Original Article

Prevalence of Preeclampsia and Associated Biomarkers in Pregnant Women in Auchi

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Abstract

Background: Preeclampsia is a multi-organ system disorder of pregnancy which is responsible for a significant rate of maternal morbidity and mortality worldwide. Studies on the prevalence of preeclampsia in the developing countries appear inadequate. **Aim and Objective:** This study was designed to assess the prevalence of preeclampsia and its associated risk factors in pregnant women in Auchi and environs. **Materials and Methods:** In this cross-sectional study, a total number of 200 participants were enrolled. Anthropometric parameters and blood pressure were measured by standard procedures. 5 ml of blood was obtained from each participant. Serum obtained from the centrifugation of the blood was used for the determination of creatinine, uric acid, alanine aminotransferase, aspartate aminotransferase, and lipid profile. Analysis of data was done using analysis of variance and Pearson correlation coefficient. Statistical significance was set at $P \leq 0.05$. **Results:** The prevalence of preeclampsia in this study was 4%. Body mass index, waist circumference, serum creatinine, uric acid, and total cholesterol (TC) were significantly elevated in pregnant women with preeclampsia in comparison with women without preeclampsia. **Conclusion:** Observations in this study indicate that elevated serum creatinine, uric acid, and TC are risk factors of preeclampsia.

Keywords: Creatinine, lipid profile, obesity, preeclampsia, uric acid

Introduction

Preeclampsia is a multiple-system derangement in pregnancy which is related to metabolic syndrome with proteinuria and hypertension being its principal features.[1] It affects over 9 million pregnancies yearly with accompanying 500,000 and 76,000 fetal and maternal mortalities, respectively.[2]

The prevalence of preeclampsia in Nigeria is currently uncertain. The prevalence rates of preeclampsia in Nigerian Federal Capital Territory (Abuja) and Bayelsa state were reported to be 3.02% and 3.53%, respectively.[3,4] These were much lower than 6.0% being the prevalence reported in Sokoto State of Nigeria.[5] Information on the prevalence of preeclampsia in Edo North Senatorial District, Edo State, Nigeria, is currently sparse.

The exact etiology of preeclampsia is not clearly understood. Defective placentation contingent on the invasion of cytotrophoblast by the spiral arteries has been implicated. This occurs in a series of events that lead to dysfunctional endothelium which is the basis of the clinical features of preeclampsia.[6]

The effects of preeclampsia can extend beyond pregnancy. Postpreeclampsia effects can result in irreversible biochemical and vascular impairments, which can increase the susceptibility of both the mother and child to cardiovascular diseases.[2] Therefore, early detection and precise and adequate management are key in reducing both pregnancy and postpregnancy complications.

Currently, predicting the risk of preeclampsia in pregnant women is herculean. However, some biomarkers have been suggested. These include dyslipidemia, uric acid, and creatinine. Serum lipids are involved in endothelial function, thus endothelial dysfunction is characterized by dyslipidemia which may be involved in the pathogenesis

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Access this article online

Quick Response Code:

Website: https://journals.lww.com/mtsp

DOI: 10.4103/mtsp.mtsp_28_24_1

How to cite this article: Mahmud M, Ajayi OO, Ugbenyen AM. Prevalence of preeclampsia and associated biomarkers in pregnant women in Auchi. Matrix Sci Pharma 2025;9:21-6.

Received: 16-11-2024, **Accepted:** 02-01-2025, **Published:** 25-07-2025

of preeclampsia.[7] While a lot of studies have reported dyslipidemia in preeclamptic women, the pattern of variability of dyslipidemia is controversial.[7,8]

Studies have suggested an association of elevated levels of serum uric acid and creatinine with preeclampsia.[9] Uric acid was reported as a marker of severity of preeclampsia, its role in the causation of preeclampsia is controversial.[10] Since elevated serum uric acid:serum creatinine ratio predicts preeclampsia and unfavorable pregnancy outcomes, this ratio has been suggested as a better marker of preeclampsia than uric acid alone.[11]

Alanine aminotransferase (ALT) and aspartate aminotransferase (AST) have been suggested as markers of exacerbating hypertensive disorders of pregnancy, therefore they could be components of interest in the diagnosis of preeclampsia.[12]

In spite of the studies conducted on preeclampsia in Nigeria, there is a paucity of information on the prevalence and the risk factors of preeclampsia in Auchi and its environs, and this led to the conduct of this study.

