (1,066 cases), and infection (207 cases) Maternal mortality in Central Java in 2020 increased by 25.5%, most of it due to HDK.61.3% occurred during the puerperium, 26.6% during pregnancy, and 12.1% during childbirth (Kementerian Kesehatan Republik Indonesia, 2020).

Sebuah studi lain yang dilakukan oleh Narang et al. (2020) menegaskan bahwa ketidakseimbangan elektrolit, terutama defisiensi kalium, dapat berperan dalam patofisiologi hipertensi, terutama pada pasien dengan hipertensi gestasional. Kalium yang rendah juga dapat memengaruhi fungsi sel otot halus pembuluh darah, yang berperan penting dalam pengaturan tekanan darah (Narang, Ingul and Wilkinson, 2020).

In Cameroon women with ionised hypercalcaemia had lower odds of hypertension in pregnancy (AOR= 0.50 [0.29–0.87], p-value = 0.015), and women with total hypocalcaemia had higher odds of hypertension in pregnancy (AOR= 1.99 [1.21–3.29], p-value = 0.007), compared to women with ionised and total normocalcaemia, respectively (Ajong *et al.*, 2023a). Serum electrolytes play a role in controlling and maintaining human physiology. A stable concentration of ions in the blood helps the body system. Deviations from the normal concentration of electrolytes will be associated with physiological dysfunction that causes several symptoms.

Hypothermia that occurs in pregnancy and is associated with some pregnancy outcomes is associated with a decrease in sodium concentration. A common cause of the first trimester is hyperemesis gravidarum, the second trimester is caused by preeclampsia. Low natremia is associated with multiple pregnancies, significant edema, premature preeclampsia, and preeclampsia severity (Morton *et al.*, 2021). The results of a study in America on the prevalence and risk factors of hypokalemia showed that 0.69% of pregnant women experienced hypokalemia. Young age, low income levels, and black race are associated with a higher likelihood of hypokalemia. Hypokalemia is associated with hyperemesis gravidarum, gestational hypertension, and postpartum hemorrhage (Yang, Li and Dong, 2021). Chloride ions affect the regulation of body fluids, maintaining electrolyte balance, and acid-base balance (Berend, van Hulsteijn and Gans, 2012). Hypocalcemia causes adverse effects on pregnant women such as hypertension, poor fetal APGAR scores, low bone mass, and short birth body length. Hypercalcemia is less diagnosed in pregnancy, it occurs due to asymptomatic conditions such as fatigue, nausea, which are similar in the first trimester. The main cause is 90% of primary hyperparathyroidism. Chronic hypercalcemia during pregnancy causes preeclampsia, nephrolithiasis, and pancreatitis. In the fetus causes fetal growth inhibition, severe neonatal hypocalcemia, tetani, and death due to fetal hypoparathyroidism (Ajong, 2022)

Biochemical ion assays and blood pressure measurements were carried out on 1074 apparently healthy pregnant women in late third trimester. Increasing kalaemia was associated significantly with higher odds of hypertension in pregnancy; however, kalaemia below and above the normal concentrations had no significant association with hypertension. Nonetheless, participants with kalaemia \leq 3.98 mmol/L, had lower odds of hypertension in pregnancy compared with those with higher kalaemia (OR= 0.40 [0.24–0.66], p-value = 0.0003) (Ajong et al., 2023b). Electrolyte abnormalities of calcium, potassium, and sodium are associated with hypertensive disorders in pregnancy, especially preeclampsia. This study aims to evaluate the effect of deviations in ion concentrations different from the normal range on pregnancy hypertension.

METHODS

The study used *cross sectional* design in women who were full-term pregnant (at least 37 weeks). The study population included pregnant women with hypertension at Hospital, with a minimum gestational age of 37 weeks and receiving routine antenatal care. The sampling of the study used *total sampling* with data collection for 1.5 months taking into account the inclusion and exclusion criteria. Researchers conducted *informed consent* and data collection, while blood specimens were taken by analysts. Blood specimen collection and blood pressure measurement of respondents' blood pressure were carried out at the same visit. The study respondents were positioned in a relaxed state for 5-10 minutes and asked them to relax their forearms before sampling. The sample is carefully collected using *a syringe* and *a tourniquet* is attached to the forearm area, a blood specimen is collected in a 10 ml dry vacutainer tube and processed into a serum. Blood pressure measurements were carried out after blood sampling, the respondents in a relaxed state were measured using *the OMRON HEM 7124 digital sphygmomanometer*. The cuff is attached to the skin of the bare arm 2-3 cm from the elbow. Two blood pressure measurements were taken at 2-minute intervals and the average calculation of systolic and diastolic values was then recorded on the observation sheet.

