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Comprehensive review on pregnancy-associated cardiovascular conditions

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Abstract

Despite substantial progress in maternal healthcare and reproductive medicine, cardiovascular disease continues to pose significant challenges during pregnancy. Expectant mothers with underlying cardiac conditions—including valvular disorders, chronic hypertension, congenital heart abnormalities, and non-ischemic cardiomyopathies—face considerably elevated risks for both maternal and foetal complications. The concurrent management of pregnancy and cardiovascular disease remains clinically complex, requiring nuanced understanding and specialized expertise. This comprehensive review synthesizes current evidence and emerging insights regarding pregnancy-associated cardiovascular conditions, aiming to inform evidence-based practice and improve outcomes for this vulnerable population. By examining contemporary approaches to risk stratification, monitoring protocols, and therapeutic interventions, this work seeks to enhance clinical decision-making and support optimal care delivery for women navigating the intersection of cardiac disease and pregnancy.

Keywords: Physiological adaptation, Cardiovascular hemodynamic, Multidisciplinary care, Maternal-foetal safety, Risk stratification

1. Introduction

The landscape of maternal health has undergone profound transformations over the past two decades, with one of the most notable changes being the increasing prevalence of cardiovascular disease among pregnant women. This epidemiological shift reflects broader societal trends that have fundamentally altered the demographic profile of expectant mothers and, consequently, the complexity of obstetric care.

Central to this transformation is the evolving pattern of reproductive choices, particularly the trend toward delayed childbearing. Women are increasingly postponing pregnancy from their early twenties to their thirties and forties, a demographic shift that inherently increases the likelihood of encountering acquired cardiovascular conditions during pregnancy [1, 2]. This maternal age advancement represents more than a statistical change—it reflects evolving societal priorities, educational pursuits, and career development patterns that influence when women choose to start families.

Complementing this age-related factor are several other contributing elements that have collectively reshaped the maternal population. The growing utilization of assisted reproductive technologies, particularly *in vitro* fertilization among perimenopausal women, has extended reproductive possibilities

while simultaneously introducing new cardiovascular considerations [2]. Furthermore, the contemporary prevalence of multiple cardiovascular risk factors—including diabetes mellitus, hypertension, pre-eclampsia, and multifetal pregnancies—has created a more complex risk profile among pregnant women.

Perhaps most remarkably, advances in pediatrics and adult congenital heart disease management have enabled a generation of individuals with congenital heart conditions to reach reproductive age with unprecedented frequency. This medical success story, while celebrating improved survival outcomes, has introduced new challenges as these individuals navigate pregnancy with pre-existing cardiac conditions.

Current epidemiological data reveals that cardiovascular disease now affects approximately 1-4% of all pregnancies, representing a substantial population of high-risk maternal cases [3]. More sobering is the contribution of cardiovascular conditions to maternal mortality, accounting for nearly 10-15% of all pregnancy-related deaths. These statistics underscore the critical importance of understanding and managing cardiovascular disease in the obstetric setting.

The intersection of pregnancy and cardiovascular disease creates a complex clinical scenario with far-reaching implications. This combination poses significant risks not only for maternal well-being but also for foetal and neonatal outcomes. The potential complications include exacerbation of underlying cardiac conditions, acute cardiovascular decompensation, preterm delivery, and in severe cases, maternal or foetal mortality [4, 5]. These adverse outcomes extend beyond the immediate pregnancy period, potentially affecting both mother and child throughout the antepartum and postpartum phases, creating lasting implications for family health and well-being.

Understanding these evolving trends and their clinical implications is essential for healthcare providers, policymakers, and researchers as we work to optimize care for this increasingly complex and vulnerable population of pregnant women. When a pregnant woman develops blockages in her heart's blood vessels, both she and her baby face serious, life-threatening risks. These situations present complex medical challenges that require careful coordination between the healthcare team—including primary care physicians, heart specialists, and obstetricians—all working together to protect both mother and child [6,7].

The complexity of caring for pregnant women with heart disease cannot be overstated. Each decision must weigh the health needs of two patients: the mother and her developing baby. What might be the best treatment for the mother's heart condition could potentially affect the baby's growth and development, while pregnancy itself places additional strain on an already compromised cardiovascular system [8].

This review examines the multifaceted challenges healthcare providers face when caring for pregnant women with cardiovascular disease. We explore how to accurately diagnose heart conditions during pregnancy—when normal pregnancy changes can mask or mimic heart problems—and discuss evidence-based approaches to managing these high-risk situations. Our goal is to provide clinicians with practical insights for navigating these complex cases while optimizing outcomes for both mother and baby.

The stakes in these situations are particularly high, as untreated cardiovascular disease during pregnancy can lead to devastating consequences, including maternal death, pregnancy loss, or serious complications for the newborn. Understanding how to recognize, evaluate, and manage these conditions is essential for any healthcare provider involved in women's health care.

