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Liver Function Test between Normotensive and Hypertensive Pregnant Women in those with Preeclampsia and Pregnancy-Induced Hypertension in Benin City, Nigeria

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ABSTRACT: Hypertensive disorders of pregnancy, including preeclampsia and pregnancy-induced hypertension (PIH), are associated with liver dysfunction. Hence, the objective of this paper is to examine the differences in liver function test (LFT) parameters between normotensive and hypertensive pregnant women in those with preeclampsia and pregnancy-induced hypertension (PIH) in Benin City, Nigeria using appropriate standard methods by recruiting 190 participants: 124 with preeclampsia, 36 with PIH, and 30 normotensive controls. Liver function tests included serum alkaline phosphatase (ALP), aspartate aminotransferase (AST), alanine aminotransferase (ALT), bilirubin, and serum albumin. Results obtained showed significant differences were found in liver function test parameters among the three groups. Preeclampsia was associated with elevated AST (9.55 U/L), ALT (6.86 U/L), and ALP (46.51 IU/L) levels. PIH was characterized by elevated total bilirubin levels (2.34 mg/dL). Socio-demographic analysis revealed preeclampsia was more common among remarried individuals, while PIH was associated with lower secondary education levels. Obesity was linked to altered liver function in preeclamptic patients. This study highlights the importance of liver function tests in identifying pregnant women at risk of hypertensive disorders and related liver complications. The findings suggest that liver function test parameters can serve as useful biomarkers for early detection and management of hypertensive disorders of pregnancy.

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Except for serum alkaline phosphatase (ALP) levels, which can increase by two to four times the typical adult upper reference range, liver function tests (LFTs) during pregnancy are similar to those of non-pregnant women (Guarino *et al*., 2020). Aspartate aminotransferase (AST), alanine aminotransferase

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(ALT), transaminases, ALP, bilirubin, and serum albumin are examples of LFTs. Hepatocellular damage is indicated by ALT and AST, cholestasis is suggested by ALP, bilirubin, and bile acid, and the liver's synthetic functions are reflected by albumin and the international normalised ratio (INR). Between 0.72% to 6.7% of pregnant women experience aberrant LFTs (Sumangli and Kurian, 2017; Kishore *et al*., 2021). There are three main categories of causes for anomalies in LFT during pregnancy. The first category consists of pregnancy-specific liver disorders, which are primarily trimester-specific and include haemolysis, elevated liver enzyme and low platelets (HELLP) syndrome, acute fatty liver of pregnancy (AFLP), intrahepatic cholestasis of pregnancy (IHCP), hyperemesis gravidarum, and pre-eclampsia. Intercurrent liver illnesses during pregnancy, such as sepsis, cholelithiasis, and viral hepatitis, are included in the second group. Pregnancy with pre-existing liver conditions, such as chronic hepatitis, liver cirrhosis, and Budd-Chiari syndrome, is included in the third category (Sumangli and Kurian, 2017). Pregnancy outcomes for both the mother and the unborn child can be negatively impacted by abnormal LFTs. Pregnant women with aberrant LFTs have been found to have higher rates of pruritus, kidney damage, coagulopathy, infection, abortion, preterm birth, meconium staining of amniotic fluid, low birth weight, and intrauterine mortality [Joshi *et al*, 2010]. The range of maternal mortality in hepatic dysfunction patients is 1.37% to 39.3%. According to Ahmed *et al*. (2022), the perinatal death rate for patients with abnormal LFTs varies between 16% and 38%. In order to lower maternal and foetal morbidity and mortality, these patients need to be properly evaluated and managed promptly. Pregnancy-related hypertensive diseases are a major global cause of maternal and perinatal morbidity and mortality, especially in developing countries like Nigeria. The World Health Organisation estimates that 15% of expecting mothers could experience potentially fatal problems. The management of pregnancy-related hypertension disorders (HDP) is essential because they contribute significantly to these problems. Preeclampsia, eclampsia, prenatal hypertension, and chronic hypertension are among the conditions that are included in HDP (Yigzaw et al., 2015; Babah et al., 2018; Ayogu et al., 2020)

