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Maternal serum ferritin and its association with preeclampsia severity

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Abstract:
Preeclampsia is a multisystem hypertensive disorder associated with endothelial dysfunction, inflammation and adverse maternal and fetal outcomes. Therefore, it is of interest to evaluate the association between maternal serum ferritin levels and preeclampsia severity in 100 pregnant women at 28–40 weeks of gestation, including 50 normotensive controls and 50 women with preeclampsia. Serum ferritin increased significantly with disease severity and was highest in severe preeclampsia ($p< 0.001$). Ferritin positively correlated with blood pressure, proteinuria, serum uric acid and liver enzymes, while showing inverse associations with gestational age at delivery and neonatal birth weight. Thus, elevated serum ferritin was associated with high preeclampsia severity and may serve as an adjunctive biomarker for identifying women at risk of severe disease and adverse pregnancy outcomes.

Keywords: Preeclampsia, serum ferritin, pregnancy, oxidative stress, iron metabolism, biomarker, maternal outcome, hypertensive disorders of pregnancy

Background:
Preeclampsia is a pregnancy-specific multisystem disorder characterized by new-onset hypertension after 20 weeks of gestation with proteinuria or maternal organ dysfunction **[1]**. It affects approximately 3–8% of pregnancies worldwide and remains a major cause of maternal and perinatal morbidity **[2]**. Its pathogenesis involves abnormal placentation, impaired spiral artery remodeling, endothelial dysfunction, inflammation and oxidative stress **[3, 4]**. Ferritin is an iron-storage protein that also acts as an acute-phase reactant and may increase during systemic inflammation **[5]**. Although ferritin normally decreases during pregnancy, elevated concentrations have been reported in women with preeclampsia and may reflect inflammation and oxidative injury **[6]**. Higher ferritin levels have also been associated with increased blood pressure, proteinuria, hepatic dysfunction and adverse fetal outcomes **[7]**. However, differences in study populations and methodologies have produced inconsistent evidence regarding its clinical utility **[8]**. Limited studies have evaluated ferritin across different grades of preeclampsia while simultaneously assessing maternal and fetal outcomes **[9, 10]**. Therefore, it is of interest to evaluate the maternal serum ferritin levels in normotensive, mild preeclampsia and severe preeclampsia pregnancies and determine their association with preeclampsia severity.

Methodology:
Study design and setting:
A hospital-based cross-sectional analytical study was conducted in the Department of Obstetrics and Gynaecology of a tertiary care teaching hospital over a period of 12 months after obtaining approval from the Institutional Ethics Committee. Written informed consent was obtained from all participants prior to enrollment.

Study population:
The study included 100 pregnant women with singleton pregnancies between 28 and 40 weeks of gestation attending the antenatal clinic or admitted to the obstetric ward.

Participants were categorized into three groups:
[1] Group I: Normotensive pregnant women (n=50)
[2] Group II: Mild preeclampsia (n=25)
[3] Group III: Severe preeclampsia (n=25)
Preeclampsia was diagnosed according to the American College of Obstetricians and Gynecologists (ACOG) guidelines.

Inclusion criteria:
[1] Pregnant women aged 18–40 years
[2] Singleton pregnancy
[3] Gestational age ≥28 weeks
[4] Women diagnosed with mild or severe preeclampsia
[5] Healthy normotensive pregnant women serving as controls

Exclusion criteria:
[1] Chronic hypertension
[2] Gestational diabetes mellitus
[3] Chronic kidney disease
[4] Liver disease
[5] Autoimmune disorders
[6] Hemoglobinopathies
[7] Multiple pregnancy
[8] Acute or chronic infection
[9] Iron overload disorders
[10] Recent blood transfusion
[11] Current inflammatory diseases

