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Plasma Electrolyte Patterns among Pregnant Women with Hypertensive Heart Disorder in Benin City, Nigeria

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ABSTRACT: Pregnancy characterizes noticeable physiological and hormonal changes, which could impact on plasma volume and electrolyte balance, influencing various aspects of maternal and fetal health. Hence, the objective of this is to examine the plasma electrolyte patterns AMONG pregnant women with hypertensive heart disorders in Benin City, Nigeria, using appropriate standard methods to focus on preeclampsia, pregnancy-induced hypertension (PIH), and normotensive controls. Analysis of the plasma levels of calcium, magnesium, sodium, potassium, and chloride revealed no significant changes between the groups when all trimesters were taken into account. As investigated per trimester, preeclamptic patients showed significantly lower plasma levels of sodium in the second and third trimesters as compared to controls. Conversely, PIH individuals exhibited elevated calcium levels during these trimesters. Severity of preeclampsia did not significantly influence plasma sodium, potassium, or chloride levels, and the influence of body mass index (BMI) toward the distribution of electrolytes among preeclamptic patients was negligible. The findings suggest that while plasma electrolyte levels are generally consistent across groups, certain patterns emerge when considering the trimester and type of hypertensive heart disorder. Further studies could elucidate the implications of these variations and contribute to improved clinical management for pregnant women with hypertensive heart disorders.

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A woman is said to be in pregnancy when she harbors one or more growing embryos in her womb. This condition is also known as gravidity and gestation. For humans, this span generally lasts aroundforty (40) weeks, calculated from the beginning of the previous menstrual cycle to childbirth, or approximately 38 weeks (266 days) from conception, when a sperm meets and fertilizes an egg in the fallopian tube (Obrowski *et al*., 2016). Pregnancy may occur naturally through sexual intercourse or with the aid of assisted reproductive methods like artificial insemination. According to Tijjani *et al*. (2014), this time span is split into three segments, or trimesters, each of which has distinct maturation standards. The body's ability to maintain proper balance of fluids and electrolytes depends on the kidneys, and throughout conception, hormonal changes and stress-related factors might affect this process (Opoku-Okrah *et al*., 2015). Healthy gestation causes changes in the kidney system's physiology as well as anatomy that are impacted by the expanding uterus and elevated estrogen and progesterone levels. The total amount of plasma may alter as a result. For example, increased amounts of estrogen lower the hormonal regulation

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threshold, that affects thirst and arginine vasopressin and raises the quantity of plasma. Significant vasodilation raised kidney circulation, as well as a greater glomerular filtration rate—which peaks in the second trimester—all contribute to improved renal function. Nevertheless, a surge in kidney vasculature and interstitial volume rather than an elevation in nephron count is the reason behind the surge in plasma volume (Obembe *et al*., 2003). Preeclampsia is a disorder that usually manifests as elevated blood pressure as well as sugar in the bloodstream. In women with a normal pulse before the 20th week of pregnancy, edema may also be present. It is a pregnancy-specific syndrome and a leading cause of illness and death among mothers and babies. This condition is unique to human pregnancy (Tijjani *et al*., 2012). Research has indicated that levels of calcium and magnesium in the blood can influence blood vessel behavior during pregnancy, while other studies have offered conflicting results about how sodium and potassium levels affect blood vessel function. However, compared to normal in blood pressure pregnant and non-pregnant people, blood levels of both potassium and sodium have been found to be significantly decreased during preeclampsia as well as pregnancy-induced hypertension (Indumati *et al*., 2011). According to a comprehensive countrywide survey, only 4–11% of women with healthy blood sugar levels throughout their first pregnancy experienced elevated levels of blood pressure 10 years after giving birth, while 14–32% of women with hypertensive disorders throughout their first pregnancy experienced this condition.In addition, women with hypertensive disorders throughout the course of their earlier pregnancy had a greater likelihood of post-pregnancy hypertension than women without such disorders. This difference was seen within the initial period shortly after delivering birth, and it increased by up to 10 times over the ten years that followed childbirth (Behrens *et al*., 2017).The underlying cause of preeclampsia remains unclear despite extensive research. However, what is known is that this condition is linked to an imbalance in electrolytes among pregnant women due to significant shifts in the concentration of intracellular water. This phenomenon is linked to modifications primarily through cell membranes, which seem to be in charge of a number of pathogenic preeclampsia occurrences. According to the suggested process, such modifications entail adjustments in internal cell and systemic sodium ion transport (Faisal *et al*., 2009). In addition, an overabundance of sodium chloride can cause water and sodium utilization, which may boost the amount of intravascular as well as extracellular fluid volume as well as blood flow and heart rate. The human body regulates itself in response through increasing circulation of blood to tissues that finally causes a surge in resistance in the peripheral regions resulting in the onset of hypertension (Sullivan and Martin, 1994). According to the outside arterial vasodilation principle, elevated blood pressure, fluid retention, as well as amino acids within urine are the main signs of preeclampsia-eclampsia, which are caused by elevated damage to endothelial cells, retained sodium, along with increased responsiveness to angiotensin (Indumati *et al*., 2011). This hypothesis also has an impact on the pathogenesis of preeclampsia-eclampsia.