Materials and Methods

Study design and study participants

This cross-sectional study involved 200 apparently healthy pregnant women aged between 18 and 40 years old attending the antenatal clinic and volunteered to participate in the study. They were recruited at five health facilities in Auchi, Edo State, Nigeria: Edo State University Teaching Hospital (79), Sancta Maria Hospital (35), Hope Hospital (20), Urban Primary Health Facility (41), and Usokwili Primary Health Centre (25). The study was conducted between November 2022 and February 2023.

Exclusion criteria

Pregnant women with known existing clinical disorders such as hypertension, liver and kidney impairment, and diabetes mellitus were not included in the study.

Sample size calculation

The sample size of this study was determined using the formula:

$$n = \frac{Z^2 \times P(1-P)}{d^2}$$

where Z = standard normal variate = 1.96

P = prevalence of preeclampsia in Nigeria that ranged between 2% and 16.7% as reported by Olaoye *et al*.[13] Fifteen percent was taken as the prevalence for this study.

d = Absolute error or precision set at 5%

$$n = \frac{(1.96)^2 \times 0.15(1-0.15)}{(0.05)^2} = \frac{0.4898}{0.0025} = 195.92 = 196.$$

Anthropometric indices

- Body height and weight: This was determined when the participants were made to stand on a stadiometer. The participant stood on the weighing device without shoes and wearing light clothes, and their relative weights were recorded to the closest 0.1 kg
- Waist circumference (WC): A measuring tape was used to measure WC[14]
- Body mass index (BMI): Weight in kilograms divided by the square of height in meters was used to determine BMI.

Blood pressure

A digital blood pressure sphygmomanometer (Andon, Nigeria) was used to measure the systolic blood pressure (SBP) and diastolic blood pressure (DBP) of study participants. Hypertension was defined as levels that are ≥140 mmHg (systolic) or ≥90 mmHg (diastolic).

Urinary protein

The dipstick method (colorimetric reagent strip) was applied to determine proteinuria. The produced color was contrasted using a color chart to enable grading of the protein content. This was in accordance with the manufacturer's instructions.

Sample collection and analysis of biochemical parameters

Five ml of venous whole blood was collected by venipuncture of the study participants. The blood samples were collected into a lithium heparin container and stored in an ice pack to keep all protein intact for a short time pending centrifugation. Centrifugation was done at 4000 rpm for 10 min after which the serum was collected with a micropipette into a plain sample container and then stored in a freezer.

Analysis of biochemical parameters

Serum total cholesterol (TC), high-density lipoprotein (HDL), low-density lipoprotein (LDL), and triglycerides (TG) were determined spectrophotometrically by enzyme assay (Precision kit).[15,16] AST and ALT activities were determined by the methods used by Johnkennedy *et al*.[17] using Randox kit. Serum uric acid and creatinine were determined by methods described by Timerga and Haile[18] and Amin *et al*.[19]

Diagnostic criteria

Pregnant women with protein urinalysis result of 1+ were grouped as having proteinuria. Preeclampsia was defined as hypertension with ≥140 mmHg SBP and/or ≥90 mmHg DBP along with proteinuria. Women with gestation periods of weeks 1–12 were grouped into the first trimester, weeks 13–28 were grouped into the second trimester, and weeks 29–40 were grouped into the third trimester. Gravidity was defined as the total number of pregnancies of a woman, regardless of the outcome.

Data processing and analysis

Data were analyzed using IBM SPSS, version 26 (IBM Corp, Armonk, NY, USA). Analysis of variance was used for the comparison of quantitative variables while the comparison of qualitative variables was done using Chi-square. The association of variables was determined using the Pearson correlation coefficient. $P \leq 0.05$ was regarded as statistically significant.