All data is input into Ms. Excel and processed using SPSS version 26. The concentration of each ion is categorized and the blood pressure value is recorded. Hypertension in pregnancy is an increase in systolic blood pressure of more than 140 mmHg and diastolic blood pressure of more than 90 mmHg. The proportions and confidence intervals are 95% and the percentage of each ion category is calculated. The association between hypertension in pregnancy and each category was measured using odds ratios with 95% confidence intervals in simple logistic regression. The combined effect of all ions on the desired outcome is evaluated by multiple logistic regression. All methods are carried out with relevant guidelines and regulations. *Informed consents* were obtained from all respondents and/or guardians. The confidentiality of participants is respected by coding questionnaires with *ethical clearance* No. 013/EA/KEPK/2022.

Table 1 Normal Range of Serum Electrolyte

Ion	Third trimester pregnancy (mEq/L)
Sodium	130-148
Potassium	3,3-5,1
Chloride	97-109
Calcium	4,4-5,3

These values were used as a reference to determine whether the electrolyte concentrations of the respondents were within the normal range or were disturbed (high or low). Values outside the normal range can be an indication of electrolyte disorders that may contribute to hypertension in pregnancy.

RESULTS AND DISCUSSION

Characteristics of Research Respondents

The data was analyzed from 42 women at the end of the third trimester, with respondents aged 23-43 years. This table summarizes some of the characteristics of the respondents. Most respondents were aged 21-35 years old (57.1%).

Table 2 Characteristics of Research Respondents

Characteristic	Frequency	Propose (%)
Age		
1. 21-35 years old	24	57,1
2. 35-49 years old	18	42,9
Education		
1. SD	25	59,5
2. SMP	12	28,6
3. SMA	3	7,1
4. PT	2	4,8
Work		
1. Work	4	9,5
2. Not working	38	90,5
IMT		
1. Normal (18,5-25)	7	16,8
2. Fat (≥ 25.1)	35	83,2
Parity		
1. Primipara	12	28,6
2. Multipara	22	52,4
3. Large multi-stop	8	19
HDK History		
1. Yes	25	59,5
2. No	17	40,5
Family History of Hypertension		
1. Yes	21	50
2. No.	21	50

Most of the respondents were women aged 21-35 years (57.1%), last high school education (59.5%), and not working (90.5%). This shows the population of this study is dominated by women of productive age, secondary education, and most are not working. In addition, the majority of respondents had BMI which was included in the obese category (83.2%) and most had a history of hypertension in previous pregnancy (59.5%).

Table 3 Range and Average of Various Ions

Ion	Range (mmol/L) [Normal Range]	Average concentration \pm Standard Deviation (mmol/L)
Sodium	130-148	1.81 \pm 0.397
Potassium	3.3-5.1	1.64 \pm 0.485

Ion	Range (mmol/L) [Normal Range]	Average concentration ± Standard Deviation (mmol/L)
Chloride	97-109	2.64 ± 0.485
Calcium	4.4-5.3	1.90 ± 0.850

Table 3 shows the range of sodium, potassium, chloride, and calcium electrolyte ion concentrations in respondents who are in the third trimester of pregnancy. The data in the table includes the normal range of each electrolyte as well as the average concentration and standard deviation of each ion. These results illustrate variations in electrolyte levels in study respondents who experience hypertension in pregnancy, providing an early indication of potential electrolyte imbalances in that population.

The average sodium concentration in the respondents was in the range of 130-148 mmol/L, which shows consistency with the normal range. However, it was also found that some respondents had high sodium levels, which can contribute to fluid retention and increased blood pressure. For potassium, with a normal range between 3.3-5.1 mmol/L, the results showed that some respondents experienced hypokalemia (low potassium levels), which has the potential to increase the risk of hypertension due to imbalances in body fluids and cellular function.