Despite the fact that pregnancy is frequently lauded, there are a number of physiological, psychological, and physical changes that can occasionally have a negative effect on a woman's health. One major risk is hypertension, which raises the possibility of mental health conditions such anxiety, depression, and post-traumatic stress disorder and contributes to maternal death. Factors like stopping mental health medication, being around stressful situations, experiencing violence, having financial difficulties, and not having support can all make these mental health issues worse. As a significant life event, pregnancy brings about normal physiological, social, and psychological changes that, although usually tolerable, might become troublesome if anxiety levels rise. Overall well-being may be impacted by these mental and physical changes, which may result in health issues such as hypertensive disorders and other mental health illnesses (WHO; Nasr and Hassan, 2016; Gilbert *et al*., 2020; Braunthal and Brateanu, 2019). About 5–10% of pregnancies are affected by hypertensive diseases, which dramatically increase maternal and foetal morbidity and death. These conditions include chronic hypertension, preeclampsia, eclampsia, and gestational hypertension (Battarbee *et al*., 2020; Dachew *et al*., 2020). According to Rapaport (2020), hypertension alone complicates 2-3% of pregnancies, making these disorders among the most prevalent pregnancy problems. In addition to being linked to increased risks of stillbirth, neonatal death, and maternal and foetal health problems, such as intrauterine growth restriction, these illnesses rank as the second most common cause of maternal mortality. Knowing the aetiology of these illnesses is essential for public health because of their prevalence and severe consequences (Lahti-Pulkkinen *et al*., 2020). Two to eight percent of women suffer from preeclampsia, a pregnancy-specific condition marked by the onset of hypertension and severe proteinuria at or after the twentieth week of pregnancy (Moodley, 2004; Ghulmiyyah and Sibai, 2012). Infections associated to pregnancy are one of the most common medical problems, and their prevalence has been increasing worldwide. They are associated with significant rates of maternal morbidity and mortality, with around 50,000 deaths per year (Duley, 2009; WHO, 2011).Preeclampsia is a physiological symptom that often manifests around week 20 of pregnancy or later and goes away after delivery. Proteinuria and elevated hypertension are common signs of preeclampsia (Osungbade and Ige, 2011). There are two main types of preeclampsia, according to Wilkinson and Cole (2018) and Raymond and Peterson (2011): early-onset preeclampsia, which appears before the 34th week of pregnancy, and late-onset preeclampsia, which appears after the 34th week of pregnancy. Although the initial signs of early-onset preeclampsia may overlap with those of late-onset preeclampsia, early-onset preeclampsia is linked to a greater risk of complications, such as premature birth, foetal development limitations, and

mother-related difficulties (Wilkinson and Cole, 2018). Regardless of the presence or absence of a foetus, hydatidiform moles develop when the umbilical cord is present or typically improves postpartum circumstances (Walker, 2000; Roberts and Cooper, 2001). Hypoperfusion or ischaemic conditions strongly imply uterine dysfunction. Roberts *et al*. (2000) state that preeclampsia appears to be caused by an aberrant vascular placenta that widely disperses anti-angiogenic chemicals throughout the mother's blood, resulting in microangiopathy and systemic endothelial cell dysfunction. Glomerular endotheliosis and proteinuria, which are typified by glomerulus endothelial cell enlargement and the loss of endothelial fenestrations, are brought on by endothelial damage within the kidneys.

Studies have indicated a correlation between maternal and foetal outcomes and risk factors for preeclampsia. Elevated systolic and diastolic values also affect the procedures of premature birth and delivery. Severe maternal and neonatal issues may result in zero to several maternal and baby fatalities, according to multiple studies. These difficulties are related to the illness's severity and onset. Anmut *et al*. (2021) found three maternal deaths in a study assessing the effects of eclampsia conducted by Wassie and Anmut (2022).

The findings were quite similar to the research conducted in Enugu, Nigeria, which found 0% maternal mortality (Ugwu *et al*., 2011), although being significantly different from studies claiming 8% and 10% of the mother death rate (Belay *et al*., 2019; Anmut, 2021; Ugwu *et al*., 2011). The quick diagnosis of the illness and prompt beginning of medication in our cohort may account for the study's lack of maternal death, which contrasts with these two earlier investigations. Nonetheless, this supports the previously published Nigerian study. Despite a 0% fatality rate, several birth-related problems, including kidney infection, pneumonia, and respiratory illnesses, transpired during the investigation, much like the experiment carried out in western Kenya. According to the current study, there were more incidences of caesarean deliveries when preeclampsia-related pregnancy problems were present (63.4% vs. 36.7%). The findings are consistent with those of earlier studies, which indicated that over two-thirds of deliveries ended in caesarean sections. In parallel with our study, the previously stated researchers also showed that 9.4% of foetal deaths were associated with serious issues; they discovered that respiratory tract syndrome, baby obesity, and other related conditions were responsible for 11.1% of neonatal deaths (Mwangi *et al*, 2021).