Ethical approval

Ethical consideration was granted by the Ethics Board of Edo State University Uzairue (EDSUREC 22/0080). All the methods employed in this research were according to guidelines and regulations approved. The study participants were told about the research and its importance and informed consent was obtained from each participant after the understanding of the details and requirements of the research.

Results

Table 1 shows the blood pressure and proteinuria results of study participants. The mean systolic pressure of the participants was 124 ± 11.4, and majority of the population had a systolic pressure of ≥120/80–139/80≤; 29 of the participants which account for 14.5% of the population had turned up positive to proteinuria, among which only 8 of the study participants had systolic pressure ≥140/90 which draws the prevalence of preeclampsia in this study to 4%.

Table 2 shows the comparison of normal and elevated serum levels of creatinine, uric acid, ALT and AST as well as lipid profile between women with and without preeclampsia. A significant difference was observed in creatinine and uric acid levels. Three of the participants who were preeclamptic had elevated serum ALT. The significant difference was observed only in TC.

Table 3 shows that the mean values of anthropometrics were observed in BMI, WC, creatinine, uric acid, and TC levels and biochemical indices of women with and without preeclampsia. Significant elevation was observed in BMI, WC, creatinine, uric acid, and TC of women with preeclampsia in comparison with women without preeclampsia.

The association of variables in women with and without preeclampsia is indicated in Table 4.

Discussion

The prevalence of preeclampsia in this study was 4%. This was higher than the prevalence reported in some states in Nigeria: Gombe (1.57%), Abuja (3.02%), and Abakaliki (3.4%).[3,20,21] It was, however, less than the prevalence of 7% reported in a Cameroonian study.[22]

Table 1: Blood pressure categorization and urinary protein of study participants

Component	Frequency, *n* (%)
SBP/DBP	
≤120/80	59 (29.5)
≥120/80 and ≤130–80	132 (66)
≥140/90	9 (4.5)
Mean systolic pressure	124±11.4
Mean diastolic pressure	78±8
Proteinuria	
Positive	29 (14.5)
Negative	171 (85.5)
Total	200
Participants with proteinuria and BP ≥140/90	8 (4)
Participants with proteinuria and BP ≤140/90	21 (10.5)

BP: Blood pressure, SBP: Systolic BP, DBP: Diastolic BP

In this study, BMI and WC, indices of general and visceral obesities, were significantly higher in women with preeclampsia in comparison with other groups of women. Our observation is in tandem with reports that showed an association between obesity and preeclampsia. In a study, Alba *et al*.[23] found a strong positive association between elevated BMI and the risk of having preeclampsia. Another report showed a threefold increased risk of preeclampsia in women with BMI of 30 kg/m^2.[24] The exact mechanisms by which obesity causes preeclampsia have not been delineated, it is suggested that metabolic derangements contingent on obesity may adversely affect placental functions. Asymmetric dimethylarginine (ADMA) has been suggested as a mechanism of the involvement of obesity in preeclampsia.[25] ADMA endogenously inhibits nitric oxide synthase, hence its association with deranged endothelial function.[26]

Tesfa *et al*.[1] reported a relationship between elevated levels of TC, TG, Low density lipoprotein cholesterol (LDLc), and very low density lipoprotein cholesterol (VLDLc) and the risk of having preeclampsia. In this study, there was a significant increase in the level of TC in women with preeclampsia in comparison with other groups. Our observation is consistent with the report of Ebogo-Belobo *et al*.[27] It, however, contradicts the report of an author that found no significant difference in TC between women with and without preeclampsia.[7]

There was no difference in HDL and LDL across the groups in this study. This observation is in tandem with the report that found no difference in HDL and LDL between preeclamptic and women with preeclampsia.[7] The study, however, found a significant increase in TG level in women with preeclampsia which contradicts our observation.[7]

