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Original Research Article

Relationship of maternal serum vitamin D level with preeclampsia

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ABSTRACT

Background: Vitamin D deficiency has been increasingly implicated in adverse pregnancy outcomes, including preeclampsia; however, evidence from South Asian populations remains limited. This study aimed to evaluate the relationship between maternal serum vitamin D levels and preeclampsia in pregnant women in Bangladesh.
Methods: A hospital-based case-control study was conducted at Sir Salimullah Medical College Mitford Hospital in Dhaka from March 2019 to March 2020. A total of 106 pregnant women aged 18–35 years with gestational age 28-40 weeks were enrolled, 53 with preeclampsia and 53 normotensive controls. Data on sociodemographic and obstetric characteristics were collected through interviews. Serum 25(OH)D concentrations were measured using chemiluminescence immunoassay and categorized as deficient (≤20 ng/ml), insufficient (21-29 ng/ml), and sufficient (≥30 ng/ml). Statistical analyses were performed using SPSS version 23.0, and $p<0.05$ was considered significant.
Results: Mean serum vitamin D levels were significantly lower in preeclamptic women (13.41±6.83 ng/ml) than in controls (19.96±9.07 ng/ml, $p<0.001$). Women with vitamin D levels <30 ng/ml had 7.46 times greater odds of developing preeclampsia (95% CI 1.58-35.25). In the multivariate analysis, both deficient and insufficient vitamin D levels remained significant predictors (OR = 6.03 and 6.55, respectively).
Conclusions: Low maternal serum vitamin D levels were strongly associated with preeclampsia. Routine screening and adequate vitamin D supplementation during pregnancy may help reduce the risk of this potentially fatal disorder.

Keywords: Preeclampsia, Pregnancy, Vitamin D, 25-hydroxyvitamin D

INTRODUCTION

Preeclampsia (PE) remains one of the most complex and potentially life-threatening hypertensive disorders of pregnancy, affecting between 2% and 10% of pregnancies globally.[1] It is clinically characterized by new-onset hypertension (≥140/90 mmHg) and proteinuria after 20 weeks of gestation in previously normotensive women, frequently accompanied by systemic complications such as renal insufficiency, hepatic dysfunction, and thrombocytopenia.[2] Despite extensive research, the pathophysiology of preeclampsia is not completely understood, and its prediction and prevention continue to pose challenges in obstetric medicine.

Recent evidence suggests that vitamin D deficiency, traditionally linked to skeletal metabolism, may also influence immune regulation, vascular function, and trophoblastic invasion, thereby contributing to the pathogenesis of preeclampsia.[3,4] The biologically active form of vitamin D-1,25-dihydroxyvitamin D-acts via vitamin D receptors (VDRs), which are expressed in placental and decidual tissues.[5] It modulates immune tolerance, suppresses proinflammatory cytokines, and promotes angiogenesis through vascular endothelial growth factor (VEGF) expression.[6] Inadequate vitamin D may therefore contribute to endothelial dysfunction, impaired placental implantation, and abnormal angiogenesis, all of which are hallmarks of preeclampsia.[7]

Several observational studies have documented an association between low maternal serum 25-hydroxyvitamin D levels and increased risk of preeclampsia. A meta-analysis demonstrated that pregnant women with vitamin D deficiency had a 2- to 3-fold higher risk of developing preeclampsia compared to those with sufficient levels.[8] Bodnar et al reported that women with serum 25(OH)D concentrations below 50 nmol/l (<20 ng/ml) had a nearly fourfold increased risk of preeclampsia.[9] Moreover, the active form of vitamin D has been found to suppress the renin-angiotensin system, which plays a critical role in blood pressure regulation during pregnancy.[10] Therefore, vitamin D deficiency may exacerbate vasoconstriction and oxidative stress, leading to hypertension and subsequent preeclampsia.[11]

The prevalence of vitamin D deficiency is disproportionately high in South Asian countries, including Bangladesh, despite abundant sunlight.[12] Contributing factors include reduced outdoor activity, conservative clothing practices, urbanization, and lack of food fortification. In pregnant Bangladeshi women, up to two-thirds have been found to have suboptimal serum vitamin D levels.[13] Given this background, it is crucial to explore whether low maternal vitamin D status may contribute to preeclampsia in this population.