Some research have looked at the connection between HTN and liver impairment [Park *et al*, 2020; Gaeini 2020]. Enzymes that measure liver function include alkaline phosphatase (ALP), gamma-glutamyl transferase (GGT), aspartate aminotransferase (AST), and alanine aminotransferase (ALT) [Hanley *et al*, 2004]. Levels of these enzymes increase in a number of liver-related disorders [Clark and Diehl 2003, Clark *et al*, 2003]. Although the results in the literature are contradictory, liver enzymes may be related to high blood pressure. While an Iranian study identified no correlation between ALT and GGT and HTN [Khalili *et al*., 2022], a study conducted in Bangladesh suggested that they were [Rahman *et al*., 2020]. According to other studies conducted by Park *et al*. [2020] and Liu *et al*. (2023), incident hypertension was linked to higher AST, ALT, and GGT. Higher levels of ALP, ALT, and GGT have been associated with hypertension by some researchers, although this association has not been supported by others. Oxidative stress and inflammation could be the cause of the correlation between liver enzymes and hypertension. The development of HTN is facilitated by oxidative stress, which results in liver dysfunction, and inflammatory cytokines, which activate the renin-angiotensin system [Song *et al*., 2023] [Touyz 2004]. Additionally, elevated ALP activity may lead to arterial calcification and compromised homeostasis, which would increase the rate of hypertension [Bobryshev *et al*, 2014, Shioi *et al*, 2002]. As a result, elevated liver enzyme levels could be a sign of pre-HTN and HTN. Since hypertension is a condition with multiple causes and typically no symptoms [Samvat *et al*., 2000], early detection and treatment of high blood pressure before the onset of hypertension can prevent morbidity and early death [Hong *et al*., 2016, Mohammed *et al*., 2021]. People who are diagnosed in the pre-HTN stage can avoid developing hypertension and its problems; pre-HTN can act as an early warning for both patients and doctors. Establishing a connection between liver enzymes and pre-HTN could help detect the condition early. Although the majority of earlier research assessed the connection between liver enzymes and hypertension, there aren't many studies examining the relationship between liver enzymes and pre-HTN.

Diagnosing liver disease during pregnancy can be difficult because of the physiological changes that occur during pregnancy and can resemble chronic liver disease. Pregnant women frequently experience

tachycardia, elevated cardiac output, and a drop in blood pressure (Meah *et al*, 2016). According to de Haas *et al*. (2017), plasma volume growth is also frequent. Physical manifestations of chronic liver disease, such as palmar erythema, spider angiomas, and telangiectasias, can result from the increased levels of oestrogen during pregnancy (Muallem and Rubeiz 2006). Pregnancy causes a mild drop in haematocrit and albumin due to hemodilution and plasma volume expansion; as a result, anaemia and hypoalbuminemia are frequent test results (Jansen *et al*, 2005).

During pregnancy, alkaline phosphatase (ALP) and alpha-fetoprotein are typically raised due to placental and foetal yolk sac synthesis, respectively, whereas alanine aminotransferase (ALT), aspartate aminotransferase (AST), total bilirubin, and prothrombin time remain unaltered. Liver function tests (LFTs) measure several enzymes, proteins, and bilirubin levels in the blood to evaluate liver health, according to Pathak *et al*. (2024) in the biochemistry section. Any LFT values that are higher than the defined normal reference range are deemed abnormal and may be a sign of liver dysfunction. In particular, modestly high levels of alkaline phosphatase (ALP) can occasionally be within physiological variation or be caused by non-liver-related factors; hence, an elevated level of ALP is only deemed abnormal if it is twice the upper normal limit (UNL) for this enzyme (Pathak *et al*, 2024). The guidelines for normal LFT values are as follows, per Pathak *et al*. (2024): total serum bilirubin should be between 0.2 and 1.0 mg/dL; direct bilirubin, which is a component of total bilirubin and represents conjugated bilirubin, should be less than 0.2 mg/dL; and indirect bilirubin, also known as unconjugated bilirubin, should be between 0.2 and 0.8 mg/dL. Since these enzymes are markers of the health of liver cells, aspartate aminotransferase (AST) and alanine aminotransferase (ALT) should be within the range of 5 and 40 IU/L and 5 and 45 IU/L, respectively.

