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Pattern of Liver Biochemical Markers and Their Association with Blood Pressure in Preeclampsia: Insights from Tertiary Hospitals in Enugu, Nigeria

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Ethical clearance for the study was obtained from the Health Research Ethics Committee of the University of Nigeria Teaching Hospital (NHREC/05/01/2008B-FWA00002458-IRB00002323). All procedures conformed to the ethical standards outlined in the 1964 Declaration of Helsinki. Confidentiality and anonymity were maintained through coded data handling and secure storage of personal information.

ABSTRACT

Preeclampsia is a hypertensive disorder of pregnancy that can cause multi-organ dysfunction. In severe cases, it often manifests as hepatic impairment. This study aimed to characterize liver biochemical marker patterns and assess their association with blood pressure in preeclampsia. Data were obtained from tertiary hospitals in Enugu, Nigeria. We performed a cross-sectional study at two hospitals in Enugu metropolis, South East, Nigeria. Participants were recruited between April 2024, and March 2025. Using simple random sampling, sixty pregnant women were recruited: 30 with preeclampsia and 30 normotensive controls. Participants were matched by age and gestational age. We assessed liver function markers such as; alanine aminotransferase (ALT), aspartate aminotransferase (AST), and alkaline phosphatase (ALP) and blood pressure using standard protocols. Results showed that women with preeclampsia had significantly elevated ALT, AST, and total bilirubin levels compared to the control group ($p < 0.05$). ALP concentrations were similar between groups. We found strong positive correlations between elevated blood pressure and increased AST and ALT. These findings demonstrate a robust relationship between hypertension and hepatic dysfunction in preeclampsia. This underscores the importance of routine liver function assessment in managing preeclampsia. Early identification of hepatic involvement may enable timely intervention and reduce maternal and neonatal risks.

Key words; Preeclampsia, Alkaline phosphatase, Liver enzymes (AST, ALT), Total bilirubin, Enugu.

Introduction

Preeclampsia is a pregnancy-specific hypertensive disorder that presents after 20 weeks of gestation. It is characterized by elevated blood pressure ($\geq 140/90$ mmHg) and multisystem involvement, including proteinuria, hepatic or renal dysfunction, thrombocytopenia, or neurological complications (American College of Obstetricians and Gynecologists [ACOG], 2020; Guarino et al., 2020). The global prevalence of preeclampsia is estimated at 2-8%, with

preeclampsia as the leading cause of maternal and perinatal mortality and morbidity. Regions with little or no resources for quality primary health care, including Nigeria, are most severely affected (Chang et al., 2023). Pre-eclampsia results from abnormal placentation, systemic inflammation, oxidative stress, and endothelial dysfunction, leading to impaired maternal organ function and compromised fetal well-being (Ali et al., 2024; Yang et al., 2024). The resultant adverse perinatal and maternal effect of preeclampsia

includes impaired uteroplacental perfusion, which may cause intrauterine growth restriction, placental abruption, preterm birth, or stillbirth (Obeagu & Obeagu, 2024; Waller & Saade, 2024). The liver plays a crucial role in metabolic regulation (Mohan, 2025) and is often affected in preeclampsia. Serum enzyme levels are considered indicators of a person's overall health, especially in situations involving hepatocyte injury and related physiological stress (Obianyido et al., 2023). Although the liver is not a primary target organ in preeclampsia, its crucial role in supporting fetal intrauterine development makes it particularly vulnerable. In physiologically normal pregnancy, the liver already experiences functional stress, and this stress can become one of the earliest indicators of multisystem dysfunction during the severe progression of preeclampsia (Zhestkova et al., 2023). Liver enzymes such as alanine aminotransferase (ALT), aspartate aminotransferase (AST), and alkaline phosphatase (ALP) are biomarkers critical for evaluating liver injury. (Atoe et al., 2024; Chaudhary et al., 2024). Elevated liver enzyme activities are associated with about 10–14% of maternal deaths in preeclampsia (Mohajan, 2025). These markers can indicate early liver involvement as preeclampsia develops. For example, HELLP syndrome, a severe complication, involves spasms in the liver blood vessels, increased liver enzymes, and decreased platelet counts, ultimately resulting in fatal bleeding (Naruse, 2024). Another serious disorder, acute fatty liver of pregnancy (AFLP), can lead to rapid liver failure and, without treatment, maternal death. This highlights the importance of early detection and regular monitoring of liver markers in preeclampsia women, particularly in low- and middle-income countries (LMICs), to enhance outcomes.