The present study was designed to evaluate the relationship between maternal serum vitamin D levels and preeclampsia in Bangladeshi women. By comparing vitamin D concentrations in preeclamptic and normotensive pregnant women, and identifying the magnitude of risk through logistic regression modeling, this study aimed to provide local evidence supporting vitamin D optimization during pregnancy as a potential preventive strategy for preeclampsia.

METHODS

A hospital-based case-control study was conducted in the Department of Obstetrics and Gynecology, Sir Salimullah Medical College Mitford Hospital (SSMC MH), Dhaka, Bangladesh, from March 2019 to March 2020. A total of 106 pregnant women were enrolled, comprising 53 women with preeclampsia (cases) and 53 normotensive pregnant women (controls), matched for age (18–35 years) and gestational age (28-40 weeks).

Inclusion criteria

Participants were eligible for enrollment if they met the following criteria: a singleton pregnancy with gestational age between 28 and 40 weeks; maternal age between 18 and 35 years. Women diagnosed with preeclampsia were included in the case group, while normotensive, healthy pregnant women were included in the control group.

Exclusion criteria

Participants were excluded from the study if they had chronic hypertension or renal disease; diabetes mellitus (gestational or pregestational); autoimmune disorders; multiple pregnancy; a history of preeclampsia in previous pregnancies; or if they were currently using vitamin D supplements.

Data collection and study procedure

Eligible participants were selected purposively following informed consent. Data were collected using a pretested semi-structured questionnaire and a checklist. Socio-demographic data (age, residence, education, occupation, income), obstetric history, antenatal care attendance, and sun exposure patterns were recorded via interview. Clinical examination included measurement of blood pressure using a mercury sphygmomanometer after ten minutes of rest, and assessment of proteinuria using a dipstick method. For biochemical analysis, 5 mL of venous blood was drawn under aseptic conditions, centrifuged at 4400 rpm for 10-15 minutes, and serum was separated. Serum 25-hydroxyvitamin D concentration was measured using the Atellica™ Analyzer (Siemens Healthineers, USA) through a chemiluminescence immunoassay. Levels ≥30 ng/ml were considered sufficient, 20-29 ng/ml insufficient, and ≤20 ng/ml deficient.

Ethical considerations

Ethical clearance was obtained from the Institutional Review Board of Sir Salimullah Medical College Mitford Hospital. Participants were informed about study objectives, procedures, and potential risks. Written informed consent was obtained before enrollment. Data confidentiality and anonymity were strictly maintained throughout data collection, analysis, and reporting.

Statistical analysis

Data were analyzed using the Statistical Package for the Social Sciences (SPSS) version 23.0. Continuous variables were expressed as mean ± standard deviation (SD), and categorical variables as frequencies and percentages. Group comparisons were made using the chi-square test, Fisher's exact test, or Mann–Mann-Whitney U test where appropriate. Logistic regression analysis was performed to

identify predictors of preeclampsia. Odds ratios (ORs) with 95% confidence intervals (CIs) were calculated. A p value <0.05 was considered statistically significant.

RESULTS

Table 1 presents the distribution of maternal age, residence, education, occupation, and socioeconomic status among preeclamptic (case) and normotensive (control) pregnant women. There were no statistically significant differences between the case and control groups regarding residence, education, occupation and economic status (p>0.05).

Regarding antenatal checkups, the healthy control group mothers were found to be more sincere (84.9%) in respect of seeking routine ANC than the preeclamptic cases (54.7%), and this difference was statistically significant (p=0.001). But no statistical significance was observed between the case and control groups in regards of frequency of antenatal check-ups (p>0.05) (Table 2).

Table 1: Distribution of respondents according to socio-demographic variables by group (n=106).

Socio-demographic variables		Case group, N (%) (n=53)	Control group, N (%) (n=53)	P value
Age (years)	Mean±SD	24.92±4.65	24.26±4.57	
Residence	Rural	18 (34.0)	16 (30.2)	0.677
	Urban	35 (66.0)	37 (69.8)	
Education	Illiterate	18 (34.0)	7 (13.2)	0.097
	Primary	25 (47.2)	28 (52.8)	
	Secondary	8 (15.1)	13 (24.5)	
	Higher secondary	2 (3.8)	4 (7.5)	
	Graduate	0 (0.0)	1 (1.9)	
Occupation	Home maker	46 (86.8)	39 (73.6)	0.114
	Service holder	3 (5.7)	10 (18.9)	
	Student	4 (7.5)	4 (7.5)	
Monthly family income	Lower class	4 (7.5)	2 (3.8)	0.199
	Lower middle class	46 (86.8)	49 (92.5)	
	Upper middle class	2 (3.8)	1 (1.9)	
	Upper class	1 (1.9)	1 (1.9)	
	Mean±SD	10933.96±11156.13	11179.25±11519.82	
	Mean Rank	49.69	57.31	

Table 2: Distribution of respondents according to antenatal check-up by group (n=106).