Electrolytes are essential for basic biological functions such as producing impulses in muscles alongside neurons as well as preserving the electrical equilibrium inside cells. Chlorine, sodium, as well as potassium are important electrolytes. This comparative research looks at magnesium, calcium, phosphate, bicarbonates, and blood levels of minerals potassium and sodium during the three phases of gestation. Electrolytes are obtained via our meals and beverages. Any element with either a positive or negative charge is referred to as an "Electrolyte" in general (Terry, 1994).An electrolyte comprises an organic substance that may carry electric when it either dissolves in water or melts and separates through electric charged particles called ions. This group comprises sodium levels (Na^+), the potassium (K^+), calcium as well (Ca^{2+}), magnesium (Mg^{2+}), as well chloride (Cl^-) as its principal ions. Charged particles called ions are present in bodily fluids both within as well as outside of cells. During outside fluid, salt becomes the principal positive charge whereas chloride is the principal negatives particle. Potassium is the predominant positively charged ion in intracellular fluid (ICF). The electrolytes are found in perspiration and urine thus are essential for many body processes. The minerals in question disintegrate in liquids to generate ions, which are essential to metabolic activities and can have either a negative or positive charge (West, 2018). The typical serum sodium level of pregnant women falls between 129 mMoL/L and 149 mMoL/L. In a woman weighing 60 kilograms, the total sodium content is about 53 grams. Of this total, around 20 grams are stored in the bones, where it stays relatively static, contributing little to the daily sodium ion exchanges in the body. Fatty tissue contains virtually no sodium, with each 100 grams of fat-free body mass holding about 0.109 grams of sodium (Abbassi-Ghanavati *et al*., 2009). Pregnancy-related hormonal shifts and physiological changes can increase the risk of sodium imbalances in expectant mothers, affecting metabolism, the cardiovascular system, and the urinary system. Additionally, medications that influence electrolyte levels, like

diuretics, can also lead to sodium imbalances (Kugler and Hustead, 2000).About 20% of hospitalized patients have hypokalemia, a disease that develops when blood potassium degrees fall under 3.5 mEq/L. Renal failure linked to alkalosis of the metabolism and hyperaldosteronism may be the cause of illness. Low concentrations of potassium have been linked toward cardiac as well as neuromuscular problems that can affect breathing function (below 3.0 mEq/L). Additionally, hypokalemia can lead to glucose intolerance by inhibiting the pancreas' ability to secrete insulin (Reyes and Gadsby, 2006). Extremely low potassium levels carry the risk of cardiac or respiratory arrest (Baltazar and Hypokalemia, 2009On the other hand, hyperkalemia, which is frequently brought on by renal impairment as a result of diminished renal function, is defined as serum potassium levels over 5.0 mEq/L. Hyperkalemia can cause potentially fatal arrhythmias if it is not treated right away (Baltazar and Hypokalemia, 2009). Plasma electrolytes—sodium, potassium, calcium, and magnesium—are essential for nerve transmission, muscle contraction, fluid balance, and other critical physiological functions. Disturbances in these electrolytes can exacerbate cardiovascular conditions, complicate pregnancy, and potentially endanger the fetus. Understanding the plasma electrolyte pattern among pregnant women with hypertensive heart disorders can offer insights into the pathophysiology of these conditions and inform better clinical management strategies. This study aims to explore the electrolyte profiles in this specific group to identify any significant variations or trends that could contribute to improved patient care and treatment protocols. Hence, the objective of this study is to examine the plasma electrolyte patterns among pregnant women with hypertensive heart disorders in Benin City, Nigeria