Under normal circumstances, alkaline phosphatase (ALP) shouldn't be greater than 120 U/L unless there are particular circumstances that cause it to be raised. Because albumin is essential for preserving blood volume and pressure, total protein levels, which represent the sum of albumin and globulins, should be between 6 and 8 g/dL. Albumin levels should be between 3.5 and 5.5 g/dL. If problems are found, these standards support clinical judgements for additional research and aid in the identification of any liver irregularities (Pathak *et al*., 2024). The objective of this paper is to examine the differences in liver function test (LFT) parameters between normotensive and hypertensive pregnant women in those with preeclampsia and pregnancy-induced hypertension (PIH) in Benin City, Nigeria.

MATERIALS AND METHODS

Study Design: This study employed a prospective case-control design to investigate the variances in liver function test parameters in hypertensive disorders in pregnancies. The design allowed for the comparison of liver function test parameters between pregnant women with preeclampsia, pregnancy-induced hypertension (PIH), and normotensive controls. This approach enabled the identification of significant differences in liver function test parameters among the study groups.

Study Population: The study population consisted of pregnant women attending antenatal clinics at the Central Hospital and University Teaching Hospital, both in Benin City, Nigeria. The participants were recruited from various healthcare facilities, ensuring a representative sample of the target population. The study included pregnant women with singleton pregnancies, gestational age between 20-40 weeks, and confirmed diagnosis of preeclampsia or PIH. Normotensive pregnant women were recruited as controls.

Inclusion and Exclusion Criteria: Participants were included if they had singleton pregnancies, gestational age between 20-40 weeks, and confirmed diagnosis of preeclampsia or PIH. Normotensive pregnant women were included as controls. Participants were excluded if they had multiple pregnancies, pre-existing liver disease, or chronic medical conditions such as diabetes or hypertension.

Sampling Technique: Consecutive sampling was used to recruit participants. This involved recruiting every eligible participant presenting at the antenatal clinics during the study period.

Data Collection: Liver function tests (LFTs) were conducted on blood samples collected from participants. The LFTs included serum alkaline phosphatase (ALP), aspartate aminotransferase (AST), alanine aminotransferase (ALT), Gamma-Glutamyl Transferase (GGT), bilirubin, serum albumin, and total protein, were spectrophotometrically assayed using standardized commercial kits obtained from Randox Diagnostics (Crumlin, UK). The assays were performed according to the manufacturer's instructions.

Socio-demographic Data Collection: Socio-demographic data, including marital status and educational status, were collected using a structured questionnaire. Participants' marital status was categorized into three groups: single, first marriage, and remarried. Similarly, educational status was classified into three categories: primary education, secondary education, and tertiary education.

Data Analysis: Data analysis was conducted using descriptive and inferential statistics. Descriptive statistics were employed to summarize the socio-demographic characteristics (age, marital status, educational status, etc.) and liver function test parameters (ALP, AST, ALT, GGT, bilirubin, and serum albumin) of the study participants. The mean and standard error were calculated to provide an overview of the data distribution. Inferential statistics, specifically analysis of variance (ANOVA), were used to compare liver function test parameters among the three study groups: preeclampsia, pregnancy-induced hypertension (PIH), and normotensive controls. One-way ANOVA was performed to detect significant differences in liver function test parameters between groups.

Sample Size Justification: The sample size of 190 participants, comprising 124 women with preeclampsia, 36 with pregnancy-induced hypertension (PIH), and 30 normotensive controls, was deemed sufficient for this study. Several factors influenced this decision. Firstly, resource constraints, including limited financial, personnel, and equipment resources, necessitated a smaller sample size. Additionally, this study served as a pilot to explore the feasibility of investigating liver function test parameters in hypertensive disorders in pregnancies, and a smaller sample size allowed for an initial assessment of the research questions. Furthermore, the relatively low prevalence rates of preeclampsia (2-5%) and PIH (1-2%) made it challenging to recruit larger samples. Despite these limitations, the selected sample size enabled the detection of clinically significant differences in liver function test parameters between groups.