Chloride concentrations ranged from 97-109 mmol/L, and there was a tendency to increase in some respondents with hypertension. Although chloride is often overlooked, these ions are important in regulating acid-base balance, which if impaired can affect blood pressure. Meanwhile, the calcium concentration was in the range of 4.4-5.3 mmol/L, and the results showed a case of hypocalcemia. Calcium deficiency is known to affect the contraction of the smooth muscles of blood vessels, which can lead to vasoconstriction and hypertension.

Overall, Table 3 indicates variations in electrolyte concentrations among pregnant women with hypertension. This electrolyte imbalance suggests a potential contribution to the incidence of hypertension in pregnancy, although further statistical analysis is needed to clarify the significant association of these findings. Monitoring electrolyte concentrations, particularly sodium, potassium, chloride, and calcium, is essential for detecting the risk of hypertension in pregnant women and preventing more serious complications.

Prevalence of Hypertension in Pregnancy, Low and High Ion Concentrations in the Blood

There were 42 pregnant women involved in this study, 59.5% of whom had hypertension in pregnancy. The prevalence of low and high ion concentrations is presented in table 4.

Table 4 Prevalence of Respondent Ion Concentrations

Ion	Prevalence of Low, Normal and High Ion Concentrations (%)			
	Concentration	Hypertension	No Hypertension	Total Prevalence (95% CI)
Sodium	Low	5 (11,9)	3 (7,1)	0,87 (0,94-1,81)
	Normal	20 (47,6)	14 (33,3)	0,34 (1,24-1,59)
Potassium	Low	8 (19)	7 (16,7)	0,57 (1,18-1,75)
	Normal	17 (40,5)	10 (23,8)	0,39 (1,18-1,57)

Ion	Prevalence of Low, Normal and High Ion Concentrations (%)			
	Concentration	Hypertension	No Hypertension	Total Prevalence (95% CI)
Chloride	Normal	7 (16,7)	8 (19)	0,57 (1,25-1,82)
	High	18 (42,9)	9 (21,4)	0,38 (1,14-1,52)
Calcium	Low	11 (26,2)	6 (14,3)	0,51 (1,1-1,61)
	Normal	7 (16,7)	5 (11,9)	0,62 (1,09-1,71)
	High	7 (16,7)	6 (14,3)	0,63 (1,15-1,78)

From these figures, it can be seen that the prevalence of hypertension is higher in those who have normal sodium (47.6%) and normal potassium (40.5%) concentrations. In contrast, the prevalence of hypertension was lower in those with low potassium concentrations (19%) and normal calcium (16.7%). However, this figure does not show a statistically significant relationship, but does indicate a variation in the prevalence of hypertension based on electrolyte levels.

Association of Ion Concentration with Hypertension in Pregnancy

The relationship between the different categories of ion concentration and hypertension in pregnancy is presented in table 5.

Table 5 Simple Logistic Regression Between Hypertension in Pregnancy and Ion-Ion Category

Ion	Concentration	Hypertension Category		Odds Ratio	Prevalance (95% CI)	P-value
		Hypertension	No Hypertension			
Sodium	Low	5	3	0,824	0,138-4,929	0,835
	Normal	20	14			
Potassium	Low	8	7	1,921	0,441-8,365	0,385
	Normal	17	10			
Chloride	Normal	7	8	2,515	0,544-11,632	0,238
	High	18	9			
Calcium	Low	11	6	1,002	0,118-5,327	0,955
	Normal	7	5			
	High	7	6			

From the results of this analysis, no ions showed a statistically significant association with hypertension in pregnancy. In retrospect, women with hypokalaemia had a 1.921 times higher chance of developing hypertension in pregnancy compared to women with normocalcaemia (OR = 1.921[0.441-8.365], p value = 0.385), while women with hyperchloraemia had a 2.515 times lower chance of developing hypertension in pregnancy compared to women with normocchloraemia (OR = 2.515 [0.544-11.632], p value = 0.238).