MATERIALS AND METHODS

Participants: This study was conducted at the Department of Obstetrics and Gynecology, Central Hospital Benin. It was a prospective case-control research involving 190 women .The Study Participants were organized into three groups; a preeclampsia group (n = 124),Pregnancy induced hypertension (n=30) and a normotensive, normal pregnant group (n = 36).). For the present investigation, maternal illnesses with a history of cardiovascular disease, renal disease, diabetes mellitus, thyroid disease, hepatic disease, or any related disorders including urinary tract infections were excluded.Blood pressure measurements were performed with patients in a prone position on at least two separate occasions with a mercury sphygmomanometer.

The study Participants had a single antecubital venipuncture, during which 5ml of venous blood was drawn using a sterile disposable syringe. The obtained whole blood was drawn into a bottle that had been heparinized, instantly separated, and the plasma was collected into a 5 ml plain vial by a Pasteur pipette. The sample was stored at minus 4 degree until ready for analysis Plasma electrolytes concentration which include sodium, potassium, chloride, bicarbonate was by the use of an indirect ion selective electrolyte analyzer while calcium and magnesium was done using spectrophotometric methods.

Statistical analysis: In the present study, statistical analyses of data were carried out using SPSS, version 23 (the Statistical Package for Social Science SPSS Version 23 USA). Data obtained were presented as mean ± standard deviation

Ethical approval: Informed consent was obtained from all the study participant. The nature and aim of this work were fully discussed with the study participants and they had the right to withdraw from the study without being adversely affected regarding the medical service they received. Ethical approval of ethical committee (Ref. No. A.723/56) was also obtained from the Hospitals Management Board, Edo State

RESULTS AND DISCUSSION

The Table below presents the demographic features of the study population. There were a total of 190 respondents – 124 being preeclamptic, 30 being PIH compared to 36 respondents who were normotensive. Given that all groups were sampled at same time and day, it would therefore be suggested that preeclampsia in Benin City. May just be prevalent. Among the preeclamptic cases, there were more women who had remarried, while those within their first marriage dominated the control groups.Percentage respondents distributed by age has been presented on Figure 1. Majority of the respondents, whether preeclamptic, control or PIH, were below 40 yrs old. Grouped data (totals) for electrolytes of respondents presented irrespective of trimester has been presented on Table 2. Plasma Calcium (mg/dl) level was 9.97 mg/dl in preeclampsia, 9.45 mg/dl in the control and 9.66 mg/dl in PIH, respectively ($p>0.05$). There is no significant differences in plasma magnesium (mg/dl) were also reported among all the study groups (2.53 – 2.63 mg/dl). Similarly, no significant changes in plasma sodium, potassium and chloride levels, compared to the control, were reported (Table 2).

