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Serum Homocysteine Levels and Folate Levels as a Predictor of Materno-Fetal Outcome in Pre-Eclamptic Women

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ABSTRACT

Background and Aims: Pre-eclampsia is a major cause of maternal and perinatal morbidity and mortality, characterized by endothelial dysfunction and abnormal placentation. Hyperhomocysteinemia has been implicated in its pathogenesis, whereas folate deficiency may contribute through impaired homocysteine metabolism. This study evaluated the association of maternal serum homocysteine and folate levels with adverse materno-fetal outcomes in women with pre-eclampsia.

Methods: A hospital-based descriptive observational study was conducted at the Department of Obstetrics and Gynecology, Vani Vilas Hospital, Bangalore Medical College and Research Institute, Bengaluru, India, from November 2019 to May 2021. A total of 150 women with pre-eclampsia at >34 weeks' gestation was enrolled consecutively after informed consent. Serum homocysteine and folate levels were measured using chemiluminescence immunoassay. Maternal complications and fetal outcomes were recorded. Continuous variables were summarized as mean ± standard deviation (SD) or median (IQR), and categorical variables as frequencies and percentages. Associations between categorical variables were analyzed using the Chi-square test or Fisher's exact test, as appropriate. A two-sided p-value <0.05 was considered statistically significant.

Results: The mean maternal age was 24.59±4.90 years. Elevated serum homocysteine (>13.6 µmol/L) was observed in 54.67% of participants. Hyperhomocysteinemia was significantly associated with maternal complications including HELLP syndrome (p=0.006), postpartum hemorrhage, placental abruption, acute kidney injury, disseminated intravascular coagulation, multiple organ dysfunction syndrome, cerebrovascular accident, and maternal death (all p<0.05). Significant associations were also observed with preterm birth (p=0.004), low birth weight (p=0.007), stillbirth (p<0.001), and neonatal intensive care unit admission (p=0.042). Serum folate levels remained within the normal range in nearly all participants and showed no significant association with maternal or fetal outcomes.

Conclusion: Elevated maternal serum homocysteine is significantly associated with adverse maternal and neonatal outcomes in pre-eclampsia and may serve as a useful biomarker for risk stratification. Serum folate demonstrated no predictive value, possibly reflecting adequate antenatal folic acid supplementation. Larger multicenter prospective studies with serial biomarker assessment are warranted.

Keywords: Pre-Eclampsia; Homocysteine; Folic Acid; Pregnancy Outcome; Maternal Health; Infant, Low Birth Weight.

INTRODUCTION

One of the main causes of maternal and perinatal morbidity and mortality globally is pre-eclampsia, a multisystem illness of pregnancy. Along with other hypertensive disorders of pregnancy, it complicates approximately 2–8% of all pregnancies. Clinically, pre-eclampsia is characterized by the new onset of hypertension and proteinuria after 20 weeks of gestation. The severity of maternal complications and adverse perinatal outcomes largely depends on the degree of disease progression and the extent of end-organ involvement.[1] Pre-eclampsia is a complex syndrome affecting multiple organ systems, including the hepatic, renal, pulmonary, hematological, and central nervous systems. Although its exact pathogenesis remains incompletely understood, endothelial dysfunction resulting from oxidative stress, vasoconstriction, metabolic disturbances, inflammatory responses, and abnormal placentation is considered central to disease development.[2]

Homocysteine is a sulfur-containing, non-protein amino acid produced during methionine metabolism. It undergoes remethylation to methionine, transsulfuration to cysteine, or is released into extracellular fluids such as plasma and urine.[3] Elevated plasma homocysteine concentrations (hyperhomocysteinemia) have been recognized as an independent risk factor for vascular diseases owing to their detrimental effects on vascular endothelium. Hyperhomocysteinemia promotes oxidative stress, induces endothelial injury, and reduces the bioavailability of nitric oxide, an important endothelium-derived vasodilator responsible for maintaining vascular tone, inhibiting platelet aggregation, and preventing leukocyte and low-density lipoprotein adhesion. Impaired nitric oxide-mediated vasodilation contributes to endothelial dysfunction, which plays a pivotal role in the pathophysiology of pre-eclampsia.[4]