A priori power analysis was conducted using G*Power software (version 3.1) to determine the required sample size. The analysis revealed that a sample size of 190 would provide 80% power to detect moderate effect sizes (Cohen's d = 0.5) in liver function test parameters between groups, with an alpha level of 0.05 (two-tailed). The power analysis parameters included three groups (preeclampsia, PIH, and normotensive controls) and a moderate effect size, which is suitable for detecting clinically significant differences. The results of the power analysis supported the adequacy of the selected sample size for this study.

Ethical Considerations: Informed consent was obtained from all participants before recruitment. Participants were assured of confidentiality and anonymity. The study protocol was approved by the Edo State Health Management Board's Hospital Committee on Research Ethics (ADM/E.22/A/VOL.VII/1469).

RESULTS AND DISCUSSION

The distribution of participants across three groups – preeclampsia, pregnancy-induced hypertension (PIH), and normotensive (normal blood pressure) – is illustrated in the pie chart. Notably, preeclampsia comprised the largest proportion (64.2%), followed by PIH (18.9%) and normotensive groups (15.8%). This distribution indicates a high prevalence of hypertensive disorders in the study population, with preeclampsia being the most prevalent condition.

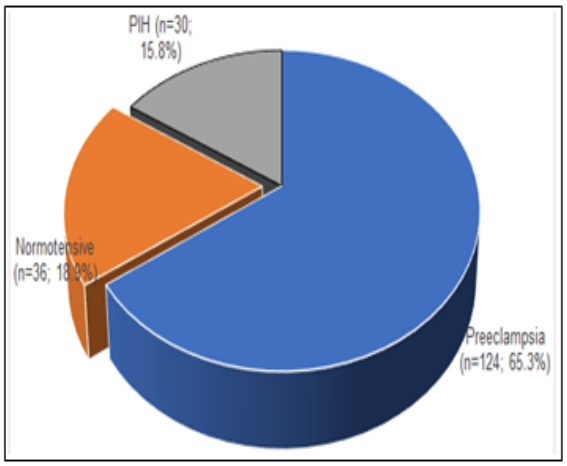

Fig. 1: Distribution of participants into preeclampsia, pregnancy induced hypertension, and normotensive groups respectively.

Table 1 displays the distribution of marital status and educational background across three groups: preeclampsia (A), normotensive (B), and pregnancy-induced hypertension (PIH) (C). The p-values indicate statistical significance between groups. The results reveal that being single or remarried is significantly less common in the PIH group ($p < 0.05$), which consists exclusively of participants in their first marriage. In contrast, the preeclampsia group has a higher proportion of remarried individuals, suggesting a potential link between marital history and preeclampsia. Additionally, secondary education levels are significantly lower in the PIH group compared to preeclampsia and normotensive groups ($p < 0.05$). However, no

significant differences are observed in primary or post-secondary education categories. These findings indicate significant socio-demographic variations between groups, particularly in marital status and secondary education levels. The observed differences suggest distinct patterns associated with each health condition, highlighting the importance of considering marital history and educational background in the context of hypertensive disorders during pregnancy.

Table 1: Marital status and educational background of the respondents

Queries	Preeclampsia cases (A) n (%) (N=124)	Normotensive (B) n (%) (N=36)	PIH (C) n (%) (N=30)	(A+B)	(A+C)	(B+C)
				p-values		
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
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)	0.110	0.028*	0.001*
Post-secondary	56 (45.2)	17 (47.2)	4 (40)	0.142	0.146	0.083