Table 1: Demographic data of respondents

Queries		Preeclampsia cases (A) n (%) (N=124)	Control (B) n (%) (N=36)	PIH(C) n (%) (N=30)	p-values		
					(A+B)	(A+C)	(B+C)
Marital status							
	Single	3 (2.4)	2 (5.6)	0	0.323	0.032*	0.041*
	First Marriage	92 (74.2)	33 (91.7)	10 (100)	0.041	0.006*	0.032*
	Remarried	29 (23.4)	1 (2.8)	0	0.013	0.027	0.072
Religion							
	Christianity	122 (98.4)	20 (55.6)	10 (100)	0.006*	0.713	0.031*
	Islam	2 (1.6)	16 (44.4)	0	0.001*	0.742	0.000*
	Others	0	0	0	0	0	0
Educational status							
	None	4 (3.2)	0	0	0	0	0
	Primary	17 (13.7)	3 (8.3)	3 (30)	0.442	0.441	0.989
	Secondary	47 (37.9)	16 (44.5)	3 (30)	0.11	0.028*	0.001*
	Post-secondary	56 (45.2)	17 (47.2)	4 (40)	0.142	0.146	0.083
Job status							
	Employed	102 (82.3)	27 (97.5)	8 (80)	0.192	0.892	0.173
	Unemployed	22 (17.7)	9 (2.5)	2 (20)	0.014	0.07	0.009*
Job type							
	Entrepreneur	86 (69.4)	26 (72.2)	9 (90)	0.211	0.045*	0.064
	Civil servant	16 (12.9)	5 (13.9)	0	0.791	0.001*	0.001*
	House wife	22 (17.7)	5 (13.9)	1 (10)	0.075	0.051	0.103

**Significant ($p<0.05$)*

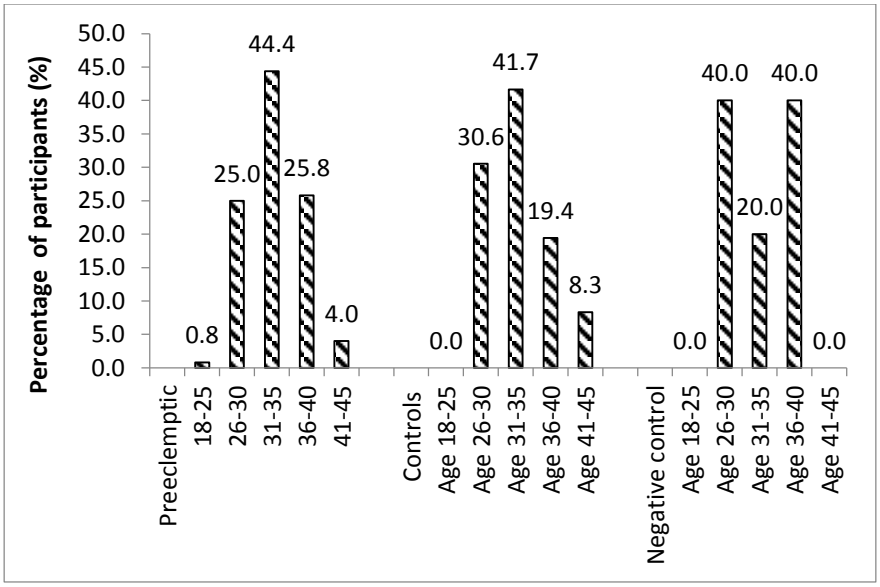

Fig 1: Percentage of respondents by age

Table 2: Grouped data (totals) for electrolytes of respondents presented irrespective of trimester

Queries	Preeclampsia cases (A) (µ±SEM) (n=124)	Control (B) (µ±SEM) (n=36)	PIH(C) (µ±SEM) (n=30)	p-value (A+B)	p-value (A+C)	p-value (B+C)
Plasma Calcium (mg/dl) (mg/dl)	9.97±0.05	9.45±0.21	9.66±0.18	0.136	0.067	0.141
Plasma Magnesium (mg/dl)(mg/dl)	2.63±0.74	2.53±0.17	2.59±0.16	0.548	0.612	0.709
Plasma Na+ (mMol/l) (mMol/l)	131.90±0.35	135.59±1.07	134.80±1.71	0.071	0.057	0.034
Plasma - K+ (mMol/l) (mMol/l)	3.32±0.02	3.37±0.03	3.31±0.02	0.191	0.116	0.190
Plasma - Cl- (mMol/l)(mMol/l)	91.91±0.36	94.38±0.76	95.00±1.49	0.305	0.251	0.092