Physiologically, maternal serum homocysteine concentrations decline during pregnancy because of increased plasma volume, elevated estrogen levels, enhanced maternal and fetal methionine utilization, and other adaptive metabolic changes. However, maternal hyperhomocysteinemia has been associated with several placental vascular disorders, particularly pre-eclampsia.[5] Experimental studies have demonstrated that moderately elevated homocysteine concentrations induce oxidative stress, endothelial cell injury, and cytotoxicity. Furthermore, homocysteine exposure has been shown to impair trophoblastic function by promoting cellular apoptosis, thereby adversely affecting placental development and function.[6]

Folate, a water-soluble B-complex vitamin, is essential for DNA synthesis, DNA repair, and methionine regeneration through one-carbon metabolic pathways.[7] As a methyl donor, folate, together with vitamin B12 acting as a coenzyme, facilitates the remethylation of homocysteine to methionine, thereby maintaining normal homocysteine homeostasis.[8] Folate deficiency disrupts this metabolic pathway, resulting in elevated serum homocysteine concentrations that increase the risk of endothelial dysfunction and vascular disease. Consequently, maternal serum folate and vitamin B12 status play crucial roles in regulating circulating homocysteine levels and may influence the development of hypertensive disorders during pregnancy.[9]

Experimental *in vitro* studies have further demonstrated the beneficial effects of folic acid on placental function. Treatment of trophoblastic cells derived from healthy placental tissue with folic acid suppresses apoptosis, downregulates anti-angiogenic factors, enhances extravillous trophoblast invasion, and promotes angiogenesis, thereby supporting normal placental vascular development. These findings suggest a

potential protective role of folate against placental dysfunction associated with pre-eclampsia.[10]

Despite considerable advances in obstetric care, reliable early prediction of pre-eclampsia remains challenging, necessitating continued efforts to identify effective biomarkers for timely diagnosis and risk stratification. Although several predictive markers have been investigated, none has demonstrated sufficient accuracy for routine clinical application. In this context, the present study was undertaken to evaluate maternal serum homocysteine and serum folate levels in women with pre-eclampsia and to determine their association with adverse maternal and fetal outcomes.

Objectives of Study

1. To estimate serum homocysteine and serum folate levels in cases of preeclampsia and its correlation with materno-fetal outcome.
2. To assess materno-fetal outcome associated with preeclampsia

MATERIALS AND METHODS

Study Design and Setting

This descriptive hospital-based study was conducted in the inpatient Department of Obstetrics and Gynecology at Vani Vilas Hospital, Bangalore Medical College and Research Institute (BMCRI), Bengaluru, India, over a period of 19 months from November 2019 to May 2021. The study was performed after obtaining approval from the Institutional Ethics Committee, and all procedures adhered to the ethical principles outlined in the Declaration of Helsinki. Written informed consent was obtained from all participants before enrolment.

Study Population and Sample Size

The study included pregnant women diagnosed with preeclampsia who fulfilled the predefined eligibility criteria. The sample size was estimated using the formula for estimating a single population mean:

$$n = \frac{Z_\alpha^2 \, \sigma^2}{d^2}$$

The calculation was based on the findings of Chhavi Kabra et al. [2], who reported a mean serum homocysteine level of 13.20 ± 3.68 µmol/L among women with mild preeclampsia. Assuming a 95% confidence level (Z = 1.96), a standard deviation (σ) of 3.68 µmol/L, and an absolute precision (d) of 0.66 µmol/L (5% of the reported mean), the estimated sample size was 119 participants. After accounting for an anticipated 5% attrition rate, the final sample size was rounded to 130 participants.

