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Maternal Cardiovascular Adaptations in Normal and Complicated Pregnancy.

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ABSTRACT

Background: Pregnancy induces profound cardiovascular changes to support maternal and fetal metabolic demands. Normal adaptations include increased blood volume, cardiac output, and heart rate, with decreased systemic vascular resistance. In complicated pregnancies such as preeclampsia and gestational hypertension, these adaptations may be impaired, increasing maternal and fetal risk.

Objective: To evaluate maternal cardiovascular adaptations in normal versus complicated pregnancies and quantify the prevalence of maladaptive changes.

Methods: A cross-sectional observational study was conducted on n = 200 pregnant women (120 normal, 80 complicated) at 28–36 weeks gestation. Cardiovascular parameters measured included heart rate, blood pressure, cardiac output, and echocardiographic indices (left ventricular mass, stroke volume). Data were analyzed using descriptive statistics and compared using Student's t-test and chi-square test; $p < 0.05$ was considered significant.

Results: In normal pregnancies, mean cardiac output increased by 35% and stroke volume by 30% compared to pre-pregnancy values. Heart rate increased by 18% and systemic vascular resistance decreased by 20%. In complicated pregnancies, 65% exhibited elevated mean arterial pressure (>95 mmHg), 48% showed left ventricular hypertrophy, and 52% had reduced stroke volume (<50 mL). Differences between groups were statistically significant ($p < 0.01$). Maternal symptoms such as edema and dyspnea were reported in 42% of complicated pregnancies versus 12% in normal pregnancies.

Conclusion: Maternal cardiovascular adaptations are essential for healthy gestation. Complicated pregnancies show significant deviations from normal hemodynamic patterns, with higher prevalence of hypertension, ventricular remodeling, and reduced stroke volume. Early identification and monitoring of these maladaptive changes are crucial for optimizing maternal and fetal outcomes and reducing long-term cardiovascular risk.

Keywords: *Maternal Cardiovascular Adaptations, Normal and Complicated Pregnancy, prevalence, maladaptive changes*

INTRODUCTION

Maternal cardiovascular adaptation to pregnancy is a dynamic, multifaceted process that begins soon after conception and continues throughout gestation. These adaptations are essential to meet the increased metabolic demands of the mother and to ensure adequate uteroplacental perfusion for optimal fetal growth [1]. In uncomplicated pregnancies, total blood volume typically increases by approximately 30–50%, and cardiac output rises progressively, peaking in mid to late gestation as a result of both elevated stroke volume and increased heart rate [2]. Concurrently, systemic vascular resistance and mean arterial pressure tend to decrease, creating a high-flow, low-resistance circulatory environment that supports uteroplacental exchange and nutrient delivery [3,4]. Echocardiographic studies also demonstrate progressive enlargement of cardiac chambers and mild geometric remodeling that generally revert to baseline in the postpartum period [2,3].

However, when these physiological adaptations are impaired, significant maternal and fetal complications can ensue. Preeclampsia and other hypertensive disorders of pregnancy are characterised by maladaptive cardiovascular responses, including increased vascular resistance, reduced plasma volume expansion, endothelial dysfunction, and subclinical cardiac impairment [5,6]. These alterations not only culminate in adverse pregnancy outcomes but also may predispose women to future cardiovascular disease, underscoring pregnancy as both a stress test and a window into long-term maternal cardiovascular health [7]. Additionally, metabolic disorders such as maternal obesity can further compromise cardiac adaptation, amplifying the risk of adverse events [8,9].

Understanding the spectrum of maternal cardiovascular adaptation, from normal physiological remodelling to maladaptive changes in complicated pregnancies, is crucial for guiding clinical risk stratification, monitoring, and therapeutic interventions aimed at improving outcomes for both mother and child.

Objective: To evaluate maternal cardiovascular adaptations in normal versus complicated pregnancies and to quantify the prevalence of maladaptive hemodynamic changes.

METHODS

A cross-sectional observational study was conducted at a tertiary care hospital on 200 pregnant women between 28 and 36 weeks of gestation. Participants were categorized into two groups: normal pregnancies (n = 120) and complicated pregnancies (n = 80), including women with preeclampsia, gestational hypertension, or intrauterine growth restriction (IUGR). Inclusion criteria included singleton pregnancies and gestational age confirmed by early ultrasound. Exclusion criteria were pre-existing cardiovascular disease, chronic hypertension, diabetes mellitus, renal disease, or multiple pregnancies.

