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Original Research Article

Hypertensive Disorder of Pregnancy and Long-Term Cardiovascular Risk in Mother

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Abstract:

Background: Hypertensive disorders of pregnancy (HDP), including gestational hypertension and preeclampsia, are known predictors of long-term cardiovascular disease (CVD) in women. Despite this, the contribution of intermediate risk factors such as chronic hypertension, diabetes, obesity, and dyslipidemia remains unclear. Understanding these pathways is crucial for early prevention strategies in at-risk women.

Materials and Methods: This hospital-based study was conducted over one year at a tertiary care center and included 212 parous women. Data on pregnancy history, HDP, and cardiovascular outcomes were collected from hospital records and validated interviews. Anthropometric, biochemical, and lifestyle information were recorded, and cardiovascular events were confirmed through clinical and investigation-based diagnosis. Statistical analyses were performed using SPSS v28, with significance set at $p<0.05$.

Results: Of the participants, 81.1% were normotensive, 8.5% had gestational hypertension, and 10.4% developed preeclampsia. Women with HDP had higher BMI, greater family history of CVD, and higher rates of preterm and cesarean deliveries. CVD occurred in 15% of women with HDP compared to 4.7% of normotensive women, with preeclampsia showing the strongest association. Mediation analysis revealed chronic hypertension accounted for 55% of the excess CVD risk.

Conclusion: HDP significantly increases long-term CVD risk in mothers, largely mediated by subsequent chronic hypertension.

Keywords: Hypertensive Disorders of Pregnancy, Preeclampsia, Gestational Hypertension, Cardiovascular Risk, Maternal Health.

Introduction

Hypertensive disorders of pregnancy (HDP), such as gestational hypertension and preeclampsia, are observed in around 15% of women and are often connected with a higher likelihood of developing cardiovascular disease (CVD) and premature CVD-related mortality compared with women who experience normotensive pregnancies [1,2]. Although this association is well established, relatively few investigations have taken pre-pregnancy health characteristics, including body mass index (BMI), into account, and even fewer have extended follow-up beyond 30 years [3–6]. This limitation underscores the importance of long-term studies that examine how HDP shapes cardiovascular outcomes across the lifespan while considering baseline health risks.

Women affected by HDP tend to develop chronic hypertension, elevated cholesterol, and type 2 diabetes mellitus (T2DM) in the later stages, which in turn increases the predisposition to CVD [7]. Recognizing these links, several organizations have classified preeclampsia as a risk-enhancing factor for hypercholesterolemia and encourage its consideration in cardiovascular risk assessment [8,9]. Nevertheless, uncertainty remains about which of these established predisposing variables explain the connection of HDP with future CVD, as most studies have assessed individual mediators in isolation rather than evaluating their combined contribution [5,10,11].

The AHA has recommended that physicians include a history of preeclampsia and gestational hypertension when screening women for CVD risk [12]. However, to optimize preventive strategies, further longitudinal research is needed to determine whether the excess risk after HDP is largely mediated through conventional risk factors or if HDP itself has an independent influence. The Nurses' Health Study II (NHS II), with its decades-long follow-up and comprehensive collection of

reproductive histories, lifestyle patterns, and incident CVD events, offers a unique opportunity to investigate these relationships. This study specifically explores the long-term cardiovascular consequences of HDP, adjusting for pre-pregnancy confounders and examining the mediating roles of other risk factors [13].

Methodology

Study Setting and Participants: This study was carried out at a tertiary care hospital for one year on 212 parous women. Eligible participants were those with at least one completed pregnancy and available clinical records. Women with a history of cardiovascular disease before their first pregnancy or with incomplete pregnancy or medical history were excluded.

Hypertensive Disorders of Pregnancy: Pregnancy-related details were collected through hospital records and validated interviews. Hypertensive disorders of pregnancy (HDP) were classified as new-onset hypertension during pregnancy, classified into gestational hypertension or preeclampsia based on physician diagnosis. Women with pre-existing chronic hypertension were excluded to ensure accurate classification.

Cardiovascular Events: Incident CVD events, including myocardial infarction, angina, and stroke, were identified through medical records, discharge summaries, and follow-up consultations. Events were confirmed using physician diagnosis and supporting investigations, such as laboratory results or imaging. Both fatal and non-fatal CVD events were included in the analysis.