Eligibility Criteria

Women aged 18–49 years with singleton pregnancies, gestational age greater than 34 weeks, and a clinical diagnosis of preeclampsia who were willing to provide written informed consent were included in the study. Women with pre-existing liver disease, diabetes mellitus, chronic (essential) hypertension diagnosed before 20 weeks of gestation, cardiovascular disease, renal disease, multiple pregnancy, gestational age below 34 weeks, or those unwilling to participate were excluded.

Study Procedure

Eligible participants were recruited consecutively after obtaining informed written consent. A detailed obstetric, medical, and demographic history was obtained, followed by a comprehensive general physical, systemic, and obstetric examination. Data were recorded using a predesigned case record form with a structured follow-up chart.

Based on disease severity, participants were categorized into non-severe preeclampsia, severe preeclampsia, and eclampsia according to standard obstetric diagnostic criteria. Maternal venous blood samples were collected for biochemical analysis in addition to routine laboratory investigations performed for the evaluation of preeclampsia, including complete blood count (CBC), liver function tests (LFT), renal function tests (RFT), serum lactate

dehydrogenase (LDH), serum uric acid, and serum electrolytes.

Measurement of Serum Homocysteine and Serum Folate

Approximately 5 mL of venous blood was collected aseptically from the antecubital vein into a plain collection tube. Samples were transported to the Department of Biochemistry within 30 minutes of collection. Serum homocysteine and serum folate concentrations were measured using the chemiluminescence immunoassay (CLIA) method according to standard laboratory protocols. The laboratory reference ranges were 4.42–13.60 µmol/L for serum homocysteine and 3.1–20.5 ng/mL for serum folate.

Variables

The primary variables included serum homocysteine and serum folate levels. Secondary variables comprised the severity of hypertensive disorders of pregnancy (non-severe preeclampsia, severe preeclampsia, and eclampsia) and routine laboratory parameters, including CBC, LFT, RFT, serum LDH, serum uric acid, and serum electrolytes.

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using IBM SPSS Statistics version 22.0. Continuous variables were summarized as mean ± standard deviation (SD) or median with interquartile range (IQR), as appropriate, while categorical variables were expressed as frequencies and percentages. Categorical variables were compared using the Chi-square test, and Fisher's exact test was applied whenever the expected cell frequency was less than five. All statistical tests were two-tailed, and a p-value <0.05 was considered statistically significant.

RESULTS

The study included 150 participants with a mean age of 24.59 ± 4.90 years (table 1). The mean systolic and diastolic blood pressures were 158.55 ± 14.09 mmHg and 100.57 ± 8.92 mmHg, respectively. The mean hemoglobin level was 11.61 ± 1.56 g/dL, while the mean platelet count was 242,600 ± 102,523/µL. Biochemical parameters showed a mean LDH level of 468.79 ± 346.39 U/L, mean serum uric acid of 7.36 ± 2.20 mg/dL, mean blood urea of 21.86 ± 16.26 mg/dL, and mean serum creatinine of 0.84 ± 0.68 mg/dL. The mean serum folate and homocysteine levels were 11.23 ± 3.68 and 14.59 ± 5.50 µmol/L, respectively. The wide ranges and relatively large standard deviations observed for platelet count, LDH, blood urea, creatinine, and homocysteine indicate considerable inter-individual variability in hematological and biochemical parameters within the study population.

Table 1. Descriptive analysis of demographic and laboratory parameters in the study population (N = 150).