Physiological Cardiovascular Adaptation in Pregnancy

Pregnancy represents one of the most remarkable examples of physiological adaptation in human biology, orchestrating a complex symphony of cardiovascular changes that ensure optimal maternal and foetal wellbeing. The maternal cardiovascular system undergoes profound transformations that begin early in gestation and continue throughout pregnancy, reflecting the body's extraordinary capacity to adapt to the growing demands of supporting new life.[9]

Early Hemodynamic Changes

The journey of cardiovascular adaptation begins in the first trimester, when the maternal body initiates a cascade of hormonal and physiological changes. The renin-angiotensin-aldosterone system (RAAS)[10,11]becomes increasingly active during this period, promoting sodium and water retention that serves as the foundation for subsequent volume expansion. This early activation represents the body's anticipatory response to the increased circulatory demands that will emerge as pregnancy progresses.

Concurrently, hormonal signals stimulate both hepatic protein synthesis and bone marrow hematopoiesis, setting the stage for significant expansion of the maternal blood compartment. These changes reflect the remarkable coordination between different organ systems as the maternal body prepares to meet the metabolic and oxygen demands of the developing foetus.

Table 1. Hemodynamic effects of pregnancy [12-14]

Hemodynamic Parameter	**Change**	**Peak Effect**	**Potential Signs and Symptoms**
Antepartum hemodynamics			
Cardiac output	Increased by 30-50%	26 weeks	hyperdynamic apex, LV S_3 (ventricular gallop), tachycardia
Heart rate	Increased by 15-20 bpm	3rd trimester	Palpitations, tachycardia
Stroke volume	Increased	26 weeks	Edema, nocturia, cardiac chamber enlargement
Total peripheral resistance	Decreased	20 weeks	Hypotension, edema, syncope
Erythrocyte volume	Increased by 20-30%	Term	Physiologic anemia of pregnancy
Blood pressure	Decreased by 10mmhg	2nd trimester	Palpitations, fainting, syncope
Blood volume	Increased by 30-40%	32 weeks	Edema, cardiac enlargement
Respiratory rate	Increased	30 weeks	Hyperpnea, dyspnea
Coagulation	Increased	3rd trimester	Thrombo-embolic event

Mother's oxygen consumption	Increases by 30%	First 20 weeks	-
Intrapartum hemodynamics			
Cardiac output	Increased	Active labor	Hyperdynamic apex, LV S_3 (ventricular gallop) tachycardia
Mother's oxygen consumption	Increases by 30%	At delivery time	-
Postpartum hemodynamics			
Cardiac output Stroke volume Heart rate	Deceased Increased Deceased	After delivery	Hyperdynamic apex, LV S_3 (ventricular gallop) tachycardia, Palpitations, tachycardia Edema, nocturia, cardiac chamber enlargement
Cardiac preload	Increased	Immediate post-partum period	-
pCO_2	Reduction to 30mmHg	After delivery	Metabolic alkalosis (vomiting, diarrhoea, swelling in the lower legs, peripheral edema, fatigue)

pCO_2 = Partial pressure of carbon dioxide, LV S3 = third heart sound of left ventricular origin.

Blood Volume and Composition Changes

As pregnancy advances into the second trimester, the effects of these early adaptations become increasingly apparent. Red cell mass expands dramatically, increasing by nearly 50% compared to pre-pregnancy values by the end of the second trimester [9]. This substantial increase in red blood cell production ensures adequate oxygen-carrying capacity to meet both maternal and foetal needs.[10,11]

Perhaps even more striking is the expansion of plasma volume, which increases by 30-50% before reaching 30 weeks of gestation[12]. This disproportionate increase in plasma volume relative to red cell mass creates the physiological anemia of pregnancy, a normal adaptation that optimizes blood flow characteristics and reduces maternal cardiac workload.[13]

Vascular and Cardiac Adaptations

The peripheral vasculature undergoes equally impressive changes during early pregnancy. Peripheral vascular resistance begins to decline in the first trimester, driven by two primary mechanisms: the development of the low-resistance uteroplacental circulation and a generalized reduction in vascular responsiveness to vasoconstrictor substances such as angiotensin-II and norepinephrine[12]. This vasodilation creates a high-flow, low-resistance circulatory state that facilitates increased cardiac output and enhanced uteroplacental perfusion.

The maternal heart responds to these circulatory changes with remarkable efficiency. Heart rate increases progressively throughout pregnancy, as documented in clinical studies, representing one of the earliest and most consistent cardiovascular adaptations observed. This chronotropic response, combined with the

hemodynamic changes of increased preload and decreased afterload, results in a substantial increase in cardiac output that can reach 30-50% above non-pregnant levels.[13,14]

Thrombotic Considerations

The adaptive changes of pregnancy extend beyond volume and flow dynamics to include alterations in hemostatic balance. The gravid woman develops a state of relative hypercoagulability, characterized by increases in several clotting factors and decreased fibrinolytic activity. While this adaptation serves an important protective function by reducing the risk of hemorrhage during delivery, it simultaneously increases the risk of thromboembolic complications throughout pregnancy and the postpartum period.[13,14]

Postpartum Recovery

The remarkable nature of these adaptations is perhaps best illustrated by their reversibility following delivery. The cardiovascular system demonstrates remarkable plasticity, with most hemodynamic parameters returning to pre-pregnancy baseline values within 2-4 weeks after vaginal delivery. For women who undergo cesarean section, this recovery process may extend to 4-6 weeks, likely reflecting the additional physiological stress of major surgery.[14]

These cardiovascular adaptations of pregnancy represent a testament to the extraordinary capacity of the human body to adapt and support new life. Understanding these changes is crucial for healthcare providers, as it enables the distinction between normal physiological adaptations and pathological conditions, ultimately supporting optimal outcomes for both mother and child throughout the pregnancy journey.