There is limited local data on liver biochemical markers in women with preeclampsia in Enugu, Nigeria. Most research has prioritized blood pressure control and obstetric results (Ali et al., 2024; Hundt et al., 2024), rather than liver function. This study aims to fill that gap by analyzing liver enzymes activity in women affected in the Enugu Metropolis. These results aim to support clinical care and improve maternal health in similar resource-limited environments.

Materials and Methods

Study design

The study employed a cross-sectional study design, conducted between April 2024 and April 2025 in Enugu Metropolis. Enugu metropolis is the capital city of Enugu State, located in the southeastern region of Nigeria, with residents engaged in diverse sectors such as public service, commerce, agriculture, and the creative industries (Obianyido et al., 2024). Enugu serves as a regional medical hub with tertiary centers specializing in high-risk obstetric conditions such as preeclampsia. The study included two referral hospitals: the University of Nigeria Teaching Hospital and the Enugu State University of Science and Technology Teaching Hospital, both of which offer comprehensive maternal care. Pregnant women were randomly recruited from antenatal clinics. Liver function parameters (ALT, AST, and ALP) were measured in women with preeclampsia and compared to normotensives.

Eligibility Criteria

Eligible participants were pregnant women aged 18 years and above who had resided in Enugu Metropolis for a minimum of six months and provided informed consent. Inclusion into the pre-eclampsia group was based on a confirmed clinical diagnosis of preeclampsia by attending obstetricians. Exclusion criteria encompassed individuals younger than 18 years, those who had lived in the area for less than six months, and individuals unable to provide informed consent due to cognitive, linguistic, or psychological limitations. Participants with a known history of liver disease, as well as those without a definitive diagnosis of preeclampsia (for the case group), were also excluded from the study.

Ethical Approval

Ethical clearance for the study was obtained from the Health Research Ethics Committee of the University of Nigeria Teaching Hospital (NHREC/05/01/2008B-FWA00002458-1RB00002323). All procedures conformed to the ethical standards outlined in the 1964 Declaration of Helsinki. Confidentiality and anonymity were maintained through coded data handling and secure storage of personal information.

Sample Size determination and Participant Recruitment

The sample size was calculated using the standard formula for cross-sectional studies, as described by Niang et al. (2022). Obianyido et al., (2024) using documented 3.3% as the prevalence of pre-eclampsia in Enugu. After adjusting for 10% non-response rate, the final sample size was approximated to sixty participants (thirty preeclampsia women and thirty normotensives used as control) to ensure adequate statistical power and representation. Participants were recruited using the simple random sampling technique, every third consenting pregnant woman that fulfilled the eligibility criteria was selected and enrolled until the target sample size was reached.

Data Collection

Upon obtaining informed consent, data were collected using pre-tested, semi-structured questionnaires administered by trained nurses. The questionnaire captured detailed socio-demographic information, medical history, obstetric parameters, and relevant clinical data, including age, gestational age and any pre-existing conditions that could influence liver function.

Anthropometric measurements

WHO recommended standard operating procedure and instruments were used to collect clinical data from the respondents. Trained nurses were utilized to measure the blood pressure of respondents using the Omron automatic sphygmomanometer (M2: HEM-7121-E, Vietnam). The participants sat comfortably with their arms resting on a table at the same level with the heart. Blood pressure was determined twice (minimum of five (5) minutes interval was observed). Average of the two readings was used for analysis.

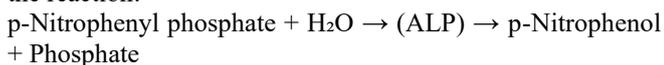
The blood pressure was measured in millimeters of mercury (mmHg).