Data Collection and Covariates: Baseline socio-demographic and lifestyle details were obtained using a structured questionnaire. Anthropometric measurements were recorded using standard protocols. Blood pressure was measured after a 10-minute rest, and fasting blood samples were collected to assess glucose levels and lipid profile. Additional information on smoking, alcohol intake, family history of CVD, and physical activity was also collected. Clinical diagnoses and medication use were used to classify hypertension, hypercholesterolemia, and type 2 diabetes mellitus.

Statistical Analysis: Statistical analysis was performed using SPSS version 20. Continuous variables were expressed as mean ± SD, and categorical variables as frequencies and percentages.

Results

The baseline characteristics of the study participants indicate that the majority of women were normotensive during pregnancy (81.1%), with smaller proportions experiencing gestational hypertension (8.5%) and preeclampsia (10.4%). Women who developed HDP tended to be slightly older at first birth compared to normotensive women. Importantly, both gestational hypertension and preeclampsia groups showed a higher mean BMI, with nearly one in five women classified as overweight or obese prior to conception. Family history of cardiovascular disease was also more frequent among women with HDP. Pregnancy outcomes revealed that preterm delivery and cesarean sections were more common among the HDP groups, particularly among those with preeclampsia, suggesting early maternal and perinatal complications associated with pregnancy hypertension (Table 1).

Table 1: Baseline Characteristics of Women by Hypertensive Status at First Pregnancy (n = 212)

Characteristic	Normotensive (n=172, 81.1%)	Gestational Hypertension (n=18, 8.5%)	Preeclampsia (n=22, 10.4%)
Mean age at first birth (years)	26.9 ± 4.5	28.1 ± 4.8	27.2 ± 4.6
Mean BMI before pregnancy (kg/m²)	22.0 ± 3.6	23.5 ± 4.2	23.0 ± 4.4
Overweight/Obese before pregnancy (%)	19 (11.0%)	4 (22.2%)	5 (22.7%)
Family history of CVD (%)	36 (20.9%)	5 (27.8%)	6 (27.3%)
Preterm delivery (<37 weeks, %)	12 (7.0%)	2 (11.1%)	3 (13.6%)
Cesarean delivery (%)	54 (31.4%)	8 (44.4%)	9 (40.9%)