**Significant*

The data analysis in Table 2 reveals significant differences in liver function markers among three groups of pregnant women: those with preeclampsia, normotensive pregnancies, and those with pregnancy-induced hypertension (PIH). Mean values and standard errors for each liver enzyme and protein, along with p-values, provide insights into how these markers vary by hypertensive status. Notably, the mean AST level was significantly elevated in the preeclampsia group (9.55 U/L) compared to both normotensive (7.11 U/L, $p < 0.001$) and PIH groups (7.1 U/L, $p = 0.032$). This suggests AST may be a sensitive marker for liver stress or damage associated with preeclampsia, consistent with liver dysfunction complications. Elevated AST levels during liver inflammation or injury support this finding. ALT levels were significantly higher in the preeclampsia group (6.86 U/L) compared to the PIH group (4.9 U/L, $p = 0.004$) but did not differ significantly from normotensive groups (6.80 U/L, $p = 0.890$). The higher ALT in preeclampsia versus PIH indicates ALT's potential as a marker for hepatic stress specific to preeclampsia, aligning with liver vulnerability to vascular stress. However, ALT elevation alone may not distinctly indicate preeclampsia due to the lack of difference between preeclampsia and normotensive groups. The analysis revealed significant variations in liver function markers among the study groups. Specifically, alkaline phosphatase (ALP) levels were significantly elevated in the preeclampsia group (46.51 IU/L) compared to the normotensive group (35.21 IU/L, $p = 0.000$). Although ALP did not significantly differ from the PIH group (39.95 IU/L, $p = 0.074$), its further elevation in preeclampsia suggests liver contribution to increased ALP levels, likely due to added hepatic stress. This finding aligns with literature indicating preeclampsia exacerbates physiological liver stress. In contrast, gamma-glutamyl transferase (GGT) levels showed no significant differences between groups (all p-values > 0.05), suggesting GGT may not reliably indicate liver dysfunction in hypertensive pregnancy disorders. GGT is more sensitive to biliary obstruction and less specific to pregnancy-induced hepatic issues. Total protein and albumin levels did not significantly differ between groups, likely due to factors such as plasma volume expansion and hemodilution, which commonly occur in pregnancy and mask small changes in liver function. Notably, total bilirubin levels were significantly higher in the PIH group (2.34 mg/dL) compared to preeclampsia (1.17 mg/dL, $p < 0.001$) and normotensive cases (1.02 mg/dL, $p = 0.005$). Elevated bilirubin in PIH may indicate increased red blood cell breakdown or impaired bilirubin clearance, suggesting liver stress. High bilirubin is clinically relevant, indicating potential hepatic involvement or hemolysis in hypertensive pregnancy disorders.

Table 3 presents a comparative analysis of liver function analytes in preeclamptic subjects categorized by disease severity (mild vs. severe). The results are discussed below, highlighting means, standard errors, and p-values for each analyte. Notably, the data reveals no statistically significant differences in liver function markers between mild and severe preeclampsia. Specifically, AST levels, although slightly lower in severe cases, did not differ significantly ($p > 0.05$). Elevated AST levels indicate hepatic stress in preeclampsia but may not correlate with disease severity. ALT levels were similarly elevated in both groups without significant difference ($p > 0.05$), suggesting ALT's utility in detecting preeclampsia-related hepatic stress but limited

specificity in assessing severity. ALP levels, slightly higher in severe preeclampsia, showed no significant difference ($p > 0.05$). ALP elevation during pregnancy, primarily due to placental production, may not reliably indicate disease severity. GGT levels, slightly higher in mild preeclampsia, did not differ significantly ($p > 0.05$), implying GGT may not directly associate with hepatic changes in preeclampsia or reflect individual variability. Total protein levels were similar in both groups ($p > 0.05$), likely influenced by hemodilution rather than hepatic dysfunction. Albumin levels, slightly higher in severe cases, did not differ significantly ($p > 0.05$), potentially masked by hemodilution-related decreases in pregnancy. Total bilirubin levels showed no significant difference ($p > 0.05$), suggesting bilirubin may not reliably reflect disease severity. These findings indicate that liver function markers may not differentiate between mild and severe preeclampsia, highlighting the complexity of hepatic involvement in this condition.

Table 2: Grouped data (totals) for analytes of respondents presented irrespective of trimester used for assessing liver function.

Queries	**Preeclampsia cases (A) (µ±SEM) (n=124)**	**Normotensive (B) (µ±SEM) (n=36)**	**PIH (C) (µ±SEM) (n=30)**	**p-value (A+B)**	**p-value (A+C)**	**p-value (B+C)**
Aspartate aminotransferase (U/l)	9.55±0.31	7.11±0.45	7.1±0.61	<0.001	0.032	0.423
Alanine aminotransferase (U/l)	6.86±0.18	6.80±0.43	4.9±0.43	0.890	0.004	0.032
Alkaline phosphatase (IU/l)	46.51±0.98	35.21±1.83	39.95±4.14	<0.000	0.074	0.193
Gamma-glutamyl transferase (g/dl)	4.87±0.23	4.49±0.42	3.60±0.31	0.454	0.135	0.125
Total Protein (g/dl)	7.011±0.05	7.011±0.11	6.96±0.22	0.800	0.796	0.728
Albumin (g/dl)	3.78±0.05	3.74±0.10	3.62±0.16	0.767	0.436	0.422
Total bilirubin (mh/dl)	1.17±0.07	1.02±0.14	2.34±0.47	0.381	<0.001	0.005