Blood Sample Collection

A total of five milliliters of venous blood was collected from each study participant by trained phlebotomists under strict aseptic conditions to ensure sample integrity and participant safety before collection. The skin around the antecubital fossa was thoroughly cleansed with methylated spirit, blood samples were collected from the antecubital vein using sterile syringes and transferred into plain tubes and were immediately transported to the laboratory. In the laboratory, blood was allowed to clot at room temperature before being centrifuged at 1500 rpm for 10 minutes to separate the serum from the blood cells. The serum were carefully aliquoted into sterile containers of the assessment of Liver enzyme activity such as alanine transaminase (ALT), aspartate transaminase (AST) and alkaline phosphatase (ALP). All samples were analyzed within 24 hours of blood sample collection, as this time-frame ensured the integrity of the biochemical parameters being assessed.

Liver function assay

The colorimetric method was used to estimate serum liver enzymes in this study. Specifically, the Reitman-Franke method, as described by Rifai (2017), was used to measure aspartate aminotransferase (AST) and alanine aminotransferase (ALT). The principle of this method is based on the formation of oxaloacetate hydrazone with 2,4-dinitrophenylhydrazine, which is then quantified spectrophotometrically to determine enzyme activity. Serum alkaline phosphatase (ALP) was measured using the spectrophotometric method developed by Belfield and Goldberg (Rifai, 2017). This assay is based on the ability of ALP to catalyze the hydrolysis of p-nitrophenyl phosphate at pH 10.4, liberating p-nitrophenol and phosphate according to the reaction:



The rate of p-nitrophenol formation, measured colorimetrically, is directly proportional to the catalytic concentration of ALP present in the sample (Burtis et al., 2012).

Data Analysis

Data obtained from this study were saved in Microsoft excel 2016 and were analyzed using Graph-Pad Prism Version 7. Descriptive statistics, including mean and standard deviation, were used to summarize continuous variables such as age, systolic blood pressure (SBP), diastolic blood pressure (DBP), gestational age, and liver enzyme levels (ALT, AST, ALP). Comparisons between the group with pre-eclampsia and the control group were performed using the Student's t-test. Pearson's correlation analysis was employed to examine the relationship between blood pressure (SBP and DBP) and liver enzyme levels. A P-values of <0.05 was used to evaluate statistical significance.

Results

Table 1 showed the sociodemographic indices of the study participants. A total of 60 women participated: 30 with preeclampsia and 30 normotensive controls. The age distribution differed significantly between groups ($p < 0.05$). In the preeclampsia group, 56.7% of participants were aged 30–39 years, 40.0% were 40–49 years, and 3.3% were 20–29 years. In contrast, the normotensive group had an even distribution across all age categories, with 33.3% in each bracket. Statistically, there is no significant ($p > 0.05$) difference in the educational attainment of test subjects within the two groups. In the preeclampsia group, 60.0% had completed tertiary education, and 40.0% had completed secondary education. Among normotensive women, 46.7% had completed tertiary education and 53.3% had completed secondary education. No participants in either group had only primary education. Occupational status did not differ significantly between groups ($p < 0.05$). In the preeclampsia group, 83.3% were employed and 16.7% were unemployed. In the normotensive group, 66.7% were employed and 33.3% were unemployed. The employment profiles of both groups are comparable. Table 2 showed the anthropometric parameters of the study participants. The mean age of the preeclamptic participants was 36.50 ± 4.55 years, while the control group had a mean age of 37.00 ± 3.52 years. Statistically, there is no significant ($p > 0.05$) difference in the age between the two groups ($P > 0.05$). The systolic blood pressure (SBP) of the participants with preeclampsia (186.00 ± 6.00 mmHg) was significantly ($p > 0.05$) higher than that of the control group (106.00 ± 10.40 mmHg). Similarly, the diastolic blood pressure (DBP) was significantly elevated in the preeclamptic group (115.00 ± 3.50 mmHg) compared to the control group (67.7 ± 2.32 mmHg; $P < 0.05$). Gestational age at the time of the study showed no significant difference between the participants with preeclampsia (31.70 ± 4.22 weeks) and the controls (31.30 ± 4.97 weeks; $P > 0.05$). The serum levels of liver enzymes were elevated in patients with preeclampsia compared to the control group. The total bilirubin levels were significantly higher in the group preeclampsia (0.72 ± 0.21 mg/dl) compared to the control group (0.47 ± 0.08 mg/dl) with a P-value of <0.001. Alanine transaminase (ALT) levels were also significantly elevated in the preeclamptic group (23.60 ± 2.72 μl) compared to the control group (15.40 ± 2.35 μl ; $P < 0.05$). Aspartate transaminase (AST) levels were markedly higher in the group with preeclampsia (39.00 ± 6.26 μl) compared to the controls (11.60 ± 1.46 μl ; $P < 0.05$). Table 3 showed the correlation between blood pressure and liver enzymes in the study participants. A significant positive correlation was observed between systolic blood pressure and Alanine Transaminase (ALT) ($r = 0.414$, $p < 0.05$) as well as Aspartate Transaminase (AST) ($r = 0.648$, $p < 0.05$). There was also a weak positive statistically significant correlation between systolic blood pressure and Alkaline Phosphatase (ALP) ($r = 0.398$, $p < 0.05$). For diastolic blood pressure, a weak positive correlation was observed with AST ($r = 0.530$, $p < 0.05$). A moderate positive correlation between systolic blood pressure and Alkaline Phosphatase was significantly ($p < 0.05$) observed.