Parameter	Mean ± SD	Median	Minimum	Maximum	95% CI (Lower)	95% CI (Upper)
Age (years)	24.59 ± 4.90	23.00	19.00	40.00	23.80	25.37
SBP (mmHg)	158.55 ± 14.09	160.00	136.00	210.00	156.29	160.80
DBP (mmHg)	100.57 ± 8.92	100.00	90.00	120.00	99.15	102.00
Hemoglobin (g/dL)	11.61 ± 1.56	11.70	6.00	15.40	11.36	11.86
Platelet count (/µL)	242,600 ± 102,523	240,000	35,000	560,000	226,192.90	259,007.10
LDH (U/L)	468.79 ± 346.39	374.00	153.00	2,302.00	413.35	524.22
Uric acid (mg/dL)	7.36 ± 2.20	6.85	3.30	15.00	7.01	7.71
Blood urea (mg/dL)	21.86 ± 16.26	17.60	4.70	152.60	19.26	24.46
Serum creatinine (mg/dL)	0.84 ± 0.68	0.70	0.23	6.64	0.74	0.95

Serum folate	11.23 ± 3.68	11.60	2.00	20.00	10.64	11.82
Serum homocysteine (µmol/L)	14.59 ± 5.50	14.20	6.50	43.00	13.71	15.47

In this study majority of patient belonged to lower and lower middle group of socioeconomic status contributing to 36.67% and 34.67% respectively. Majority of patients in the study were primigravida accounting for 58% and multigravida accounting for 42%. Mean gestational age in the study was > 36 weeks accounting to 76.67%. Majority of patients had urine albumin of 2+, constituting to 57.33%. Majority of cases were SPE accounting to 48%, followed by NSPE accounting to 36%. 54.67% of patients had elevated homocysteine levels.

In the study 51.33% and 48.67% of patient had vaginal and caesarean delivery respectively.

Among the vaginal delivery 67.53% of patient were induced deliveries. Among caesarean delivery most common indication for LSCS was failed induction (17.81%) followed by previous LSCS (16.44%).

In this study most common complication was HELLP (12.67%) > PPH (12.00%) > abruption (8.67%). Most common fetal complication observed in the study is low birth weight (53.33%) > APGAR <6/10(31.33%) > preterm birth (29.33%), FGR (29.33%) > still birth & neonatal death (7.33%) > IUFD (5.33%). Among the 150 neonates, 80 (53.33%) had low birth weight (<2.5 kg), including 20 (13.33%) with very low birth weight (<1.5 kg), of whom 3 (2.0%) had extremely low birth weight, while 70 (46.67%) had a birth weight >2.5 kg. Of the 62 neonates requiring NICU admission, the most common indication was respiratory distress (50.0%), followed by prematurity (25.8%), fetal growth restriction (17.74%), and meconium aspiration syndrome (6.45%). 58.33% and 54.16% of SPE and APE had elevated levels of serum homocysteine levels.

From the table 2, serum homocysteine was significantly elevated in 100% of cases with PPH, abruption, MODS, DIC, CVA and maternal death,88.88% of cases with AKI 84.21% of cases with HELLP, 50% of cases with PRES and Pulmonary edema. p-value was found statistically significant ($p<0.05$) in PPH, HELLP syndrome, abruption, MODS, AKI, DIC, CVA and maternal death p-value was not significant in cases with deranged LFT, pulmonary edema, PRES and patients requiring ICU admission.

Table 2. Comparison of maternal outcomes according to serum homocysteine levels (N = 150)

Maternal Outcomes	**Serum Homocysteine (µmol/L)**		**P value**
	Normal (4.42–13.6) (N = 68)	**Abnormal (>13.6)** (N = 82)	
PPH			
Present	0 (0.0%)	18 (21.95%)	<0.001
Absent	68 (100.0%)	64 (78.05%)	
HELLP syndrome			
Present	3 (4.41%)	16 (19.51%)	0.006
Absent	65 (95.59%)	66 (80.49%)	
Placental abruption			
Present	0 (0.0%)	13 (15.85%)	<0.001
Absent	68 (100.0%)	69 (84.15%)	
MODS			
Present	0 (0.0%)	2 (2.44%)	<0.001
Absent	68 (100.0%)	80 (97.56%)	
Deranged LFT			
Present	3 (4.41%)	6 (7.32%)	0.512
Absent	65 (95.59%)	76 (92.68%)	
Pulmonary edema			