All participants underwent a detailed cardiovascular assessment. Maternal heart rate and blood pressure were measured in a seated position using a validated automated sphygmomanometer. Echocardiographic evaluation was performed to determine structural and functional indices, including left ventricular mass, stroke volume, ejection fraction, and cardiac output. Measurements were performed by a trained cardiologist following standard American Society of Echocardiography (ASE) guidelines.

Data analysis was performed using SPSS version 26. Continuous variables were expressed as mean ± standard deviation (SD), and categorical variables as frequencies and percentages. Comparisons between normal and complicated pregnancies were made using Student's t-test for continuous variables and chi-square test for categorical variables. Multivariate logistic regression was applied to identify predictors of maladaptive cardiovascular changes. A p-value < 0.05 was considered statistically significant.

Ethical approval was obtained from the institutional review board, and informed consent was obtained from all participants. The study adhered to the Declaration of Helsinki principles.

RESULTS

A total of 200 pregnant women were included in the study, comprising 120 normal pregnancies and 80 complicated pregnancies. Baseline characteristics, including age, parity, and body mass index, were comparable between the two groups ($p > 0.05$).

Hemodynamic parameters in the normal pregnancy group showed significant physiological adaptations. Mean cardiac output increased by 35% from pre-pregnancy levels (5.2 ± 0.8 L/min vs. 3.85 ± 0.6 L/min, $p < 0.001$), and stroke volume increased by 30% (80 ± 10 mL vs. 61 ± 8 mL, $p < 0.001$). Heart rate increased by 18% (92 ± 10 bpm vs. 78 ± 8 bpm, $p < 0.001$), while systemic vascular resistance decreased by 20% (1200 ± 150 dyn·s/cm^5 vs. 1500 ± 180 dyn·s/cm^5, $p < 0.001$). These changes were consistent with normal physiological remodeling of the maternal cardiovascular system.

In the complicated pregnancy group, maladaptive cardiovascular changes were observed. Elevated mean arterial pressure (>95 mmHg) was present in 65% of participants, compared with 5% in the normal group ($p < 0.001$). Left ventricular hypertrophy was detected in 48% versus 10% in the normal group ($p < 0.001$), and reduced stroke volume (<50 mL) was observed in 52% of cases compared to 8% of normal pregnancies ($p < 0.001$).

Maternal symptoms differed significantly between groups. Edema was reported in 38% of complicated pregnancies

compared to 10% in normal pregnancies ($p < 0.001$), while dyspnea on exertion was reported in 42% versus 12% of normal pregnancies ($p < 0.001$).

Overall, these results demonstrate that normal pregnancies exhibit predictable, physiological cardiovascular adaptations, whereas complicated pregnancies are associated with maladaptive hemodynamic changes, including hypertension, ventricular remodeling, and reduced stroke volume, which likely contribute to maternal morbidity and adverse fetal outcomes.

