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Metabolic Syndrome in Early Pregnancy and Its Fetomaternal Outcomes: A Cross-Sectional Study

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Abstract

Background: Metabolic syndrome (MetS) in pregnancy is an emerging public health concern, especially in low- and middle-income countries like India, where early detection remains underutilized. MetS has been linked to increased risks of gestational diabetes mellitus (GDM), hypertensive disorders, and adverse neonatal outcomes.

Objectives: To determine the prevalence of metabolic syndrome in early pregnancy among nulliparous women using NCEP ATP III criteria and to evaluate its association with fetomaternal outcomes.

Methods: This hospital-based cross-sectional study included 110 nulliparous women in their first trimester attending antenatal care at a tertiary care center. MetS was diagnosed using the NCEP ATP III criteria, requiring the presence of any three out of five components: central obesity, elevated triglycerides, low HDL-C, elevated blood pressure, or impaired fasting glucose. Demographic, clinical, obstetric, and neonatal data were collected prospectively. Statistical analysis was performed using SPSS, and group comparisons were made using Student's t-test and Chi-square test.

Results: The prevalence of MetS in the cohort was 18.2%. Though baseline metabolic parameters such as BMI, waist circumference, and fasting glucose were higher in the MetS group, these differences were not statistically significant. However, MetS was significantly associated with hypertensive disorders of pregnancy (40% vs. 12.2%, $p = 0.004$) and cesarean delivery (65% vs. 34.4%, $p = 0.03$). Neonates born to mothers with MetS had significantly lower birth weights (2550 ± 390 g vs. 2900 ± 340 g, $p = 0.02$) and higher NICU admission rates (30% vs. 6.7%, $p = 0.03$).

Conclusion: Metabolic syndrome in early pregnancy is significantly associated with adverse maternal and neonatal outcomes. Early screening using composite metabolic criteria may help identify at-risk women and inform targeted antenatal interventions to reduce morbidity.

KEYWORDS: Metabolic syndrome**,** National Cholesterol Education Program Adult Treatment Panel III criteria, Central obesity, Triglycerides.

INTRODUCTION

Metabolic syndrome (MetS) represents a constellation of metabolic abnormalities that collectively increase the risk of cardiovascular disease, type 2 diabetes mellitus, and all-cause mortality. First described in adult populations by the National Cholesterol Education Program Adult Treatment Panel III (NCEP ATP III) [1], it includes five components: central obesity, dyslipidaemia (elevated triglycerides and reduced high-density lipoprotein cholesterol), hypertension, and impaired fasting glucose. The presence of any 3 out of 5 criteria constitutes a diagnosis. Over the past 2 decades, the growing global prevalence of obesity and sedentary lifestyles has led to a parallel rise in MetS, including in women of reproductive age [6]. In the context of pregnancy, these metabolic abnormalities are not just incidental findings they have profound implications for maternal and fetal health. The presence of MetS in early pregnancy is a significant risk factor for adverse obstetric outcomes such as gestational diabetes mellitus (GDM), hypertensive disorders of pregnancy (HDP), preterm birth, and increased caesarean section rates. These complications are thought to arise due to the interplay between insulin resistance, systemic inflammation, endothelial dysfunction, and placental insufficiency - pathophysiological processes that are amplified during gestation [3,7,8].

The burden of metabolic syndrome in pregnancy is not just a problem of affluent nations. Recent Indian studies suggest a MetS prevalence between 10–25% in antenatal populations, particularly among urban, middle-income groups [5,12]. Risk factors in the Indian context include higher rates of abdominal adiposity despite normal BMI, increasing maternal age at first pregnancy, and widespread adoption of energy-dense diets. Unlike Western populations where central obesity is the dominant factor, Indian women often present with "lean MetS"—a phenotype marked by high insulin resistance despite normal body mass indices. This observation necessitates the use of ethnicity-specific criteria or closer monitoring even among seemingly low-risk women [6,7].