Table 3: Analyte composition of preeclamptic subjects separated on the basis of severity of disease

Analytes	*Severity of disease	(n)	Mean	Std. Error Mean	p-value
Aspartate aminotransferase (U/l)	MP	39	9.7436	0.4952	0.687
	SP	84	9.4643	0.4102	
Alanine aminotransferase (U/l)	MP	39	6.7692	0.3682	0.613
	SP	84	6.9643	0.1986	
Alkaline phosphatase (IU/l)	MP	39	45.533	1.4033	0.461
	SP	84	47.103	1.2893	
Gamma-glutamyl transferase (g/dl)	MP	39	5.6436	0.578	0.732
	SP	84	4.5283	0.2192	
Total Protein (g/dl)	MP	39	6.8929	0.1225	0.707
	SP	84	6.8446	0.0664	
Albumin (g/dl)	MP	39	3.7222	0.1228	0.451
	SP	84	3.8138	0.0598	
Total bilirubin (mh/dl)	MP	39	1.1513	0.1113	0.893
	SP	84	1.1736	0.1006	

**Severity of disease: MP mild preeclampsia, SP severe preeclampsia*

Table 4 presents a comparative analysis of liver function analytes among preeclamptic subjects categorized by BMI: normal, overweight, and obese. The assessed analytes included AST, ALT, ALP, GGT, Total Protein, Albumin, and Total Bilirubin. Notably, the data reveals that mild variations in BMI (normal vs. overweight) do not significantly impact AST, ALT, ALP, and GGT levels. However, Total Protein and Albumin levels exhibited trends towards significance, suggesting potential liver function alterations associated with obesity. Comparing normal BMI to overweight individuals revealed a significant difference in Total Bilirubin levels, with higher levels observed in the normal BMI group. This suggests possible differences in hepatic clearance mechanisms. Furthermore, comparing normal BMI to obese subjects revealed significant differences in two analytes. Specifically, GGT levels were lower in obese individuals, while Albumin levels were also lower in this group. These findings imply that obesity may have a distinct impact on liver health, particularly in preeclamptic patients. Overall, the data indicates that BMI-related variations in liver function are more pronounced in obese preeclamptic individuals, highlighting the importance of considering BMI in the management of preeclampsia-related liver complications.

This study investigates the hepatic impact of hypertensive disorders in pregnancy, particularly preeclampsia and pregnancy-induced hypertension (PIH), as assessed by variations in liver function tests

(LFTs). These findings extend our understanding of the physiological and pathological changes that affect liver function during hypertensive pregnancies and have significant implications for clinical management. In normal pregnancies, liver function tests generally mirror those of non-pregnant individuals, with the exception of serum alkaline phosphatase (ALP), which can increase by up to four times due to placental production (Guarino *et al*., 2020). However, preeclampsia, PIH, and other hypertensive pregnancy disorders markedly disrupt this stability, as indicated by alterations in enzymes such as aspartate aminotransferase (AST), alanine aminotransferase (ALT), and ALP.

Table 4: Comparing Analyte composition of preeclamptic subjects separated on the basis of BMI

Analytes	Normal (n=23)	Overweight (n=71)	p-value	Normal (n=23)	Obese (n=30)	p-value
Aspartate aminotransferase (U/l)	9.9565	9.5352	0.633	9.9565	9.300	0.440
Alanine aminotransferase (U/l)	6.5217	7.0141	0.304	6.5217	6.9333	0.427
Alkaline phosphatase (IU/l)	48.2283	44.8349	0.192	48.228	49.19	0.786
Gamma-glutamyl transferase (g/dl)	5.8152	4.9441	0.207	5.8152	3.9733	0.008
Total Protein (g/dl)	6.6383	6.9326	0.075	6.6383	6.8629	0.178
Albumin (g/dl)	4.0087	3.7597	0.086	4.0087	3.6629	0.047
Total bilirubin (mh/dl)	1.605	1.0738	0.014	1.605	1.068	0.051

