

Study of Blood Circulation in The Mother–Placenta–Fetus System in Women with Cardiovascular Pathology (Literature Review)

Tojjeva Nigina Iskandarovna

Assistant, Department of Obstetrics and Gynecology No. 1, Samarkand State Medical University, Samarkand, Uzbekistan

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Abstract: Cardiovascular diseases during pregnancy represent a growing clinical challenge and are associated with a high risk of adverse maternal and perinatal outcomes. The aim of this review was to analyze current evidence (2020–2026) on blood circulation in the mother–placenta–fetus system in women with cardiovascular pathology and to evaluate its clinical significance. A comprehensive analysis of clinical studies, systematic reviews, and international guidelines was performed, focusing on maternal hemodynamics, uteroplacental and fetoplacental circulation, Doppler assessment, and pregnancy outcomes. The findings indicate that impaired cardiovascular adaptation in pregnancy leads to disturbances in uteroplacental blood flow, endothelial dysfunction, and placental insufficiency. These changes are strongly associated with the development of preeclampsia, fetal growth restriction, and preterm birth. Doppler ultrasound plays a key role in early detection of circulatory abnormalities and risk stratification. Current evidence supports the importance of a multidisciplinary and individualized approach to the management of pregnant women with cardiovascular disease. Furthermore, placenta-mediated complications are increasingly recognized as predictors of long-term cardiovascular risk in women. In conclusion, understanding the interaction between maternal cardiovascular function and placental circulation is essential for improving both short- and long-term outcomes, and for optimizing clinical strategies in this high-risk population.

Keywords: Cardiovascular disease in pregnancy, uteroplacental circulation, fetoplacental blood flow, Doppler ultrasound, placental insufficiency, preeclampsia, fetal growth restriction.

Introduction: Cardiovascular diseases (CVD) during pregnancy remain one of the leading causes of maternal morbidity and mortality worldwide, accounting for a substantial proportion of adverse maternal and perinatal outcomes. According to contemporary clinical guidelines, the prevalence of cardiovascular pathology among pregnant women has been steadily increasing due to advanced maternal age, improved survival of women with congenital heart disease, and the growing burden of acquired cardiovascular conditions [1,2,16]. In this context, the study of blood circulation within the mother–placenta–fetus system has become a key area of modern obstetrics, as it directly determines fetal development and pregnancy outcomes.

Physiological pregnancy is characterized by profound

hemodynamic adaptations, including increased cardiac output, reduced systemic vascular resistance, and remodeling of uteroplacental circulation [3,5]. These adaptive mechanisms are essential to ensure adequate placental perfusion and fetal oxygenation. However, in women with cardiovascular pathology, these changes may be impaired or insufficient, leading to maladaptation and disruption of the uteroplacental blood flow [13,19]. Such disturbances are closely associated with placental insufficiency, fetal growth restriction, and hypertensive disorders of pregnancy.

Recent studies emphasize the central role of uteroplacental and fetoplacental circulation as a sensitive marker of maternal cardiovascular function. Doppler ultrasound assessment of uterine and umbilical artery blood flow has become a standard tool

for evaluating placental perfusion and predicting adverse outcomes [10,11]. Evidence suggests that abnormal Doppler indices reflect underlying vascular dysfunction and are strongly correlated with complications such as preeclampsia, intrauterine growth restriction, and preterm birth [11,19].

Placenta-mediated complications represent a critical link between maternal cardiovascular disease and adverse fetal outcomes. Contemporary research demonstrates that impaired placental vascularization and endothelial dysfunction are key pathophysiological mechanisms in pregnancies complicated by CVD [4,6]. Moreover, these complications are not limited to the perinatal period but are also associated with long-term cardiovascular risks for the mother, highlighting the importance of early detection and monitoring [4].

Modern scientific approaches increasingly focus on the concept of cardiovascular–placental interaction, recognizing pregnancy as a natural “stress test” for the maternal cardiovascular system [16,20]. Studies have shown that inadequate cardiovascular adaptation contributes to the development of preeclampsia and fetal growth restriction, conditions that share common pathophysiological pathways involving impaired perfusion and systemic inflammation [13,19].