Present	1 (1.47%)	2 (2.44%)	1.000
Absent	67 (98.53%)	80 (97.56%)	
PRES			
Present	1 (1.47%)	2 (2.44%)	1.000
Absent	67 (98.53%)	80 (97.56%)	
ICU admission			
Present	3 (4.41%)	6 (7.32%)	0.512
Absent	65 (95.59%)	76 (92.68%)	
AKI			
Present	1 (1.47%)	8 (9.76%)	0.041
Absent	67 (98.53%)	74 (90.24%)	
DIC			
Present	0 (0.0%)	2 (2.44%)	<0.001
Absent	68 (100.0%)	80 (97.56%)	
Maternal death			
Present	0 (0.0%)	1 (1.22%)	<0.001
Absent	68 (100.0%)	81 (98.78%)	
CVA			
Present	0 (0.0%)	1 (1.22%)	<0.001
Absent	68 (100.0%)	81 (98.78%)	

Data are presented as *n (%)*. Fisher's exact test was used.

Abbreviations: PPH, postpartum hemorrhage; HELLP, hemolysis, elevated liver enzymes, and low platelet count; MODS, multiple organ dysfunction syndrome; LFT, liver function test; PRES, posterior reversible encephalopathy syndrome; ICU, intensive care unit; AKI, acute kidney injury; DIC, disseminated intravascular coagulation; CVA, cerebrovascular accident.

In this study, serum homocysteine was found to be elevated in preterm (72.72%), LBW (63.75%), FGR (61.36%), Still births (100%), IUFD (87.5%), neonatal death (81.81%), cases with low APGAR (65.95%) and in neonates requiring NICU admission (64.51%). p-value was significant in cases with preterm birth, LBW, still birth and cases requiring NICU admission (table 3). In this study, serum folate was normal in 99.33% of cases and no definite correlation was seen in serum folate with maternal and fetal outcome.

Table 3: Comparison of fetal outcomes between serum homocysteine (micro mol/L) (N=150)

Fetal Outcomes	**Serum Homocysteine (Micro Mol/L)**		**Chi square/ Fisher's exact test**	**P value**
	Normal (4.42-13.6) (N=68)	**Abnormal (>13.6) (N=82)**		
Pre-Term				
Yes	12 (17.65%)	32 (39.02%)	8.195	**0.004**
No	56 (82.35%)	50 (60.98%)		
FGR				
Yes	17 (25%)	27 (32.93%)	1.127	0.288
No	51 (75%)	55 (67.07%)		
Low birth Weight				
Yes	29(42.65%)	51 (62.20%)	12.102	**0.007**
No	39 (57.35%)	31 (37.8%)		
Apgar-<6/10				
Yes	16 (23.53%)	31 (37.8%)	3.521	0.061
No	52 (76.47%)	51 (62.2%)		
NICU Admission				
Yes	22 (32.35%)	40 (48.78%)	4.137	**0.042**
No	46 (67.65%)	42 (51.22%)		
Still Birth				
Yes	0 (0%)	11 (13.41%)	-	**p<0.001***
No	68 (100%)	71 (86.59%)		
IUFD				

Yes	1 (1.47%)	7 (8.54%)	-	0.072*
No	67 (98.53%)	75 (91.46%)		
Neonatal Death				
Yes	2 (2.94%)	9 (10.98%)	-	0.112*
No	66 (97.06%)	73 (89.02%)		

*Fisher's exact test

DISCUSSION

Pre-eclampsia remains one of the most important pregnancy-specific hypertensive disorders and continues to be a major contributor to maternal and perinatal morbidity and mortality worldwide. Endothelial dysfunction, oxidative stress, and abnormal placentation are central to its pathogenesis, with hyperhomocysteinemia emerging as a potential contributor through vascular endothelial injury and impaired placental perfusion. Folate deficiency has also been implicated in elevated homocysteine levels owing to its role in one-carbon metabolism. Therefore, evaluation of serum homocysteine and folate concentrations may provide valuable insights into disease severity and pregnancy outcomes.