In this study, uric acid was significantly higher in women with preeclampsia compared with other groups. This is consistent with the report of Enaruna *et al*.[28] that found a significantly elevated level of uric acid in preeclamptic compared with nonpreeclamptic women in a study they conducted at the University of Benin Teaching Hospital, Nigeria. It has been reported that uric acid is implicated in renal ailments via mechanisms involving the induction and activation of endothelial dysfunction and the renin–angiotensin–aldosterone system, respectively.[29] Furthermore, there are also insinuations that elevated uric acid level could interact with pro-inflammatory cytokines in preeclamptics. This could be the basis of inflammation in the pathophysiology of preeclampsia.[2]

Other mechanisms of elevated levels of uric acid and creatinine in preeclamptic compared with other groups could be due to reduced urinary clearance secondary to decreased glomerular filtration rate and elevated absorption, elevated tissue degradation, and elevated xanthine oxidase activity.[30,31]

Table 2: Comparison of normal and elevated levels of serum creatinine, uric acid, alanine, and aspartate aminotransferases as well as lipid profile between women with and without preeclampsia

Component	Normotensive (*n*=192)	Preeclampsia (*n*=8)	Total (*n*=200)	χ^2	*P*
Creatinine					
Normal	179	4	183	18.453	0.002*
High	13	4	17		
Uric acid					
Normal	144	3	147	5.545	0.032*
High	48	5	53		
ALT					
Normal	155	5	160	1.595	0.207
High	37	3	40		
AST					
Normal	189	8	197	0.127	0.722
High	3	0	3		
TG					
Normal	122	6	128	0.438	0.508
High	70	2	72		
TC					
Normal	124	2	126	5.162	0.023*
High	68	6	74		
HDL					
Normal	76	3	79	0.014	0.906
High	116	5	121		
LDL					
Normal	114	2	116	3.725	0.054
High	78	6	84		

*Significant at P≤0.05. Creatinine concentration range ≤0.84 mg/dL and ≥0.85 mg/dL were considered normal and high, respectively. Uric acid concentration ≤5.60 mg/dL and ≥5.7 mg/dL were considered normal and high, respectively. AST concentration ≥32 U/L was considered high and a concentration lesser than that was normal. ALT concentration ≥43 U/L was considered high while a concentration lesser than that was taken normal. TG levels >150 mg/dL as borderline high and ≤150 mg/dL normal, HDL concentration ≥50 mg/dL was considered normal while <50 mg/dL was considered abnormal, LDL concentration >150 mg/dL was considered high and a concentration ≤150 mg/dL was considered normal, TC level ≥240 was defined as high and <240 mg/dL was considered normal. AST: Aspartate aminotransferase, ALT: Alanine aminotransferase, HDL: High density lipoprotein, LDL: Low density lipoprotein, TG: Triglyceride, TC: Total cholesterol

Table 3: Mean values of anthropometry and biochemical indices of women with and without preeclampsia

Variables	Overall (*n*=200)	Preeclampsia (*n*=8)	Normotensive (*n*=192)	*P*
BMI (kg/m^2)	25.80±3.82	30.22±4.94	25.72±3.71	0.001*
WC (cm)	83.81±5.12	88.80±6.93	83.61±4.90	0.005*
Creatinine (mg/dL)	0.57±0.21	0.82±0.43	0.56±0.20	0.003*
Uric acid (mg/dL)	5.10±1.91	7.73±2.72	4.90±1.81	<0.001*
AST (µL)	17.90±6.42	16.82±3.51	18.00±6.52	0.601
ALT (µL)	24.80±6.91	29.20±9.72	24.61±6.70	0.061
TG (mg/dL)	140.63±57.82	163.71±71.00	139.60±57.23	0.249
TC (mg/dL)	237.91±51.60	277.62±50.80	236.20±51.12	0.026*
HDL cholesterol (mg/dL)	54.61±12.82	54.91±14.82	54.72±12.80	0.949
LDL (mg/dL)	154. 62±41.10	179.30±25.11	153.62±41.30	0.083

*Significant at *P*≤0.05. TC: Total cholesterol, BMI: Body mass index, AST: Aspartate aminotransferase, ALT: Alanine aminotransferase, HDL: High-density lipoprotein, LDL: Low-density lipoprotein, WC: Waist circumference, TG: Triglyceride

There was no difference in the activities of ALT and AST in the participants of the three groups in this study, i.e. overall, normotensive, and preeclamptic groups.