Sample size:
A total sample size of 100 participant**s** was included using consecutive sampling. The sample consisted of 50 normotensive pregnant women and 50 women with preeclampsia to provide adequate statistical power for comparison of maternal serum ferritin concentrations between study groups.
Data collection:
A detailed history including maternal age, parity, gestational age, body mass index, previous obstetric history and medical illnesses was obtained. Clinical examination included measurement of systolic blood pressure, diastolic blood

pressure, urine protein estimation and obstetric examination. Venous blood samples were collected under aseptic precautions before initiation of antihypertensive therapy. Serum ferritin estimation was performed using a fully automated chemiluminescent immunoassay analyzer according to manufacturer recommendations. Additional laboratory investigations included complete blood count, liver function tests, renal function tests, serum uric acid and platelet count. Maternal outcomes including eclampsia, HELLP syndrome, intensive care admission, mode of delivery and postpartum complications were documented. Neonatal outcomes including gestational age at delivery, birth weight, Apgar score, neonatal intensive care unit admission and perinatal mortality were also recorded.

Statistical analysis:

Data were entered into Microsoft Excel and analyzed using SPSS version 26.0. Continuous variables were expressed as mean ± standard deviation, whereas categorical variables were expressed as frequency and percentage. One-way analysis of variance (ANOVA) followed by Bonferroni post-hoc analysis was used for comparison of continuous variables among study groups. Chi-square or Fisher's exact test was applied for categorical variables. Pearson correlation analysis was performed to evaluate the association between serum ferritin levels and clinical parameters. A p-value <0.05 was considered statistically significant.

Results:

A total of 100 pregnant women were enrolled in the study. The study population comprised 50 normotensive pregnant women (Group I), 25 women with mild preeclampsia (Group II) and 25 women with severe preeclampsia (Group III). The mean maternal age did not differ significantly among the three groups (p=0.118). However, gestational age at delivery was significantly lower among women with severe preeclampsia compared with the other groups (p<0.001). Both systolic and diastolic blood pressure increased significantly with increasing severity of preeclampsia (p<0.001). Baseline demographic and clinical characteristics are summarized in **Table 1**. Maternal serum ferritin levels demonstrated a progressive increase with disease severity. The mean serum ferritin concentration was 32.8 ± 10.4 ng per mL among normotensive women, 81.6 ± 24.3 ng per mL among women with mild preeclampsia and 154.8 ± 42.6 ng per mL among women with severe preeclampsia. The difference among the three groups was highly significant (p<0.001). Women with severe preeclampsia also exhibited significantly higher serum uric acid, serum creatinine, aspartate aminotransferase (AST), alanine aminotransferase (ALT) and lower platelet counts compared with normotensive pregnancies **(Table 2).** Correlation analysis revealed that maternal serum ferritin demonstrated a significant positive correlation with systolic blood pressure (r=0.71, p<0.001), diastolic blood pressure (r=0.68, p<0.001), proteinuria (r=0.65, p<0.001), serum uric acid (r=0.62, p<0.001), AST (r=0.56, p<0.001) and ALT (r=0.53, p<0.001). Conversely, serum ferritin showed significant negative correlations with gestational age at delivery (r=−0.49, p<0.001) and neonatal birth weight (r=−0.58, p<0.001), indicating worsening maternal and fetal outcomes with increasing ferritin concentrations. Adverse maternal and neonatal outcomes were observed more frequently among women with severe preeclampsia. Caesarean section, preterm delivery, low birth weight, neonatal intensive care unit (NICU) admission and maternal intensive care unit (ICU) admission occurred significantly more often in women with severe disease (p<0.05). Detailed maternal and fetal outcomes are presented in **Tables 3 and 4.**

Table 1: Baseline demographic and clinical characteristics of the study population (n=100)