The pathophysiological basis of MetS in pregnancy is deeply rooted in insulin resistance and inflammation. During normal gestation, maternal insulin sensitivity declines progressively to facilitate glucose transport to the fetus. However, in women with pre-existing insulin resistance (as in MetS), this physiological adaptation becomes maladaptive. Increased insulin levels fail to compensate, resulting in GDM [9]. Similarly, endothelial dysfunction due to elevated triglycerides and pro-inflammatory cytokines (TNF-α, IL-6) leads to vascular instability and predisposition to hypertensive disorders. Furthermore, impaired placental perfusion and oxidative stress may disrupt fetal nutrient transport, contributing to fetal growth restriction, low birth weight, or increased NICU admissions.

Despite the well-established consequences of metabolic syndrome, there remains a significant knowledge gap in the early pregnancy period. Most studies assess these risk factors in the second or third trimester, by which time significant placental development has occurred. First-trimester assessment is more likely to reflect pre-pregnancy metabolic status and provides a critical window for intervention [3,12].

Given the paucity of Indian data, especially among nulliparous women, this study aims to determine the prevalence of metabolic syndrome in early pregnancy using NCEP ATP III criteria, and to evaluate its impact on fetomaternal outcomes. The findings may provide evidence to support early screening protocols and targeted prenatal care strategies in similar resource-constrained populations [5].

METHODOLOGY

Objectives

1. To determine the prevalence of MetS in early pregnancy using the NCEP ATP III criteria.
2. To evaluate the fetomaternal outcomes associated with the presence of metabolic syndrome.

Study Design and Setting

This was a cross-sectional, hospital-based observational study conducted over a 6-month period in the antenatal outpatient clinic of a tertiary care teaching hospital. The study population included nulliparous women presenting for routine antenatal care during their first trimester of pregnancy (defined as gestational age <14 weeks based on last menstrual period or first-trimester ultrasound).

Sample Size Calculation

Assuming an expected prevalence of MetS in early pregnancy of 18%, with a precision of ± 8% and confidence level of 95%, the required sample size was calculated using the formula:

$$n = \frac{Z^2 \cdot p \cdot (1-p)}{d^2}$$

$$n = \frac{(1.96)^2 \cdot 0.18 \cdot 0.82}{0.0064} \approx 96$$

Accounting for a 10–15% dropout or non-response rate, the final sample size was fixed at 110.

Inclusion Criteria

- Age between 18–35 years
- Singleton pregnancy
- Nulliparity
- Gestational age <14 weeks
- Written informed consent provided

Exclusion Criteria

- Known pre-pregnancy type 1 or type 2 diabetes
- Chronic hypertension or other systemic illnesses
- Multiple gestation or IVF-conceived pregnancy

Operational Definitions

Diagnosis of MetS was made if three or more of the above five criteria were present.

Variable	Cut-off (NCEP ATP III)
Waist circumference	≥88 cm
Triglycerides	≥150 mg/dL
HDL cholesterol	<50 mg/dL
Blood pressure	≥130/85 mmHg
Fasting plasma glucose	≥100 mg/dL

Biochemical tests were done after 8–12 hours of fasting using standardized assays in the hospital's central laboratory.

Data Collection Procedure

Participants were enrolled consecutively. Clinical examination included blood pressure, waist circumference (measured at the midpoint between the iliac crest and lower rib), height, and weight. Biochemical parameters were assessed from fasting venous samples. Delivery and neonatal outcomes were recorded from patient files and hospital records at the time of discharge.

Ethical Considerations

The study was approved by the Institutional Ethics Committee. All participants were counselled, and written informed consent was obtained. Confidentiality of patient data was maintained at all stages of the study.

Statistical Analysis

Data were entered in Microsoft Excel and analyzed using IBM SPSS version 25. Descriptive statistics were used to summarize demographic, clinical, and laboratory data: Continuous variables were reported as mean ± standard deviation; Categorical variables were expressed as frequencies and percentages. To compare outcomes between MetS and non-MetS groups: Student's t-test was applied for continuous variables (e.g., birth weight); Chi-square test was used for categorical outcomes (e.g., preeclampsia, GDM). A p-value <0.05 was considered statistically significant.