The association among parameters was determined in this study. A significant association was observed between WC and ALT in women with preeclampsia. This suggests the involvement of obesity in hepatic damage in preeclampsia. Lee *et al*.[32] reported an association between high level of ALT and increased susceptibility to preeclampsia.

A significant positive association was also observed between SBP and TG in women with preeclampsia while a nonsignificant inverse association was observed in women

Table 4: Correlation of anthropometric indices, blood pressure, and biochemical parameters in pregnant women with and without preeclampsia

Index	Pregnant women with preeclampsia		Pregnant women without preeclampsia	
	r	*P*	*r*	*P*
Cholesterol				
HDL	−0.034	0.935	0.633	0.000*
LDL	0.916	0.001*	0.639	0.000*
BMI	0.542	0.165	0.690	0.000*
WC	0.083	0.844	0.644	0.000*
SBP	−0.524	0.182	0.365	0.000*
DBP	−0.194	0.646	0.153	0.034*
HDL				
LDL	−0.058	0.892	0.395	0.000*
BMI	−0.166	0.694	0.283	0.000*
WC	−0.161	0.703	0.373	0.000*
ALT	−0.185	0.662	0.154	0.033*
SBP	−0.344	0.405	0.179	0.013*
LDL				
BMI	0.449	0.264	0.687	0.000*
WC	−0.019	0.965	0.617	0.000*
SBP	−0.658	0.076	0.379	0.000*
DBP	−0.391	0.338	0.183	0.011*
BMI				
WC	0.778	0.023*	0.631	0.000*
SBP	0.246	0.558	0.404	0.000*
DBP	−0.151	0.722	0.169	0.019*
Creatinine	0.004	0.993	0.143	0.048*
WC				
ALT	0.710	0.048*	0.053	0.464
SBP	0.562	0.147	0.351	0.000*
DBP	0.262	0.530	0.180	0.012*
Uric acid				
ALT	0.422	0.297	0.198	0.006*
SBP	0.074	0.863	0.220	0.002*
ALT				
AST	0.220	0.601	0.561	0.000*
SBP				
TG	0.911	0.002*	−0.120	0.098
DBP	0.021	0.960	0.502	0.000*

*Significant at $P \leq 0.05$. *r*: Pearson correlation coefficient.
HDL: High-density lipoprotein, LDL: Low-density lipoprotein, TG: Triglyceride, ALT: Alanine aminotransferase, AST: Aspartate aminotransferase, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, WC: Waist circumference, BMI: Body mass index

without preeclampsia. This indicates the influence of blood pressure on lipid metabolism in preeclampsia.

The significant positive association between cholesterol and LDL as well as between BMI and WC in both cases and women without preeclampsia may require further studies.

The positive correlation of BMI with creatinine in women without preeclampsia suggests the relationship of obesity with renal function. Furthermore, in this study, serum uric acid was associated with ALT in women without preeclampsia. This is similar to a report of such association in apparently healthy population.[33] The hypothesized mechanism of this relationship is insulin resistance, which could result in the reduction of renal uric acid excretion. This could in turn trigger the elevation of plasma uric acid levels.

In women without preeclampsia in this study, HDL correlated positively with LDL, BMI, and WC. Furthermore, the positive correlation of HDL with ALT indicates the association of lipid metabolism with liver enzymes. Alteration in the activities of liver enzymes has been reported in obese individuals. Obesity is a key causal factor of insulin resistance that has been implicated in metabolic diseases.[34]

Conclusion

Observations in this study indicate elevated serum level of creatinine, uric acid, and TC in women with preeclampsia in comparison with women without preeclampsia. Therefore, our observations align with previous studies that report these analytes as biomarkers of preeclampsia.