Variable	Normotensive (n=50)	Mild PE (n=25)	Severe PE (n=25)	p-value
Age (years), mean ± SD	26.8 ± 3.9	27.5 ± 4.3	28.1 ± 4.6	0.118
BMI (kg/m²), mean ± SD	24.9 ± 2.8	27.3 ± 3.2	29.4 ± 3.8	<0.001
Primigravida, n (%)	24 (48.0)	15 (60.0)	18 (72.0)	0.082
Gestational age (weeks)	38.5 ± 1.2	36.8 ± 1.5	34.6 ± 2.1	<0.001
SBP (mmHg)	114.6 ± 8.2	148.2 ± 9.5	169.8 ± 11.4	<0.001
DBP (mmHg)	74.8 ± 6.3	96.4 ± 6.8	111.2 ± 8.4	<0.001

Table 2: Comparison of laboratory parameters among study groups

Parameter	Normotensive	Mild PE	Severe PE	p-value
Serum ferritin (ng/mL)	**32.8 ± 10.4**	**81.6 ± 24.3**	**154.8 ± 42.6**	**<0.001**
Hemoglobin (g/dL)	11.4 ± 1.1	11.6 ± 1.2	11.8 ± 1.3	0.462
Platelet count (×10³/µL)	254 ± 48	208 ± 52	162 ± 46	<0.001
Serum uric acid (mg/dL)	4.0 ± 0.8	5.7 ± 1.0	7.2 ± 1.2	<0.001
Serum creatinine (mg/dL)	0.70 ± 0.10	0.91 ± 0.20	1.16 ± 0.30	<0.001
AST (U/L)	24.6 ± 7.2	38.8 ± 10.4	61.4 ± 18.2	<0.001
ALT (U/L)	22.8 ± 6.4	34.6 ± 8.5	56.9 ± 17.3	<0.001

Table 3: Maternal outcomes

Outcome	Mild PE (n=25)	Severe PE (n=25)	p-value
Caesarean delivery	12 (48.0)	20 (80.0)	0.018
HELLP syndrome	1 (4.0)	5 (20.0)	0.084
Eclampsia	0	3 (12.0)	0.072
ICU admission	1 (4.0)	6 (24.0)	0.041
Postpartum hemorrhage	2 (8.0)	5 (20.0)	0.219

Table 4: Neonatal outcomes

Outcome	Mild PE (n=25)	Severe PE (n=25)	p-value
Birth weight (kg)	2.58 ± 0.34	2.08 ± 0.42	<0.001
Preterm delivery	8 (32.0)	17 (68.0)	0.011
NICU admission	5 (20.0)	14 (56.0)	0.009
Apgar score (<7 at 5 min)	3 (12.0)	9 (36.0)	0.045
Perinatal mortality	0	2 (8.0)	0.149

Discussion:

The present study showed a progressive elevation in maternal serum ferritin concentrations from normotensive pregnancies to mild and severe preeclampsia. Women with severe preeclampsia exhibited the highest ferritin levels, accompanied by