It was necessary to investigate if concentrations of electrolytes would differ according to incidence of trimesters (Table 3) and on the basis of severity of disease (Table 4). Comparative with normotensive individuals, Calcium (mg/dl) levels in PIH individuals may be significantly elevated ($p<0.05$) at both 2nd and 3rd trimesters respectively. For plasma sodium, there was significant reduction in preeclampsia at both trimesters. The severity of preclampsia did not influence the levels of plasma sodium, potassium or chloride ($p>0.05$) (Table 4). Similarly, the influence of body mass index among the distribution of electrolytes in preeclamptic patients compared to normotensive was negligible ($p>0.05$) (Table 5). The research aimed to investigate the plasma electrolyte patterns among pregnant women with hypertensive heart disorders in Benin City, with a focus on preeclampsia and pregnancy-induced hypertension (PIH). The physiological changes during pregnancy, such as increased plasma volume, hormonal fluctuations, and changes in renal function, are known to influence electrolyte levels. Considering that preeclampsia and PIH significantly increase the morbidity and mortality of both mothers and fetuses, understanding these patterns provides crucial insights into the pathophysiology of these conditions. Hypertensive heart disorder in pregnant women is a critical condition that requires a thorough understanding of the plasma electrolyte pattern to manage the associated risks effectively. Studies show that postpartum hypertension, ischemic coronary artery disease, and strokes are more common in women having previous episodes of hypertensive problems during pregnancy (Behrens *et al*., 2017). Reputable associations such as the American Cardiovascular Association as well as the European Association of Cardiology have changed their guidelines in response to these results in order to treat hypertension problems during pregnancy (Behrens *et al*., 2017). Additionally, studies have demonstrated the significance of controlling hypertension before to, during, and following pregnancy because of its substantial influence on the health and mortality of both mothers and fetuses (James *and* Nelson-Piercy, 2004). Studies have also emphasized the relevance of assessing plasma concentrations of various biomarkers and vasoactive peptides in pregnant women with hypertensive disorders to understand the underlying pathophysiology (Manninen *et al*., 1994; Lu *et al*., 2017; Iorio *et al*., 1998).

Table 3: Electrolytes of respondents presented on the basis of trimesters. Only means of replicates have been presented.

Queries	**Trimester**	**Preeclampsia cases (A) (n=62)**	**Control (B) (n=16)**	**PIH(C) (n=15)**	**(A+B)**	**(A+C)**	**(B+C)**
					p-values		
Calcium (mg/dl)	Second	9.93	7.77	9.85	0.644	***<0.001***	***<0.001***
	Third	9.92	4.72	9.14	0.006	***<0.001***	***<0.001***
Magnesium (mg/dl)	Second	2.82	3.12	2.56	0.315	0.503	0.453
	Third	2.44	3.18	2.54	0.624	0.045	0.051
Plasma Na+ (mMol/l)	Second	132.27	135.19	134.60	***0.028***	0.235	0.312
	Third	131.54	135.93	135.00	***<0.001***	0.072	0.102
Plasma - K+ (mMol/l)	Second	3.29	3.40	3.38	0.073	0.350	0.365
	Third	3.34	3.36	3.48	0.932	0.362	0.423
Plasma - Cl- (mMol/l)	Second	91.41	93.88	95.80	0.068	0.053	0.132
	Third	92.41	94.80	94.20	0.113	0.262	0.523

Table 4: Analyte composition of preeclamptic subjects separated on the basis of severity of disease

Analytes	Groups	N	Mean	Std. Error Mean	p-value
Plasma Na+ (mMol/l)	Mild	39	132.87	0.5039	0.087
	Severe	84	131.58	0.4545	
Plasma - K+ (mMol/l)	Mild	39	3.3276	0.0403	0.875
	Severe	84	3.3199	0.027	
Plasma - Cl- (mMol/l)	Mild	39	92.878	0.4854	0.102
	Severe	84	91.628	0.4646	