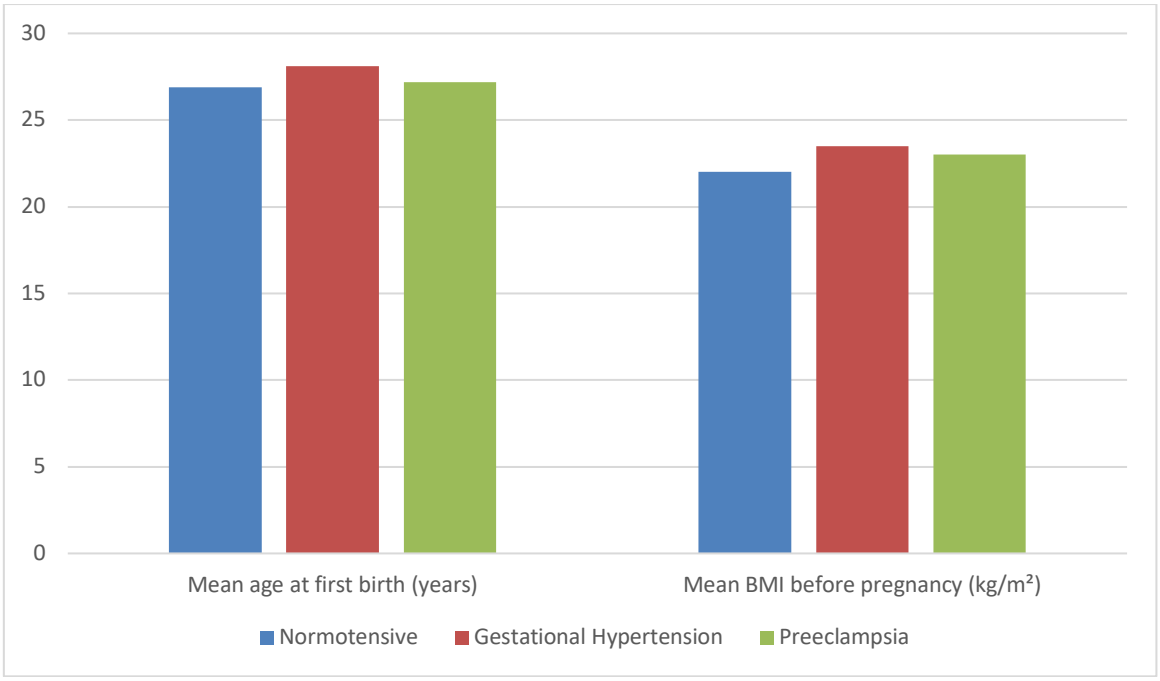

Figure 1: Baseline Characteristics of Women by Hypertensive Status at First Pregnancy (n = 212)

Analysis of cardiovascular outcomes revealed a clear gradient of risk, with women who experienced HDP showing higher rates of incident CVD compared to those with normotensive pregnancies. Only 4.7% of normotensive women developed CVD, whereas 11.1% of those with gestational hypertension and 18.2% of those with preeclampsia had CVD events during follow-up. Preeclampsia was particularly associated with myocardial infarction, affecting nearly one in ten women. The median age at first CVD event was slightly lower among preeclampsia patients (54 years), highlighting earlier onset of disease. After adjustment for baseline covariates, women with any HDP had a 70% higher risk of CVD compared to normotensive women, with the strongest effect observed for preeclampsia (Table 2).

Table 2: HDP and Cardiovascular Disease Outcomes

Outcome	Normotensive (n=172)	Gestational Hypertension (n=18)	Preeclampsia (n=22)	Any HDP (n=40)
Incident CVD cases (%)	8 (4.7%)	2 (11.1%)	4 (18.2%)	6 (15.0%)
Myocardial infarction (%)	3 (1.7%)	1 (5.6%)	2 (9.1%)	3 (7.5%)
Stroke (%)	2 (1.2%)	0	1 (4.5%)	1 (2.5%)
Angina/other ischemic events (%)	3 (1.7%)	1 (5.6%)	1 (4.5%)	2 (5.0%)
Median age at first CVD event (years)	56	57	54	55
Adjusted hazard ratio (95% CI)	1.00 (ref)	1.4 (0.7–2.6)	1.9 (1.2–2.8)	1.7 (1.2–2.3)