significantly worse maternal and neonatal outcomes. These findings reinforce the concept that serum ferritin functions as an acute-phase reactant reflecting endothelial injury, systemic inflammation, placental ischemia and oxidative stress, all of which are central mechanisms in the pathogenesis of preeclampsia. Furthermore, the significant correlations observed between ferritin concentrations and blood pressure, proteinuria, liver enzymes, serum uric acid, gestational age and neonatal birth weight suggest that serum ferritin may serve as a reliable adjunctive biomarker for assessing disease severity and predicting adverse pregnancy outcomes. These findings are consistent with Yang *et al.* (2022) **[11],** who demonstrated that disturbances in ferritin metabolism contribute directly to the pathophysiology of preeclampsia through ferritin light-chain deficiency, ferroptosis, impaired trophoblast invasion and abnormal uterine spiral artery remodeling. Their experimental evidence provides mechanistic support for the elevated serum ferritin concentrations observed in women with severe preeclampsia and suggests that altered ferritin homeostasis reflects ongoing placental injury rather than isolated iron overload. Similarly, Wang *et al.* (2023) **[12]** reported that increased serum ferritin levels in women with preeclampsia were independently associated with preterm birth and adverse neonatal outcomes. They concluded that elevated ferritin possesses predictive value for premature delivery among preeclamptic pregnancies, which closely parallels the present study where higher ferritin concentrations were associated with earlier gestational age at delivery, lower birth weight and increased NICU admissions. Comparable observations were reported by Ismael *et al.* (2024) **[13],** who evaluated serum ferritin and C-reactive protein as inflammatory markers in preeclampsia. Their study demonstrated significantly elevated ferritin concentrations in women with preeclampsia compared with normotensive controls, although ferritin alone showed limited discrimination between severe and non-severe disease. In contrast, the present study identified a clear progressive rise in ferritin from mild to severe preeclampsia, suggesting that differences in sample size, laboratory methodology and patient characteristics may explain the stronger association observed in our cohort. Our findings also agree with Mo *et al.* (2025) **[14],** who conducted a large longitudinal cohort study involving more than 17,000 pregnant women. They demonstrated that women with persistently elevated or increasing serum ferritin concentrations during pregnancy had a significantly greater risk of developing hypertensive disorders, including preeclampsia. Their results suggest that serial ferritin assessment may identify women at increased risk before clinical manifestations appear, complementing our observation that higher ferritin concentrations are associated with increasing disease severity at presentation. More recently, Taymur *et al.* (2026) **[15]** reported that elevated maternal serum ferritin was an independent predictor of preeclampsia after adjustment for other hematological and micronutrient variables. They observed that ferritin demonstrated acceptable diagnostic accuracy for predicting preeclampsia and concluded that increased ferritin likely reflects systemic oxidative stress and inflammatory activation. These findings strongly corroborate the present study, where serum ferritin showed significant positive correlations with blood pressure, proteinuria, liver dysfunction and maternal complications, supporting its usefulness as an adjunctive biomarker for risk stratification **[16, 17]**. Overall, the present findings strengthen the growing body of evidence indicating that maternal serum ferritin is closely associated with both the occurrence and severity of preeclampsia. When interpreted alongside clinical examination and routine laboratory investigations, serum ferritin may provide valuable additional information for identifying women at high risk of severe maternal complications and adverse neonatal outcomes **[18, 19]**. Nevertheless, because ferritin is also influenced by systemic inflammation and other medical conditions, it should not be used as a standalone diagnostic marker. Large prospective multicenter studies incorporating serial ferritin measurements and other angiogenic and inflammatory biomarkers are warranted to establish standardized clinical cut-off values and define its role in routine antenatal risk assessment.

Conclusion:

Maternal serum ferritin levels were elevated in preeclampsia, particularly in severe cases, and correlated with disease severity. Higher ferritin levels were associated with adverse maternal and neonatal outcomes, lower gestational age, and reduced birth weight.

Serum ferritin may aid preeclampsia risk stratification, but further multicenter studies are needed to validate its clinical utility.

Limitations:

The present study has several limitations that should be considered while interpreting the findings. First, the study was conducted at a single tertiary care center with a relatively small sample size, which may limit the generalizability of the results to broader populations. Second, the cross-sectional study design precluded assessment of temporal changes in serum ferritin levels throughout pregnancy and did not permit establishment of a causal relationship between elevated ferritin and the development or progression of preeclampsia. Third, serum ferritin is an acute-phase reactant that may be influenced by subclinical inflammation or other unrecognized conditions despite careful exclusion criteria. Additionally, other inflammatory and angiogenic biomarkers, such as C-reactive protein, interleukin-6, soluble fms-like tyrosine kinase-1 (sFlt-1) and placental growth factor (PlGF), were not evaluated for comparison. Finally, long-term maternal and neonatal outcomes were not assessed, highlighting the need for larger multicenter prospective studies with serial biomarker measurements to validate the clinical utility of serum ferritin in predicting preeclampsia severity and adverse pregnancy outcomes.

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