Table 1. Socio-demographic indices of the study participants

Parameters	Preeclampsia N (%)	Normotensive N (%)	p-value
Sex			
Female	30(100.0)	30(100.0)	
Total	30(100.0)	30(100.0)	
Age(years)			0.009
20-29	01(3.3)	10(33.3)	
30-39	17(56.7)	10(33.3)	
40-49	12(40.0)	10(33.3)	
Total	30(100.0)	30(100)	
The highest level of education completed			0.450
Completed Primary	0(0)	0(0,0)	
Completed Secondary	12(40.0)	16(53.3)	
Completed Tertiary	18(60.0)	14(46.7)	
Total	30(100.0)	30(100)	
Occupational status			0.140
Employed	25(83.3)	20(66.7)	
Unemployed	05(16.7)	10(33.3)	
Total	30(100.0)	30(100.0)	

Table 2. Anthropometric parametrs and serum liver enzymes in Preeclampsia patients attending tertiary hospitals in Enugu metropolis.

Parameters	Preeclampsia	Normotensive	P-value
Age (Year)	36.50 ± 4.55	37.00 ± 3.52	0.659
Gestational Age (wks)	31.70 ± 4.22	31.3 ± 4.97	0.7805
SBP (mmHg)	186.00 ± 6.00	106.00 ± 10.40	0.001
DBP (mHg)	115.00 ± 3.50	67.7 ± 2.32	0.001
Total Bilirubin mg/dl	0.72 ± 0.21	0.47 ± 0.08	<0.001
Alanine Transaminase IU/l	23.60 ± 2.72	15.40 ± 2.35	0.005
Aspartate Transaminase IU/l	39.00 ± 6.26	11.60 ± 1.46	<0.001
Alkaline Phosphatase IU/l	140.00 ± 13.20	127.00 ± 4.44	0.353

Table 3: correlating the blood pressure of the study participant with ALT ,AST and ALP

Parameters	Coefficient of correlation(r)	P-value
SBP vs ALT	0.414	0.023
SBP vs ASP	0.648	<0.001
SBP vs ALP	0.398	0.032
DBP vs ALT	0.267	0.153
DBP vs AST	0.530	0.003
DBP vs ALP	0.325	0.070

SBP = Systolic Blood Pressure; DBP = Diastolic Blood Pressure; ALT = Alanine Aminotransferase; AST = Aspartate Aminotransferase; ALP = Alkaline Phosphatase. Pearson's correlation analysis was performed to evaluate associations between blood pressure and hepatic enzymes. A statistically significant positive association was observed between systolic blood pressure and all assessed hepatic enzymes. Conversely, diastolic blood pressure was significantly associated solely with aspartate aminotransferase.

Discussion

This study assessed liver enzyme activity in pregnant women diagnosed with pre-eclampsia in Enugu Metropolis and compared the values with normotensive pregnant women used as controls. Aminotransferases are the most sensitive indicators of hepatocyte damage. This study's findings revealed a significant increase in ALT and AST in the preeclamptic group compared to the normotensives.