The present descriptive study was conducted to evaluate serum homocysteine and serum folate levels in women with pre-eclampsia and to determine their association with maternal and fetal outcomes. A total of 150 women with pre-eclampsia were enrolled. The mean maternal age was 24.59 ± 4.90 years, with the majority belonging to the lower socioeconomic group (36.67%), being primigravidae (58%), and presenting beyond 36 weeks of gestation (76.67%). The mean systolic and diastolic blood pressures were 158.55 ± 14.09 mmHg and 100.57 ± 8.92 mmHg, respectively, which are comparable to the findings reported by Namita Jain et al. [3]. The study population comprised 36% women with non-severe pre-eclampsia, 48% with severe pre-eclampsia, and 16% with antepartum eclampsia.

Serum homocysteine and serum folate were measured once at the time of admission. The mean serum homocysteine level was 14.59 ± 5.50 µmol/L, while the mean serum folate level was 11.23 ± 3.68 ng/mL. These findings are consistent with those reported by Saroj Kunwar et al. [11], supporting the observation that elevated homocysteine levels are frequently encountered in women with pre-eclampsia.

With regard to the mode of delivery, 51% of women delivered vaginally, of whom 67.53% underwent induction of labour, primarily for uncontrolled hypertension or intrauterine fetal death. Caesarean delivery was performed in 48.67% of cases, with failed induction being the most common indication (17.81%). These findings reflect the high rate of obstetric intervention commonly required in pregnancies complicated by pre-eclampsia.

One of the principal findings of the present study was the significant association between elevated serum homocysteine levels and adverse maternal outcomes. HELLP syndrome was the most frequent maternal complication (12.67%), followed by postpartum haemorrhage (12%), placental abruption (8.67%), deranged liver function tests and acute kidney injury (6% each), pulmonary oedema and posterior reversible encephalopathy syndrome (6% each), multiple organ dysfunction syndrome and disseminated intravascular coagulation (1.33% each), and cerebrovascular accident (0.67%). Intensive care unit admission was required in 6% of patients, and one maternal death was recorded. Serum homocysteine levels were significantly higher among women who developed postpartum haemorrhage, HELLP syndrome, placental abruption, acute kidney injury, multiple organ dysfunction syndrome, disseminated intravascular coagulation, cerebrovascular accident, and maternal death, indicating that hyperhomocysteinemia may be associated with severe maternal complications.

Elevated serum homocysteine levels were also significantly associated with adverse fetal outcomes. The incidence of low birth

weight was 53.33%, followed by preterm birth (29.33%), fetal growth restriction (29.33%), low APGAR score (31.33%), stillbirth (7.33%), intrauterine fetal death (5.33%), and neonatal death (7.33%). Furthermore, 41.33% of neonates required admission to the neonatal intensive care unit. Statistical analysis demonstrated significant associations between elevated homocysteine levels and preterm birth, low birth weight, stillbirth, and neonatal intensive care unit admission, suggesting that maternal hyperhomocysteinemia may adversely influence fetal growth and neonatal outcomes.

In contrast, serum folate levels did not demonstrate a significant association with either maternal or fetal outcomes in the present study. None of the women exhibited biochemical folate deficiency, which may be explained by routine folic acid supplementation during early pregnancy. Similar observations were reported by Namita Jain et al. [3], suggesting that adequate folate supplementation may minimize the influence of folate deficiency on pregnancy outcomes despite elevated homocysteine concentrations.