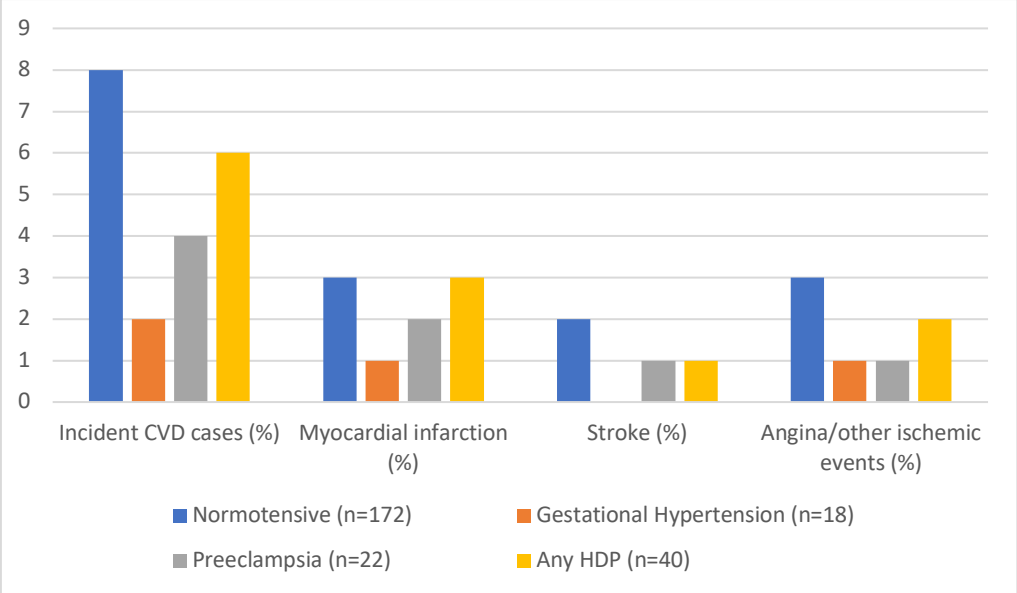

Figure 2: HDP and Cardiovascular Disease Outcomes

The mediation analysis demonstrated that much of the elevated CVD risk in women with HDP could be attributed to the development of chronic hypertension, which accounted for more than half (55%) of the excess risk. Changes in BMI after pregnancy contributed around 20%, indicating that weight gain during the later life course also plays a significant role. Hypercholesterolemia explained about 15% of the risk, while type 2 diabetes accounted for 10%. These results suggest that while traditional cardiovascular risk factors collectively mediate the association between HDP and CVD, hypertension remains the single most important driver (Table 3).

Table 3: Mediation of HDP–CVD Relationship by Intermediate Risk Factors

Mediator	Contribution to Excess Risk (%)
Chronic Hypertension	55%
Hypercholesterolemia	15%
Type 2 Diabetes	10%
Changes in BMI	20%

Discussion

Women with HDP in their first pregnancy showed a substantially higher risk of developing CVD in later life compared to those with normotensive pregnancies, even after considering baseline factors such as pre-pregnancy BMI, smoking, and family history of CVD. In our cohort of 212 women, CVD occurred in 15% of those with HDP compared to 4.7% among normotensive women, with the risk being particularly pronounced in women with preeclampsia. Much of this increased risk was mediated by the later development of established CVD risk factors, including chronic hypertension, hypercholesterolemia, type 2 diabetes, and weight gain. Chronic hypertension alone accounted for over half of the excess risk, a finding that aligns with earlier mediation analyses [5,12,13]. Similar to evidence from the UK Biobank, where chronic hypertension explained 64% of the elevated CAD risk among women with HDP [13], our study reinforces the pivotal role of hypertension in driving long-term cardiovascular outcomes.

Our findings further suggest that the type of HDP influences the pattern of cardiovascular sequelae. Preeclampsia was associated with a greater risk of coronary artery disease (CAD), whereas gestational hypertension was more strongly linked to stroke. These differential associations indicate that gestational hypertension and preeclampsia may represent distinct disease entities rather than points along the same spectrum of severity. These findings align with observations from the Northern Finland Birth Cohort 1966, which demonstrated a stronger correlation between gestational hypertension and stroke [4]. In addition, our mediation analysis indicated that chronic hypertension contributed more substantially to cardiovascular risk after gestational hypertension than after preeclampsia. This supports earlier evidence showing that women with gestational hypertension have a higher likelihood of developing chronic hypertension later in life [10]. The pronounced connection between gestational hypertension and stroke can thus be attributed to the pivotal role of hypertension as a major risk factor for cerebrovascular disease [14].

The differing underlying mechanisms of gestational hypertension and preeclampsia may help explain their distinct cardiovascular consequences. Gestational hypertension is generally viewed as a "pure hypertensive phenotype," whereas preeclampsia is driven by abnormal placental development, resulting in vascular dysfunction, endothelial injury, and ischemic changes during pregnancy [15]. Over time, women with preeclampsia are more likely to experience lasting endothelial impairment, alterations in cardiac structure, accelerated vascular aging, and early signs of atherosclerosis [15-20]. Among these, endothelial dysfunction appears to be a key factor linking preeclampsia with coronary artery disease, as it compromises blood flow regulation in both the uterine circulation during pregnancy and the coronary vessels in later life [19]. By demonstrating these subtype-specific risks in an Indian hospital-based population, our study adds to global evidence that early identification and management of women with HDP may provide a valuable opportunity for reducing future cardiovascular burden.

Conclusion

In the present investigation, metabolic syndrome was significantly more prevalent among individuals with advanced knee osteoarthritis requiring total knee replacement and was strongly associated with higher Kellgren-Lawrence grades. Obesity-related parameters, including BMI and WC, were notably higher in cases, highlighting the contribution of metabolic abnormalities to disease severity. These findings suggest that MetS not only elevates the incidence rate of developing knee OA but may also accelerate its progression, emphasizing the importance of early identification and management of metabolic risk factors. Integrating metabolic evaluation and lifestyle interventions into the care of OA patients may help mitigate disease progression and reduce the need for surgical intervention.

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