Serum ALT and AST is indicative of hepatocellular injury (Chinnappan et al., 2023). Traditionally, ALT and AST is released into the bloodstream following liver cell damage due to ischemia, oxidative stress, and inflammation in preeclampsia (Nachshon et al., 2022; Chang et al., 2023). These findings aligns previous research identifying liver involvement as central to severe preeclampsia and HELLP syndrome (Guerra Ruiz et al., 2021). This study revealed increase total bilirubin in the preeclampsia women as against the normotensives. This finding tends towards hemolysis or

cholestasis, a characteristic of preeclampsia, even though total bilirubin alone is not sufficient for the diagnosis of hemolysis and cholestasis (Fang et al., 2024; Hammoud & Ibdah, 2014; Oliveira et al., 2022). In contrast, alkaline phosphatase (ALP) levels did not differ significantly between the normotensive and preeclampsia women. ALP is known to increase physiologically during pregnancy due to placental production (Titau et al., 2023). This increase may obscure liver-specific changes. Its non-specificity likely accounts for its limited utility in distinguishing liver dysfunction in preeclampsia, as previously reported (Orman et al., 2024). Correlation analyses revealed that higher systolic blood pressure was strongly associated with increased levels of AST and moderately associated with ALT. This suggests that as systolic blood pressure increases, there is a corresponding rise in markers of liver injury. Systolic pressure also correlated weakly but significantly with ALP; however, due to ALP's non-specificity, this finding may not directly reflect liver-specific changes. Elevated systolic BP may contribute to hepatocellular injury through hypoperfusion, oxidative stress, inflammation, and metabolic dysregulation, leading to elevations in AST and ALT. The weak association with ALP likely reflects its non-specificity rather than direct liver damage (Matyas et al., 2021). Diastolic pressure showed a significant correlation with AST, indicating an association with this specific marker of liver injury. However, diastolic pressure did not correlate significantly with ALT or ALP, suggesting it may be less predictive of overall hepatic dysfunction than systolic pressure. This study revealed no statistically significant difference in the mean age of participants with preeclampsia compared to the control group, suggesting that age may not be a major determinant in this population. These findings compared favourably with other documented studies (Sheen et al., 2020; Khan et al., 2022). As expected, systolic and diastolic blood pressures were significantly higher in the preeclamptic group, consistent with the condition's diagnostic hallmark. The hypertensive state in preeclampsia contributes to systemic endothelial and vascular dysfunction, underlying many complications (ACOG, 2021; Dimitriadis et al., 2023; Karrar et al., 2024). Gestational age did not differ significantly between groups, suggesting that the timing of disease onset was relatively uniform and that disease severity may not necessarily correlate with gestational age, contrasting the findings of Venkatesh et al. (2020). These findings underscore the clinical relevance of liver enzyme monitoring in preeclampsia. Regular biochemical assessment can enable early identification of hepatic involvement and timely intervention to prevent complications such as liver failure, HELLP syndrome, and adverse perinatal outcomes. The observed association between blood pressure and liver enzymes further underscores the importance of blood pressure control in mitigating hepatic damage. This hospital-based study provides valuable insight into liver dysfunction in preeclampsia but has notable limitations that affect its generalizability. The inclusion of likely more severe cases and a relatively small sample size reduces statistical power and may mask subtle associations. To build on these findings, longitudinal studies are needed to monitor liver function before, during, and after pregnancy, while mechanistic research on the molecular links between preeclampsia and

hepatic injury could uncover useful biomarkers and therapeutic targets.

Conclusion

Significant elevations in liver enzymes were observed among women with preeclampsia, confirming the association between hypertensive pregnancy disorders and liver dysfunction. The strong correlations between blood pressure and liver enzyme levels underscore the need for rigorous blood pressure control and regular liver function monitoring to mitigate complications, especially in resource-limited settings. These results expand the current understanding of hypertension as a multi-organ disease, offer evidence supporting routine liver assessment in hypertensive populations, and highlight potential mechanisms that connect elevated blood pressure to hepatocellular injury.

Conflict of interest

The authors have no conflict of interest to declare.

Author contributions

OHO, OOE, and MA conceived and designed the experiment. OOE and OHO did the laboratory work. OHO performed the statistical analysis. OOE, OHO, and MA wrote the manuscript. All authors read and approved the final draft.

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