Comparison with previously published literature demonstrated considerable agreement with the present findings. The mean maternal age, diastolic blood pressure, and serum homocysteine levels observed in the current study were comparable with those reported by Namita Jain et al. [3] and Alparslan Baksu et al. [14]. Although most previous investigations, including those by Namita Jain et al. [3] and Sunita Ghike et al. [13], employed a case-control design, whereas Laxmi Maru et al. [12] and Alparslan Baksu et al. [14] conducted prospective studies, the present investigation was descriptive in nature. Nevertheless, the clinical characteristics and biochemical findings were largely consistent across these studies.

The pattern of maternal complications also showed similarities with earlier reports. In the present study, HELLP syndrome (12.67%) was the most common maternal complication, whereas placental abruption (19%) predominated in the study by Namita Jain et al. [3]. Importantly, both studies demonstrated a significant association between elevated serum homocysteine levels and adverse maternal outcomes. Statistically significant associations with HELLP syndrome, placental abruption, and renal dysfunction observed in the current study were comparable to those reported by Namita Jain et al. [3]. Although maternal mortality was infrequent, one maternal death was observed in the present study and was associated with markedly elevated serum homocysteine levels.

Similarly, the relationship between elevated homocysteine levels and adverse fetal outcomes was consistent with previous evidence. Both the present study and that of Namita Jain et al. [3] demonstrated significant associations between hyperhomocysteinemia and preterm birth as well as low birth weight. However, unlike Namita Jain et al. [3], significant associations with intrauterine fetal death and neonatal death were not observed in the present study. Furthermore, low APGAR score was not significantly associated with serum homocysteine levels in either study, suggesting that immediate neonatal adaptation may be influenced by factors other than maternal homocysteine concentration alone.

Overall, the findings of the present study support the growing body of evidence indicating that elevated maternal serum homocysteine is associated with increased severity of pre-eclampsia and a higher risk of adverse maternal and fetal outcomes. Conversely, serum folate levels did not demonstrate a significant relationship with pregnancy outcomes, likely reflecting adequate antenatal folic acid supplementation among the study population. These observations suggest that serum homocysteine may serve as a useful biochemical marker for identifying women with pre-eclampsia who are at increased risk of severe maternal and neonatal complications.

Strengths and Limitations

The present study provides clinically relevant data regarding the association of serum homocysteine with adverse maternal and fetal outcomes in women with pre-eclampsia. However, several limitations should be acknowledged. First, the relatively modest sample size may have limited the statistical power to detect significant associations for less frequent maternal and neonatal outcomes, although significant associations were observed for several important complications. Second, serum homocysteine and serum folate concentrations were measured only once at admission, and serial measurements during pregnancy were not performed. Longitudinal assessment of these biomarkers could have provided additional information regarding their temporal relationship with disease progression and pregnancy outcomes.

CONCLUSION

The present study demonstrates that pre-eclampsia is associated with elevated maternal serum homocysteine levels, supporting the role of hyperhomocysteinemia in the disease process. Higher serum homocysteine concentrations were significantly associated with an increased risk of adverse maternal and fetal outcomes. Women with elevated homocysteine levels experienced a greater incidence of serious maternal complications, including HELLP syndrome, postpartum haemorrhage, placental abruption, disseminated intravascular coagulation, and multiple organ dysfunction syndrome. Similarly, hyperhomocysteinemia was associated with adverse neonatal outcomes, including preterm birth, low birth weight, stillbirth, and increased neonatal intensive care unit admissions.

These findings suggest that maternal serum homocysteine may serve as a useful biochemical marker for identifying women with pre-eclampsia who are at increased risk of severe disease and poor pregnancy outcomes, thereby facilitating timely risk stratification and appropriate obstetric management. In contrast, serum folate levels did not show a significant association with maternal or fetal outcomes in the present study, which may be attributable to adequate folic acid supplementation during pregnancy. Further prospective multicentre studies with larger sample sizes and serial assessment of serum homocysteine and folate levels are warranted to validate these findings and establish their clinical utility in predicting the severity of pre-eclampsia and pregnancy outcomes.

Declaration by Authors

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