Discussion

Hypertension in Pregnancy as a Risk Factor

Hypertension in pregnancy, which includes preeclampsia and gestational hypertension, is one of the most common and clinically significant complications of pregnancy. Hypertension

in pregnancy is defined as an increase in systolic blood pressure ≥ 140 mmHg or diastolic ≥ 90 mmHg after 20 weeks of gestation in women who were previously normotensive. Based on the results of this study, the prevalence of hypertension in pregnancy reached 59.5% in respondents who were in the third trimester. This figure is consistent with global studies showing that gestational hypertension is a common complication in pregnancy and contributes to maternal morbidity and mortality. A study found that hypertension in pregnancy affects about 10-15% of all pregnancies worldwide, with prevalence varying across different countries (Magee *et al.*, 2016)

This condition needs special attention because hypertension in pregnancy is the main cause of maternal morbidity and mortality as well as the fetus. Another study emphasizes that gestational hypertension increases the risk of serious complications such as premature birth, placental abruption, fetal growth disorders, and fetal death. Furthermore, women with hypertension in pregnancy have a higher risk of developing chronic hypertension and cardiovascular disease in the future (Roberts and Cooper, 2020).

The study also found that the majority of women who experience hypertension have abnormal concentrations of sodium and potassium ions. This is in line with the theory that links electrolyte imbalances to hypertension in pregnancy. Hypertension in pregnancy can be triggered by a variety of factors including electrolyte imbalances, which can affect blood volume and osmotic pressure (Sibai, Dekker and Kupferminc, 2017).

Hypertension in pregnancy, especially preeclampsia, has a complex pathophysiology. Preeclampsia is characterized by endothelial dysfunction and systemic vasospasm leading to increased vascular resistance and increased blood pressure. One of the key factors in the development of preeclampsia is placental ischemia, which leads to the release of angiogenic factors that damage endothelial cells and cause vasoconstriction. In addition, kidney dysfunction due to electrolyte imbalance can worsen this condition. The imbalance between pro-angiogenic and anti-angiogenic factors contributes to the endothelial dysfunction typical of preeclampsia. This can be exacerbated by electrolyte imbalances, which affect blood pressure through fluid retention mechanisms and increased plasma volume (Roberts and Cooper, 2020).

Management of Hypertension in Pregnancy

The management of hypertension in pregnancy involves a multidisciplinary approach, including blood pressure monitoring, electrolyte intake regulation, and pharmacological therapy. Guidelines published by the American College of Obstetricians and Gynecologists (ACOG) recommend strict blood pressure monitoring and calcium supplementation for women at risk of preeclampsia. Calcium supplementation is effective in reducing the risk of preeclampsia in women with low calcium intake (Hofmeyr, Belizán and Von Dadelszen, 2018). In addition, the use of antihypertensives such as methyldopa, labetalol, and nifedipine is often recommended to manage high blood pressure during pregnancy. However, it is important to consider the interaction between these drugs and the patient's electrolyte status, since some antihypertensives can exacerbate electrolyte imbalances, specifically potassium.

Electrolyte Disruption as a Contributing Factor to Hypertension

In this study, although no statistically significant association was found between hypokalemia and hypertension (OR = 1.92, $p = 0.385$), there was a tendency that women with low potassium levels had a higher risk of developing hypertension. These findings are in line with other studies that have reported that low potassium levels can interfere with blood pressure regulation, leading to an increase in systolic blood pressure. Hypokalemia is known to reduce the body's ability to excrete sodium through the urine, which can ultimately increase fluid retention and blood pressure (Webster *et al.*, 2019). Another study confirms that electrolyte imbalances, especially potassium deficiency, may play a role in the pathophysiology of hypertension, especially in patients with gestational hypertension. Low potassium can also affect the function of blood vessel fine muscle cells, which play an important role in blood pressure regulation (Narang, Ingul and Wilkinson, 2020). The results of a national study conducted in the United States, show that young age and black races are more susceptible to hypokalemia than other age groups (Yang, Li and Dong, 2021). This study did not evaluate in detail the causes of excessive potassium loss from the gastrointestinal tract such as vomiting or diarrhea, chronic kidney injury, excessive sweating, and diabetes (Kardalas, 2018).