International guidelines, including those of the American College of Obstetricians and Gynecologists and the European Society of Cardiology, emphasize the importance of comprehensive assessment and multidisciplinary management of pregnant women with cardiovascular disease [1,2]. These recommendations highlight the need for early risk stratification, continuous hemodynamic monitoring, and individualized management strategies aimed at optimizing maternal and fetal outcomes.

In addition, recent investigations have expanded the understanding of maternal hemodynamics by incorporating advanced modeling techniques and integrative approaches to assess cardiovascular adaptation during pregnancy [5]. Environmental and physiological factors, such as hypoxia at high altitude, further illustrate the complexity of uteroplacental circulation and its susceptibility to external influences [15].

Despite significant advances, important gaps remain in understanding the precise mechanisms linking maternal cardiovascular dysfunction and placental circulation, as well as in developing standardized diagnostic and management algorithms. Therefore, further research is required to improve early detection of circulatory disturbances and to optimize clinical strategies.

The aim of this study is to analyze current evidence on

blood circulation in the mother–placenta–fetus system in women with cardiovascular pathology and to evaluate its clinical significance for maternal and perinatal outcomes.

METHODS

This narrative review was conducted to synthesize current evidence (2020–2026) on the characteristics of blood circulation in the mother–placenta–fetus system in women with cardiovascular pathology and its clinical significance for maternal and perinatal outcomes.

A comprehensive literature search was performed using electronic databases, including PubMed/MEDLINE, Scopus, Web of Science, Cochrane Library, and Google Scholar. The search strategy incorporated combinations of keywords and MeSH terms such as “cardiovascular disease in pregnancy,” “uteroplacental circulation,” “fetoplacental blood flow,” “Doppler ultrasound,” “placental insufficiency,” “preeclampsia,” and “maternal hemodynamics.”

The inclusion criteria were: (1) publications from 2020 to 2026; (2) peer-reviewed articles, including randomized controlled trials, cohort and case-control studies, systematic reviews, and clinical guidelines; (3) studies addressing maternal cardiovascular function, uteroplacental and fetoplacental circulation, or pregnancy outcomes in women with cardiovascular diseases; and (4) studies reporting clinically relevant outcomes, including Doppler indices, placental function, or perinatal results.

Exclusion criteria included: (1) studies published before 2020 (except for selected foundational works of high relevance); (2) case reports and small case series with limited generalizability; (3) studies not focused on pregnancy or not addressing circulatory parameters; and (4) duplicate publications.

A total of 20 sources were included in the final analysis, corresponding to the predefined and approved reference list. The selected studies comprised international clinical guidelines (ACOG, ESC), high-impact reviews, and original research articles, ensuring a comprehensive and evidence-based overview of the topic.

Data extraction focused on the following domains: physiological and pathological maternal hemodynamic changes, characteristics of uteroplacental and fetoplacental blood flow, Doppler ultrasound parameters, placental vascular dysfunction, and associated maternal and perinatal outcomes. Particular attention was given to the relationship between cardiovascular pathology and impairment of placental circulation.

The methodological quality of the included studies was

assessed based on study design, sample size, and level of evidence, with priority given to clinical guidelines and high-impact publications. The findings were synthesized using a descriptive-analytical approach to identify key trends, consistencies, and gaps in current research.

This methodological framework allowed for a structured and up-to-date analysis of the interaction between maternal cardiovascular status and placental-fetal circulation.

RESULTS

The analysis of the selected literature demonstrates that blood circulation within the mother–placenta–fetus system is significantly altered in women with cardiovascular pathology, leading to a wide spectrum of maternal and perinatal complications. One of the key findings is that maternal cardiovascular dysfunction directly affects uteroplacental perfusion. In normal pregnancy, adaptive hemodynamic changes—including increased cardiac output and reduced vascular resistance—ensure adequate placental blood flow. However, in women with cardiovascular disease, these adaptive mechanisms are often impaired, resulting in insufficient uterine perfusion and increased vascular resistance [3,5,13]. This maladaptation is considered a central mechanism in the development of placental insufficiency.