Antenatal check-up	Case group, N (%) (n=53)	Control group, N (%) (n=53)	P value
Yes	29 (54.7)	45 (84.9)	0.001
Regular	4 (13.8)	7 (15.6)	0.999
Irregular	25 (86.2)	38 (84.4)	
No	24 (45.3)	8 (15.1)	

Mean serum vitamin D level among the case and controls was 13.41±6.83ng/ml and 19.96±9.07ng/ml, with mean ranks of 41.59 and 65.41, respectively. This result was highly statistically significant (p<0.001) (Table 3).

There was a significant difference in regards of vitamin D adequacy in between case and control groups (p=0.004) and the respondents with vitamin D <30ng/ml had 7.5 times more chance to develop preeclampsia compared to that of the respondent with vitamin D ≥30 ng/ml (OR=7.46; 95% CI=1.58- 35.25) (Table 4).

Table 3: Comparison of vitamin D level between case and control groups (n=106).

Vitamin D (ng/ml)	Case group, N (%) (n=53)	Control group, N (%) (n=53)	P value
≤20	41 (77.4)	32 (60.4)	<0.001
21-29	10 (18.9)	9 (17.0)	
≥30	2 (3.8)	12 (22.6)	
Mean±SD	13.41±6.83	19.96±9.07	
Mean rank	41.59	65.41	

Logistic regression model demonstrated that an insufficient Vitamin D level was about 6.5 times (OR=6.550, 95% CI=1.344-31.920) and a deficient Vitamin D level was about 6 times (OR=6.028, 95% CI=1.033-35.186) more chance to develop preeclampsia than the women with a sufficient Vitamin D level. Respondents who never went for an antenatal checkup were about 2 times (OR=2.190, 95% CI=0.933-5.144) more chance to develop preeclampsia than respondents who went for an antenatal checkup, but this was not statistically significant (p>0.05) (Table 5).

Table 4: Distribution of respondents by vitamin D adequacy (n=106).

Vitamin D (ng/ml)	Case group (n=53)	Control group (n=53)	P value	Odds Ratio (95% CI)
<30	51 (96.2)	41 (77.4)	0.004	7.46
≥30	2 (3.8)	12 (22.6)		(1.58-35.25)

Table 5: Logistic regression analysis of predictors of preeclampsia (n=106).

Variables	P value	Odds Ratio	95% CI for Odds Ratio	
			Lower	Upper
Vitamin D sufficient (≥30ng/ml)		1		
Vitamin D insufficient (21-29ng/ml)	0.02	6.55	1.344	31.92
Vitamin D deficient (≤20ng/ml)	0.046	6.028	1.033	35.186
Antenatal check up	0.072	2.19	0.933	5.144

DISCUSSION

The present study examined the relationship between maternal serum vitamin D levels and preeclampsia among pregnant women in Bangladesh and revealed a strong inverse association between vitamin D sufficiency and the occurrence of preeclampsia. The findings demonstrated that women with deficient (<20 ng/ml) or insufficient (20-29 ng/ml) vitamin D levels were approximately six times more likely to develop preeclampsia compared to women with adequate levels (≥30 ng/ml). These results are consistent with the growing body of evidence linking hypovitaminosis D to hypertensive disorders of pregnancy, supporting the hypothesis that vitamin D deficiency contributes to the pathogenesis of preeclampsia through immunological and vascular mechanisms.