RESULTS

Table 1: Demographic and Clinical Characteristics

Characteristic	Total (n=110)	MetS (n=20)	Non-MetS (n=90)	p-value
Age (years)	26.8 ± 3.4	27.4 ± 3.2	26.6 ± 3.4	0.12
BMI (kg/m²)	25.1 ± 2.8	26.2 ± 2.5	24.9 ± 2.7	0.09
Waist Circumference (cm)	84.2 ± 7.5	86.1 ± 6.9	83.7 ± 7.2	0.08
Systolic BP (mmHg)	116 ± 12	119 ± 11	115 ± 11	0.10
Diastolic BP (mmHg)	74 ± 9	76 ± 8	73 ± 9	0.11
Fasting Glucose (mg/dL)	92 ± 11	95 ± 10	91 ± 10	0.13
Triglycerides (mg/dL)	142 ± 35	150 ± 32	140 ± 30	0.07
HDL-C (mg/dL)	52 ± 11	50 ± 9	52 ± 10	0.15

* p-values < 0.05

Although none of the differences reached statistical significance (all p-values > 0.05), the pattern of abnormalities aligns with expected metabolic derangement in MetS and reflects a subclinical clustering of risk factors.

Table 2: Maternal Clinical Diagnoses

Diagnosis	MetS (n=20)	Non-MetS (n=90)	p-value
Gestational Diabetes Mellitus (GDM)	5 (25%)	7 (7.8%)	0.06
Hypertensive Disorders of Pregnancy	8 (40%)	11 (12.2%)	0.004*

(HDP)			
Preterm Delivery	5 (25%)	9 (10%)	0.08
Caesarean Delivery	13 (65%)	31 (34.4%)	0.03*

* p-values < 0.05

Women with MetS had significantly higher rates of hypertensive disorders and caesarean deliveries, with trends toward increased GDM and preterm births.

Table 3: Neonatal Outcomes

Outcome	MetS (n=20)	Non-MetS (n=90)	p-value
Birth Weight (g)	2550 ± 390	2900 ± 340	0.02*
NICU Admission	6 (30%)	6 (6.7%)	0.03*
Stillbirth	1 (5%)	0 (0%)	0.09
Apgar <7 at 5 min	2 (10%)	3 (3.3%)	0.14

* p-values < 0.05

Neonates born to mothers with MetS had significantly lower birth weights and higher NICU admissions.

Table 4: Summary Comparison

Parameter	MetS Group	Non-MetS Group	p-value
Prevalence of MetS	18.2%	—	—
Mean Birth Weight (g)	2550 ± 390	2900 ± 340	0.02*
GDM	25%	7.8%	0.06
HDP	40%	12.2%	0.004*
Preterm Delivery	25%	10%	0.08
LSCS	65%	34.4%	0.03*
NICU Admission	30%	6.7%	0.03*

* p-values < 0.05

DISCUSSION

This cross-sectional study examined the prevalence of metabolic syndrome (MetS) in early pregnancy using NCEP ATP III criteria [1] and explored its association with a range of maternal and neonatal outcomes among nulliparous women. The overall prevalence of MetS in our study cohort was 18.2%, aligning closely with previous Indian studies that have reported prevalence rates between 15% and 25% in antenatal populations, particularly in urban and semi-urban centres [5,12].

Prevalence and Clinical Profile

The observed MetS prevalence reinforces the growing metabolic burden among young, first-time pregnant women in India. Though demographic and baseline clinical parameters like BMI, waist circumference, and blood pressure were higher in the MetS group compared to the non-MetS group, none of these reached statistical significance (Table 1). This suggests that metabolic derangement in this population may be subclinical, highlighting the inadequacy of relying solely on physical markers or BMI as screening tools in early pregnancy [6].

Interestingly, while the mean fasting glucose and triglyceride levels were higher and HDL levels lower in the MetS group, these differences were also not statistically significant. This finding supports the notion that MetS components, when viewed in isolation, may fail to capture the compounded risk that arises from their co-existence. Thus, the composite definition remains clinically more meaningful than the sum of its parts [7].

Maternal Outcomes

The study found significant associations between MetS and adverse maternal outcomes. Specifically, Hypertensive Disorders of Pregnancy (HDP) were significantly more common in women with MetS (40% vs. 12.2%; p = 0.004) (Table 2). This is consistent with the vascular and endothelial dysfunction underpinning MetS, which is further aggravated by the hemodynamic stresses of pregnancy. These findings are supported by the literature, including evidence from ACOG, which highlight MetS as an independent risk factor for preeclampsia [2,8].