Elevated levels of these enzymes are indicative of hepatocellular stress, potentially driven by vascular and systemic inflammation linked to hypertensive conditions (Kishore *et al*., 2021). AST and ALT levels were significantly elevated in preeclamptic pregnancies compared to both normotensive and PIH groups. These enzymes, recognized as markers of liver injury, reflect hepatocellular damage commonly associated with preeclampsia. The heightened AST levels in preeclampsia support its role as an indicator of hepatic stress under vascular strain, likely caused by endothelial dysfunction and systemic inflammation. Although ALT was also elevated in preeclampsia, its lack of significant difference from normotensive levels suggests it may not be as specific to the condition as AST. These findings align with prior observations that hepatocellular injury is a frequent complication in hypertensive pregnancies, warranting close monitoring of AST and ALT to detect early liver stress (Guarino *et al*., 2020) Elevated ALP levels in the preeclamptic group, compared to normotensive pregnancies, suggest additional hepatic contributions beyond placental ALP production. While ALP is naturally elevated in pregnancy, its further increase in preeclampsia may indicate added hepatic stress due to vascular and inflammatory changes specific to the condition. Intermediate ALP levels observed in PIH suggest that ALP could help differentiate between hypertensive pregnancy disorders, as the enzyme appears more responsive in cases of preeclampsia than PIH. The hepatic origin of this elevation underscores the liver's susceptibility to preeclampsia-induced vascular injury and supports prior studies that link ALP increases with hepatic involvement in hypertensive pregnancies (Kishore *et al*., 2021). Gamma-glutamyl transferase (GGT) did not significantly differ across groups, suggesting it is not as responsive to hepatic stress specific to hypertensive disorders. GGT is typically elevated in cases of biliary obstruction rather than liver injury due to systemic inflammation or vascular compromise, which may explain its limited role as an indicator in hypertensive pregnancies. This lack of significant variation implies that GGT is a less effective marker for hypertensive liver dysfunction, consistent with studies showing GGT's limited association with hypertensive conditions (Sumangli and Kurian, 2017). The absence of significant differences in total protein and albumin levels among groups may be attributed to the physiological hemodilution common in pregnancy. Hemodilution lowers protein concentrations, potentially masking liver-related changes in hypertensive conditions. Consequently, these markers may be less reliable for detecting liver involvement in hypertensive pregnancies. This aligns with observations that total protein and albumin reductions in pregnancy are often due to plasma volume expansion rather than liver pathology (Meah *et al*., 2016; Jansen *et al*., 2005. Notably, total bilirubin levels were significantly higher in the PIH group compared to preeclampsia and normotensive pregnancies. Elevated bilirubin may reflect hemolysis or hepatic clearance impairment due to vascular strain, suggesting distinct hepatic responses in PIH. These differences underline bilirubin's potential as a marker for liver stress specific to PIH and point to underlying mechanisms that differ from those in preeclampsia, which merits further exploration. The study also examined liver analytes by preeclampsia severity but found no significant differences between mild and severe cases. This suggests that while markers like AST and ALT indicate hepatic involvement in preeclampsia, they may not differentiate between stages of severity. This finding aligns with existing literature indicating that AST and ALT elevations do not necessarily reflect progression in preeclampsia but rather the presence of hepatic

stress (Pathak *et al*., 2024). Variations in liver function markers based on BMI categories were observed, with normal-BMI preeclamptic patients showing higher bilirubin levels than their overweight or obese counterparts. This pattern suggests a potential interaction between BMI and hepatic stress responses in preeclampsia, which may influence clinical outcomes and management strategies.

Conclusion: This study confirms that hypertensive disorders in pregnancy, particularly preeclampsia and PIH, significantly impact liver function. Elevated AST, ALT, ALP, and bilirubin levels were observed. Specific liver function test (LFT) markers can monitor liver health in hypertensive pregnancies, improving early detection and intervention. Future research should examine these markers and their utility in distinguishing between hypertensive disorders. A tailored approach to liver function monitoring can aid in early detection, risk stratification, and management, potentially improving maternal and fetal outcomes. Further investigation into hypertension and liver health during pregnancy is essential for advancing diagnostic precision and management strategies.

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Data Availability Statement: Data are available upon request from the first author or corresponding author.

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