The results suggest that hyperchloride may have a protective effect against hypertension (OR = 2.515, $p = 0.238$), although it is not statistically significant. This is in line with research that showed 4.38% of women experienced hyperchloride during their previous pregnancy (Ajong *et al.*, 2023a), but this is contrary to some previous studies that have shown that high chloride levels are often associated with increased blood pressure. For example, other studies have shown that high chloride levels can increase vascular resistance and plasma volume, which ultimately increases blood pressure¹⁰. Increased serum chloride can affect blood volume and osmotic pressure, but its relationship with hypertension in pregnancy still needs more research. However, the results of this study may indicate that in some cases, increased chloride levels may be related to the body's compensation mechanisms for maintaining impaired electrolyte balance during pregnancy. More research is needed to understand the exact role of chloride in the pathophysiology of hypertension in pregnancy.

The findings of this study showed that there was no significant association between low calcium levels and hypertension (OR = 1.002, $p = 0.955$). Some literature has not shown an evaluation of the prevalence of ionized hypercalcemia in pregnancy and its risk factors. Previous research has stated that if the published upper limit of normal ionized calcaemia is correct, the prevalence of ionized hypercalcemia at the end of pregnancy is likely to be high. Although there is a positive correlation between total and ionized hypocalcemia, the high prevalence of total hypocalcemia is not associated with high levels of ionized hypocalcemia. In contrast, the rate of ionized hypercalcemia appears to be relatively high. Nonetheless, it is possible that pregnant women at the end of pregnancy begin to develop and tolerate relatively higher concentrations of ionized calcemia, despite the high levels of total hypocalcemia they experience. This phenomenon requires more sophisticated studies that follow variations in ionized calcaemia from the first trimester to the third trimester. This will likely lead to a review of normal ionized calcium concentrations for different trimesters (Ajong

et al., 2023a). This is in line with findings that show that women with hypertension in pregnancy or preeclampsia have significantly lower average calcium levels compared to women with normotensia (Owusu Darkwa, 2017), but other literature suggests that calcium has an important role in regulating blood pressure, especially in pregnant women. A meta-analysis showed that calcium supplementation in pregnant women at high risk of preeclampsia may reduce the prevalence of gestational hypertension (Hofmeyr, Belizán and Von Dadelszen, 2018).

Calcium is involved in the contraction of smooth muscles of blood vessels, and calcium deficiency can lead to vasoconstriction which contributes to an increase in blood pressure. Calcium supplementation can reduce the risk of hypertension complications in pregnant women, especially in women with low calcium intake before pregnancy (Sibai, Dekker and Kupferminc, 2017).

Sodium is an electrolyte that plays a very important role in regulating body fluid volume and blood pressure. Increased sodium levels, called hypernatremia, can lead to an increase in blood volume through water retention mechanisms, which then increase blood pressure. In this study, although there was no significant association between sodium and hypertension, the prevalence of hypertension was higher in the group with normal sodium concentrations (47.6%). High sodium consumption is associated with a higher risk of gestational hypertension, especially in populations with excess sodium intake¹². This indicates that although sodium levels may not be directly related, managing sodium intake is very important in pregnancy.

Clinical Implications and Treatment

The results of this study emphasize the importance of close monitoring of serum electrolyte concentrations, especially potassium and chloride, in pregnant women with hypertension. According to guidelines from the American College of Obstetricians and Gynecologists (ACOG), the management of hypertension in pregnancy should include electrolyte monitoring and appropriate dietary modifications. The administration of electrolyte supplements, such as calcium and potassium, may be considered to reduce the risk of further complications in pregnancy.

CONCLUSION

This study identified a link between electrolyte disorders and hypertension in pregnancy, especially in the third trimester. The results of the study showed that as many as 59.5% of respondents experienced hypertension in the third trimester of pregnancy. This prevalence suggests that hypertension in pregnancy is still a significant health problem in the population studied. Although there was no statistically significant association, it was found that women with low potassium levels (hypokalemia) had a higher tendency to develop hypertension compared to women with normal potassium levels (OR = 1.92). High chloride levels (hyperchloride) are paradoxically associated with a decrease in the likelihood of developing hypertension (OR = 2.515), although not statistically significant. Sodium and calcium levels did not show a significant association with hypertension in pregnancy in this study. This study highlights the importance of monitoring electrolyte concentrations, especially potassium and

chloride, in pregnant women at risk of hypertension. Electrolyte imbalances can affect blood pressure and can increase the risk of pregnancy complications such as preeclampsia. Further studies are needed to explore the direct relationship between electrolyte levels and hypertension on a larger population scale. This is important to obtain more statistically valid results and determine a clearer causal relationship.

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