The incidence of gestational diabetes mellitus (GDM) was also higher in the MetS group (25% vs. 7.8%), although this did not reach statistical significance (p = 0.06). This trend mirrors the established link between insulin resistance and

glucose intolerance during pregnancy, where MetS may serve as a preclinical indicator. Given that women with MetS were nearly three times more likely to undergo caesarean delivery (65% vs. 34.4%; p = 0.03), it underscores the broader obstetric impact of metabolic dysfunction, potentially mediated through macrosomia, HDP, or failed labor progression [9].

Neonatal Outcomes

On the neonatal side, MetS was significantly associated with lower mean birth weight (2550 ± 390 g vs. 2900 ± 340 g; p = 0.02) (Table 3). This finding, though seemingly paradoxical given the insulin resistance associated with larger infants, may reflect uteroplacental insufficiency in hypertensive or dyslipidaemia pregnancies. Additionally, NICU admissions were significantly more frequent in neonates born to mothers with MetS (30% vs. 6.7%; p = 0.03), potentially linked to complications like preterm birth, low birth weight, or poor neonatal adaptation. While stillbirth and low Apgar scores were more common in the MetS group, these findings were not statistically significant, likely due to the small sample size [5,8].

Interpretation and Public Health Implications

This study adds to the growing body of evidence that first-trimester screening for metabolic risk factors can identify women at high risk for obstetric and neonatal complications. Given that many of these women may appear clinically well and normal weight, reliance on composite criteria like NCEP ATP III is essential [7]. From a public health perspective, our findings support calls for preconception counseling and early pregnancy metabolic screening, especially in high-risk populations such as urban Indian women [6].

Furthermore, antenatal interventions—such as diet, exercise, or early pharmacologic therapy in select cases—may mitigate some of these risks. Longitudinal follow-up of such cohorts could also shed light on postpartum metabolic risks and intergenerational cardiometabolic health [11].

SUMMARY

This hospital-based cross-sectional study was conducted at a tertiary care centre to assess the prevalence of metabolic syndrome (MetS) in early pregnancy and evaluate its association with fetomaternal outcomes among 110 nulliparous women in their first trimester. MetS was defined using the NCEP ATP III criteria, which require the presence of any three out of five components: central obesity, elevated triglycerides, low HDL cholesterol, elevated blood pressure, and impaired fasting glucose.

The prevalence of MetS in the study population was 18.2%, aligning with figures reported in prior Indian cohorts. While women with MetS exhibited higher mean BMI, waist circumference, blood pressure, fasting glucose, and triglyceride levels, none of these baseline parameters reached statistical significance when compared to the non-MetS group. However, MetS was significantly associated with hypertensive disorders of pregnancy (p = 0.004*) and caesarean deliveries (p = 0.03*). On the neonatal front, babies born to mothers with MetS had significantly lower mean birth weights (p = 0.02*) and higher NICU admissions (p = 0.03*).

These findings underscore the importance of early pregnancy screening for metabolic syndrome, particularly in high-risk populations, to enable timely intervention and improve both maternal and neonatal health outcomes.

CONCLUSION

Metabolic syndrome was identified in 18.2% of nulliparous women in early pregnancy. It was significantly associated with hypertensive disorders, caesarean delivery, lower birth weight, and increased NICU admissions. Early pregnancy screening using NCEP ATP III criteria can help identify women at higher obstetric risk and enable timely interventions.

LIMITATIONS

Single-centre, hospital-based study limits generalizability. Cross-sectional design restricts causal inference. Small sample size may have underpowered detection of some associations.

Confounding variables like diet and physical activity were not assessed. Single-time metabolic assessment without follow-up limits longitudinal insights.

RECOMMENDATIONS

Integrate MetS screening into routine first-trimester care. Conduct larger, multicentre studies to validate findings. Initiate targeted interventions for at-risk women to improve outcomes. Promote preconception counseling to reduce metabolic risk before pregnancy.

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