Limitation

The cross-sectional design could be a limitation of the study. Further study could consider a prospective study design. A larger sample size than that used in this study should be considered in future studies.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Tesfa E, Nibret E, Munshea A. Maternal lipid profile and risk of pre-eclampsia in African pregnant women: A systematic review and meta-analysis. PLoS One 2020;15:e0243538.
2. Corominas AI, Medina Y, Balconi S, Casale R, Farina M, Martínez N, *et al.* Assessing the role of uric acid as a predictor of preeclampsia. Front Physiol 2021;12:785219.
3. Akaba GO, Anyang UI, Ekele BA. Prevalence and materno-fetal outcomes of preeclampsia/eclampsia amongst pregnant women at a teaching hospital in North-central Nigeria: A retrospective cross-sectional study. Clin Hypertens 2021;27:20.
4. Adokiye EA, Isreal J, Tubotonye HC, Levi WO. Factors influencing the prevalence of preeclampsia/eclampsia in booked and unbooked patients: 3 years retrospective study in NDUTH, Okolobiri. World J Med Med Sci 2015;3:1-14.
5. Singh S, Ahmed EB, Egondu SC, Ikechukwu NE. Hypertensive disorders in pregnancy among pregnant women in a Nigerian teaching hospital. Niger Med J 2014;55:384-8.
6. Abraham T, Romani AM. The relationship between obesity and pre-eclampsia: Incidental risks and identification of potential biomarkers for pre-eclampsia. Cells 2022;11:1548.
7. Siddiqui Ia. Maternal serum lipids in women with pre-eclampsia. Ann Med Health Sci Res 2014;4:638-41.
8. Antonić TD, Ardalić DČ, Vladimirov SS, Banjac GS, Cabunac PJ, Zeljković AR, *et al.* Cholesterol homeostasis is dysregulated in women with preeclampsia. Pol Arch Intern Med 2021;131:16144.
9. Ryu A, Cho NJ, Kim YS, Lee EY. Predictive value of serum uric acid levels for adverse perinatal outcomes in preeclampsia.