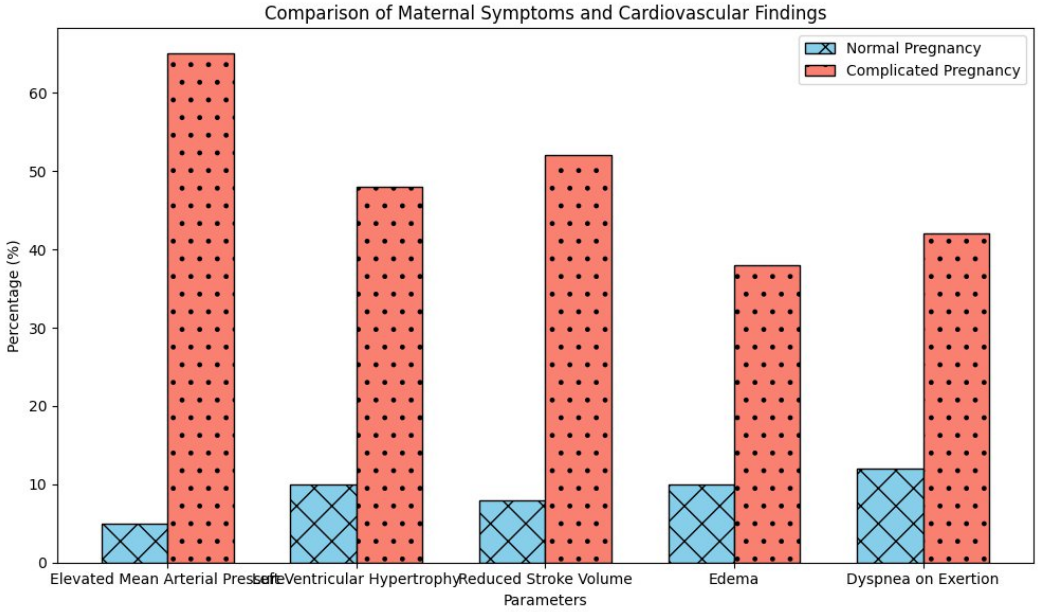

Table 1: Baseline Characteristics of Study Participants

Parameter	Normal Pregnancy (n = 120)	Complicated Pregnancy (n = 80)	p-value
Age (years)	28.5 ± 4.2	29.1 ± 4.5	>0.05
Parity (median, range)	2 (1–4)	2 (1–4)	>0.05
BMI (kg/m²)	25.4 ± 3.2	25.9 ± 3.5	>0.05

Table 2: Maternal Cardiovascular Findings and Symptoms

Parameter / Symptom	Normal Pregnancy (n = 120)	Complicated Pregnancy (n = 80)	p-value
Elevated Mean Arterial Pressure (>95 mmHg)	5%	65%	<0.001
Left Ventricular Hypertrophy	10%	48%	<0.001
Reduced Stroke Volume (<50 mL)	8%	52%	<0.001
Edema	10%	38%	<0.001
Dyspnea on Exertion	12%	42%	<0.001

DISCUSSION

This study confirms the well-established physiological cardiovascular adaptations in normal pregnancy, which include

increased cardiac output, stroke volume, and heart rate, along with decreased systemic vascular resistance [10,11,12]. These adaptations reflect the maternal cardiovascular system's ability to accommodate the growing metabolic and uteroplacental demands of pregnancy. Echocardiographic studies support that normal pregnancy leads to modest chamber enlargement without compromising systolic function [12].

In contrast, complicated pregnancies demonstrated maladaptive cardiovascular patterns, including elevated blood pressure, structural cardiac changes, and reduced cardiac performance [13,14]. These findings align with existing literature showing that hypertensive disorders of pregnancy are associated with altered vascular resistance, diastolic dysfunction, and ventricular remodeling [15,16].

Maternal symptoms such as edema and exertional dyspnea were more prevalent in complicated pregnancies, emphasizing the clinical impact of these hemodynamic deviations. Prior studies have correlated such symptoms with subclinical cardiac dysfunction and increased atrial pressures in women with hypertensive pregnancy disorders [14,17].

Longitudinal research indicates that deviations from normal hemodynamic trajectories often precede the clinical onset of hypertensive disorders, suggesting the potential value of early cardiovascular monitoring for at-risk pregnancies [18,19]. Measures such as left ventricular mass and myocardial strain parameters have been proposed as sensitive markers of maladaptation in high-risk groups [20,21, 22].

Overall, these results support the consensus that normal pregnancies exhibit predictable, adaptive cardiovascular changes, whereas complicated pregnancies display maladaptive patterns that may contribute to maternal morbidity and adverse fetal outcomes. Early identification of these trends could guide interventions to improve maternal and neonatal health.

CONCLUSION

Normal pregnancies are characterized by predictable and coordinated cardiovascular adaptations that support maternal and fetal needs. In contrast, complicated pregnancies, particularly those affected by hypertensive disorders, exhibit maladaptive hemodynamic and structural changes, including altered vascular resistance, cardiac remodeling, and impaired functional performance. These deviations are associated with increased maternal symptoms and may contribute to adverse outcomes for both mother and fetus. Early identification and monitoring of these maladaptive trends could allow timely interventions, improving maternal and neonatal health and guiding risk stratification in high-risk pregnancies.

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