According to research, pregnant women with hypertensive conditions had considerably decreased plasma nitrite levels than pregnant women having healthy blood Pressure (Sandrim *et al*., 2008). Moreover, a number of pulmonary, cardiovascular, as well as metabolic problems have been connected to women with undiagnosed obstructive sleeping apnea. These conditions may raise the chance of acquiring persistent hypertension and even hypertensive diseases while pregnant (Dominguez *et al*., 2018). According to our research, women with preeclampsia had far lower plasma sodium levels than normotensive controls did, especially throughout the second and third trimesters. This result is consistent with past research that suggests an imbalance in sodium mobility and absorption plays a role in preeclampsia, leading to elevated levels of blood pressure, swelling, as well as proteinuria (Faisal *et al*., 2009). Decreased

concentrations of sodium may be explained through the peripheral vascular dilation theory (Indumati *et al*., 2011), which suggests that preeclampsia may develop as a result of elevated salt retention alongside sensitivity to angiotensin.

Table 5: Comparing Analyte composition of preeclamptic subjects separated on the basis of BMI

	Group 1 – Normal vs Overweight					Group 2 – Normal vs Obese				
		N	Mean	SEM	p-value		N	Mean	SEM	p-value
Calcium (mg/dl)	Normal	23	9.843	0.112	0.498	Normal	23	9.843	0.112	0.343
	Overweight	71	9.932	0.065		Obese	30	9.9922	0.106	
Magnesium (mg/dl)	Normal	23	2.5073	0.223	0.491	Normal	23	2.5073	0.223	0.466
	Overweight	71	2.6439	0.087		Obese	30	2.7033	0.16	
Plasma Na	Normal	23	131.174	0.978	0.33	Normal	23	131.17	0.978	0.496
	Overweight	71	132.099	0.435		Obese	30	132.02	0.774	
Plasma K	Normal	23	3.3924	0.072	0.185	Normal	23	3.3924	0.072	0.191
	Overweight	71	3.3088	0.027		Obese	30	3.2933	0.036	
plasma Cl	Normal	23	92.2935	0.926	0.51	Normal	23	92.294	0.926	0.993
	Overweight	71	91.6444	0.472		Obese	30	92.283	0.766	

Interestingly, the plasma calcium levels were found to be higher in women with PIH during the second as well as third trimesters compared to controls. This elevation among calcium may contribute to vascular changes seen in hypertensive pregnancies, as calcium ions are vital for muscle contraction and maintaining vascular tone (Terry, 1994). The increase in plasma calcium could be related to the body's response to increased peripheral resistance, a characteristic of hypertensive heart disorders (Sullivan and Martin, 1994). Despite these differences, other electrolyte levels, such as potassium, magnesium, and chloride, did not show significant variations across the groups. This suggests that while some electrolytes like sodium and calcium may play crucial role in the development or progression of hypertensive heart diseases, others might not be as closely linked. The results align with previous studies that reported lower sodium concentrationas well as potassium levels in preeclampsia and PIH, indicating a potential relationship between these electrolyte levels and hypertensive conditions (Indumati *et al*., 2011). Our findings also revealed that the severity of preeclampsia did not significantly influence the levels of plasma sodium, potassium, or chloride, indicating that the severity of the condition might be driven by other factors. Moreover, body mass index (BMI) showed a negligible influence on electrolyte distribution among preeclamptic patients, suggesting that BMI alone may not be a significant determinant of electrolyte imbalances in these conditions. Pregnant women with heart disease are vulnerable to cardiovascular complications; therefore, it is important to track plasma BNP ranges in relationship to heart dysfunction (Singh *et al*., 2019). According to the ESC EORP ROPAC Registry, high blood pressure conditions in pregnancy are highly prevalent and poorly tolerated in pregnant women via heart condition (Ramlakhan *et al*., 2022).

Conclusion: In summary, this study's findings advance our knowledge of the connection between pregnant women's hypertensive cardiac problems and plasma electrolyte patterns. The observed trends highlight the potential impact of sodium and calcium imbalances in preeclampsia and PIH, offering avenues for further research. Future studies could explore the role of hormonal changes, kidney function, and lifestyle factors in these conditions to develop better clinical management strategies for affected women. Understanding these relationships can ultimately improve maternal and fetal health outcomes in Benin City and beyond.

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