Medicine (Baltimore) 2019;98:e15462.
10. Colmenares-Mejia CC, Quintero-Lesmes DC, Bautista-Niño PK, Guío E, Paez MC, Beltrán M, *et al.* Uric acid and risk of pre-eclampsia: Results from a large case-control study and meta-analysis of prospective studies. Sci Rep 2023;13:3018.
11. Piani F, Agnoletti D, Baracchi A, Scarduelli S, Verde C, Tossetta G, *et al.* Serum uric acid to creatinine ratio and risk of preeclampsia and adverse pregnancy outcomes. J Hypertens 2023;41:1333-8.
12. Greiner KS, Rincón M, Derrah KL, Burwick RM. Elevated liver enzymes and adverse outcomes among patients with preeclampsia with severe features. J Matern Fetal Neonatal Med 2023;36:2160627.
13. Olaoye T, Oyerinde OO, Elebuji OJ, Ologun O. Knowledge, perception and management of pre-eclampsia among health care providers in a maternity hospital. Int J MCH AIDS 2019;8:80-8.
14. Ajayi OO, Okhani AU. The association of ABSI with biochemical and clinical indices in undergraduates of a Nigerian South-Southern University. MUJAST 2023;3:94-104.
15. Dabou S, Ongbayokolak NS, Fonkeng Sama L, Matene Foking E, Kamdom NM, Telefo PB. Metabolic syndrome during pregnancy: Prevalence and determinants among pregnant women followed-up at the Dschang district hospital, West region of Cameroon. Diabetes Metab Syndr Obes 2022;15:743-53.
16. Ogbera AO, Fasanmade OA, Chinenye S, Akinlade A. Characterization of lipid parameters in diabetes mellitus – A Nigerian report. Int Arch Med 2009;2:19.
17. Johnkennedy N, Adamma E, Ndubueze EH. Evaluation of serum hepatocellular enzymes in Nigerian with goitre. Asian J Med Sci 2011;2:79-81.
18. Timerga A, Haile K. Evaluation of uric acid disorders and associated factors in essential hypertensive patients at Wolkite University specialized hospital, Southern Ethiopia. PLoS One 2021;16:e0256557.
19. Amin N, Mahmood RT, Asad MJ, Zafar M, Raja AM. Evaluating urea and creatinine levels in chronic renal failure pre and post dialysis: A prospective study. J Cardiovasc 2014;2:1-4.
20. Onoh RC, Mamah JE, Umeokonkwo CD, Onwe EO, Ezeonu PO, Okafor L. Severe preeclampsia and eclampsi: A 6-year review at the federal teaching hospital Abakaliki, Southeast Nigeria. Trop J Obstet Gynaecol 2019;36:418-23.
21. Muhammad S, El-Nafaty AU, Garba MB, Kullima AA. Prevalence and outcomes of eclampsia at federal teaching hospital Gombe, Nigeria. JJMEDSCI 2022;3:117-25.
22. Nkwabong E, Djientcheu Deugoue F, Fouedjio J. Pre-eclampsia in a Sub-Saharan African country and maternal-perinatal outcome. Trop Doct 2023;53:61-5.
23. Fernández Alba JJ, Mesa Páez C, Vilar Sánchez Á, Soto Pazos E, González Macías MD, Serrano Negro E, *et al.* Overweight and obesity at risk factors for hypertensive states of pregnancy: A retrospective cohort study. Nutr Hosp 2018;35:874-80.
24. Mbah A, Kornosky J, Kristensen S, August E, Alio A, Marty P, *et al*. Super-obesity and risk for early and late pre-eclampsia. BJOG Int J Obstet Gynaecol 2010;117:997-1004.
25. Roberts JM, Bodnar LM, Patrick TE, Powers RW. The role of obesity in preeclampsia. Pregnancy Hypertens 2011;1:6-16.
26. Dymara-Konopka W, Laskowska M. The role of nitric oxide, ADMA, and homocysteine in the etiopathogenesis of preeclampsia-review. Int J Mol Sci 2019;20:2757.
27. Ebogo-Belobo JT, Bilongo CM, Voufo RA, Atembeh-Noura E, Djabidatou O, Kenfack MT, *et al.* Maternal serum lipids in some women with pre-eclampsia in Yaoundé. Pan Afr Med J 2021;39:14.
28. Enaruna NO, Idemudia JO, Aikoriogie PI. Serum lipid profile and uric acid levels in preeclampsia in university of Benin teaching hospital. Niger Med J 2014;55:423-7.
29. Tseng WC, Chen YT, Lin YP, Ou SM, Yang CY, Lin CH, *et al.* Hyperuricemia predicts an early decline in renal function among older people: A community-based cohort study. Sci Rep 2019;9:980.
30. Vyakaranam S, Bhongir AV, Patlolla D, Chintapally R. Study of serum uric acid and creatinine in hypertensive disorders of pregnancy. Int J Med Sci Public Health 2015;4:1424-8.
31. Kumar N, Singh AK. Maternal serum uric acid as a predictor of severity of hypertensive disorders of pregnancy: A prospective cohort study. Curr Hypertens Rev 2019;15:154-60.
32. Lee SM, Park JS, Han YJ, Kim W, Bang SH, Kim BJ, *et al.* Elevated alanine aminotransferase in early pregnancy and subsequent development of gestational diabetes and preeclampsia. J Korean Med Sci 2020;35:e198.
33. Molla NH, Kathak RR, Sumon AH, Barman Z, Mou AD, Hasan A, *et al.* Assessment of the relationship between serum uric acid levels and liver enzymes activity in Bangladeshi adults. Sci Rep 2021;11:20114.
34. Liu C, Shao M, Lu L, Zhao C, Qiu L, Liu Z. Obesity, insulin resistance and their interaction on liver enzymes. PLoS One 2021;16:e0249299.