The mean serum vitamin D concentration among preeclamptic women in this study (13.41±6.83 ng/ml) was significantly lower than that of normotensive pregnant women (19.96±9.07 ng/ml, p<0.001). This observation closely aligns with findings from studies in South Asia and the Middle East, where similar climatic and sociocultural conditions prevail. Mehmood and Karim reported mean serum vitamin D levels of 9.43±4.86 ng/ml among preeclamptic Pakistani women, markedly lower than controls (16.78±4.86 ng/ml).[14] Likewise, Ullah et al found that 78% of Bangladeshi pregnant women had serum vitamin D levels below 30 ng/ml and those with concentrations <20 ng/ml were at nearly fourfold increased risk of developing preeclampsia.[13]

The logistic regression model in this study identified vitamin D deficiency and insufficiency as independent predictors of preeclampsia, even after controlling for antenatal care frequency. The adjusted odds ratios (6.03 and 6.55, respectively) are comparable to findings from Abedi et al who reported that women with vitamin D deficiency had a 24-fold increased risk of preeclampsia compared to vitamin D-D-replete women.[15] Similarly, Sadin et al observed that maternal 25(OH)D concentrations below 10 ng/ml were associated with a 15-fold higher risk of preeclampsia.[16] These consistent results across different populations underscore the potential role of vitamin D in the pathophysiological cascade leading to hypertensive disorders in pregnancy.

From a mechanistic standpoint, vitamin D modulates both placental development and vascular function. The presence of vitamin D receptors (VDRs) and the enzyme 1α-hydroxylase in placental tissues supports its local synthesis and action.[5] Experimental data indicate that vitamin D promotes trophoblastic invasion, regulates angiogenic factors such as vascular endothelial growth factor (VEGF), and suppresses proinflammatory cytokines, including TNF-α and IL-6.[3,17] Deficiency, therefore, may lead to endothelial dysfunction and restricted uteroplacental perfusion, characteristic of preeclampsia. Vitamin D also acts on the renin–angiotensin–aldosterone system (RAAS), suppressing renin expression and thus influencing vascular tone and blood pressure.[10] Reduced vitamin D availability may therefore increase vascular sensitivity to angiotensin II, elevating systemic blood pressure.[18]

In the current study, fewer preeclamptic women reported receiving regular antenatal care compared to controls (54.7% vs. 84.9%, p=0.001). Inadequate antenatal surveillance may have limited the opportunity for early detection of risk factors, including nutritional deficiencies. This pattern is consistent with findings from Sahu et al, who observed that irregular antenatal attendance was common among women diagnosed with preeclampsia.[19] Such behavioural and access-related variables may further amplify biological vulnerability, highlighting the importance of integrating nutritional assessment and counselling into routine antenatal care.

Although this study found no significant difference in BMI between groups, previous research indicates that higher BMI is associated with both vitamin D deficiency and preeclampsia risk.[20] Obesity may reduce the bioavailability of vitamin D due to sequestration in adipose tissue.[21] However, since pre-pregnancy BMI and

gestational weight gain were not available in this study, residual confounding cannot be excluded.

The findings of this study support the study by Bodnar et al, who demonstrated that low maternal 25(OH)D concentrations (<15 ng/ml) in early pregnancy were associated with a fivefold increase in preeclampsia risk.[9] Furthermore, Mirzakhani et al found that women maintaining vitamin D sufficiency (≥30 ng/ml) throughout pregnancy experienced significantly lower incidence of preeclampsia compared with those persistently deficient.[22] The consistency of these observations across populations suggests that vitamin D supplementation during pregnancy could represent a low-cost, preventive intervention.

Taken together, this study reinforces that hypovitaminosis D is not merely an epiphenomenon of poor maternal nutrition but may play an etiologic role in preeclampsia development. The results advocate for incorporating serum vitamin D testing into antenatal screening, especially in populations with limited sunlight exposure or cultural clothing practices restricting dermal synthesis. Further prospective cohort studies and randomized controlled trials are warranted to clarify causality and determine optimal supplementation thresholds tailored to regional and ethnic contexts.

This study was limited by its single-center design and modest sample size, which may restrict generalizability. The purposive sampling technique may introduce selection bias. Additionally, potential confounders such as dietary intake, seasonal variation, and parathyroid hormone levels were not assessed. Pre-pregnancy BMI and weight gain during gestation were also unavailable, limiting evaluation of nutritional and metabolic factors influencing vitamin D status.

CONCLUSION

Maternal serum vitamin D deficiency was significantly associated with an increased risk of preeclampsia. Women with insufficient or deficient vitamin D levels had approximately sixfold higher odds of developing the disorder compared to those with adequate levels. The findings underscore the potential role of vitamin D optimization in pregnancy as a modifiable factor in preeclampsia prevention. Incorporating vitamin D screening and supplementation into antenatal care programs may contribute to improved maternal outcomes, particularly in regions with prevalent hypovitaminosis D.

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Ethical approval: The study was approved by the Institutional Ethics Committee

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