Risk Assessment of the Pregnant Patient with Known Cardiovascular Disease

The comprehensive evaluation of cardiovascular risk during pregnancy represents one of the most critical components in managing women of childbearing age who have existing cardiovascular disease (CVD). This assessment forms the cornerstone of clinical decision-making and significantly influences both maternal and foetal outcomes throughout the gestational period.

Pre-conception Counselling and Risk Stratification

Pre-conception counselling emerges as an invaluable intervention for all women with cardiovascular conditions who are considering pregnancy. This counselling process provides patients and their families with detailed information regarding the potential risks of adverse maternal and foetal outcomes, incorporating essential genetic considerations that may influence decision-making. The comprehensive nature of this counselling allows prospective parents to make informed choices about their reproductive future while understanding the full spectrum of potential complications.

The foetal risks associated with maternal cardiovascular disease during pregnancy are multifaceted and require careful consideration (Table 2) [15.] These risks extend beyond immediate pregnancy complications and may have long-term implications for neonatal health and development. Similarly, maternal risks must be thoroughly evaluated based on the specific type and severity of cardiovascular lesions present, as outlined in established classification systems (Table 3) [15.]

Table 2. Potential fetal risks associated with heart disease in pregnancy mother [15].

Fetal Risks
a) Miscarriage/stillbirth b) Maternal cardiovascular state leading to placental hypoperfusion and/or cyanosis leading to fetal growth restriction and prematurity c) Teratogenicity d) The risk of bleeding due to maternal anticoagulation e) Inheritance risk f) Fetal hypoxia due to maternal cyanosis

Table 3. Classification of maternal risks based on the type of cardiovascular abnormality; adapted from Thorne *et al.*[15].

Category	Maternal Risk Factors
Class I: No detectable increase in maternal mortality and no or mild increase in morbidity)	Uncomplicated small or mild: pulmonary stenosis, VSD, PDA, mitral valve prolapse Successfully repaired simple lesions, such as secundum ASD, VSD, PDA, total anomalous pulmonary, and venous drainage
Class II: Small increase in maternal mortality and moderate increase in morbidity	Unoperated ASD Repaired tetralogy of Fallot Most arrhythmias
Classes II-III	Mild left ventricular impairment Hypertrophic cardiomyopathy Native or tissue valve disease not considered class IV Marfan syndrome (or other aortopathy, such as, EDS type IV, FTAA or LDS) without aortic dilatation Repaired coarctation Heart transplantation
Class III: Significantly increased in risk of maternal mortality or severe morbidity	Mechanical valve Systemic right ventricle: CCTGA, TGA Post-Fontan repair Cyanotic heart disease Other complex congenital heart disease Marfan syndrome with aorta 40-45 mm
Class IV: Extremely high risk of maternal mortality or severe morbidity	Pulmonary hypertension of any cause Severe systemic ventricular impairment e-LVEF <30% or NYHA III-IV Previous peripartum cardiomyopathy with any residual ventricular impairment Severe left heart obstruction Marfan syndrome with aorta >45 mm

† VSD, Ventricular septal defect; PDA, Patent ductus arteriosus; ASD, Atrial septal defect; EDS, Ehlers Danlos syndrome; CCTGA, congenitally corrected transposition of the great arteries; TGA, Transposition of the great arteries; LDS, Loeys-Dietz syndrome; FTAA, Familial thoracic aortic aneurysm; LVEF, Left ventricular ejection fraction; NYHA, New York Heart Association (NYHA) Classification.

Clinical Management of High-Risk Pregnancies

When managing women with severe cardiovascular conditions during pregnancy, clinicians must carefully consider any therapeutic intervention that has the potential to reduce CVD-related complications. This approach requires balancing the benefits of treatment against potential risks to both mother and foetus. In certain clinical scenarios where maternal survival is significantly threatened, difficult decisions regarding pregnancy termination, implementation of highly effective contraceptive measures, or consideration of alternative reproductive options may need to be explored [16].

2. Conclusion

Pregnancy involves multiple physiological adaptations that may be difficult to tolerate by patients with existing CVD. Most women with CVD can conceive pregnancy successfully; hence, such women should not be discouraged. Women with suspected CVD who wish to become pregnant, risk assessment and proper concealing and monitoring throughout pregnancy as well as multidisciplinary team management are crucial to achieve successful maternal and foetal outcomes.

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