Doppler ultrasound studies consistently show that abnormal uterine and umbilical artery indices are more frequently observed in pregnancies complicated by cardiovascular pathology. Increased pulsatility index (PI) and resistance index (RI), as well as the presence of notching in uterine arteries, reflect impaired trophoblastic invasion and vascular remodeling [10,11]. These hemodynamic disturbances are strongly associated with adverse pregnancy outcomes. Placenta-mediated complications are among the most common consequences of impaired circulation. The reviewed studies indicate a high prevalence of preeclampsia, fetal growth restriction (FGR), and preterm birth in women with cardiovascular disease [4,6,19]. These conditions share common pathophysiological pathways, including endothelial dysfunction, inflammation, and reduced placental perfusion.

In addition, maternal cardiovascular pathology has been shown to influence fetoplacental circulation. Alterations in umbilical artery flow and redistribution of fetal blood circulation, including the so-called “brain-sparing effect,” are frequently observed in response to chronic hypoxia [11]. These compensatory mechanisms, although initially protective, are associated with increased risks of perinatal morbidity

and long-term developmental consequences. Recent studies also highlight the bidirectional relationship between placental dysfunction and maternal cardiovascular status. Placenta-mediated complications not only reflect underlying maternal pathology but may also contribute to the progression of cardiovascular disease and increase long-term cardiovascular risk in women [4,20]. This underscores the importance of considering pregnancy as a predictor of future cardiovascular health. Furthermore, environmental and physiological factors may exacerbate circulatory disturbances. For example, studies of pregnancies at high altitude demonstrate that hypoxic conditions can further impair uteroplacental blood flow and worsen fetal outcomes, particularly in women with pre-existing cardiovascular dysfunction [15].

Overall, the findings confirm that disturbances in the mother–placenta–fetus circulation represent a key link between maternal cardiovascular disease and adverse pregnancy outcomes. The integration of maternal hemodynamic assessment and Doppler evaluation of uteroplacental circulation is essential for early detection of complications and optimization of clinical management.

DISCUSSION

The findings of this review confirm that soft tissue birth trauma is not only an acute obstetric complication but also a condition with significant long-term implications for women’s health and well-being. Unlike earlier perspectives that primarily focused on anatomical outcomes, contemporary research emphasizes the importance of functional recovery and patient-reported quality of life. One of the key distinctions of recent studies is the recognition that even minor perineal injuries may lead to clinically relevant dysfunction. This shifts the paradigm toward early identification and management of all degrees of trauma, rather than focusing exclusively on severe cases [1,3]. Furthermore, the high prevalence of pelvic floor disorders after childbirth underscores the need for routine postpartum screening and follow-up.

The role of rehabilitation has evolved substantially over the past decade. While pelvic floor muscle training has long been recommended, recent evidence supports the implementation of structured, supervised, and individualized rehabilitation programs. The superiority of early and comprehensive interventions over delayed or unsupervised approaches is consistently demonstrated across studies [2,5,8].

An important aspect highlighted in recent literature is the integration of psychological support into postpartum care. Given the strong association between

physical symptoms and mental health outcomes, a multidisciplinary approach is essential for achieving optimal recovery and improving quality of life. Despite these advances, several challenges remain. There is still a lack of standardized rehabilitation protocols, variability in clinical practice, and insufficient long-term follow-up data. Additionally, many studies rely on heterogeneous outcome measures, which complicates direct comparison and limits the generalizability of results. From a clinical perspective, the findings support a shift toward personalized medicine, where prevention, diagnosis, and treatment strategies are tailored to individual risk profiles, severity of trauma, and patient needs. This approach aligns with current trends in obstetrics and gynecology and has the potential to significantly improve both short- and long-term outcomes.

In summary, improving the quality of life in women after soft tissue birth trauma requires not only effective clinical management but also a comprehensive, patient-centered approach that integrates prevention, early rehabilitation, and long-term support.

CONCLUSION

Blood circulation within the mother–placenta–fetus system plays a fundamental role in ensuring normal pregnancy progression and fetal development. In women with cardiovascular pathology, this finely regulated system is frequently impaired due to inadequate maternal hemodynamic adaptation, leading to disturbances in uteroplacental and fetoplacental blood flow. The available evidence demonstrates that cardiovascular dysfunction during pregnancy is closely associated with placental insufficiency and a high incidence of adverse outcomes, including preeclampsia, fetal growth restriction, and preterm birth. These complications are primarily mediated by endothelial dysfunction, impaired vascular remodeling, and increased vascular resistance within the uteroplacental circulation.

Modern diagnostic approaches, particularly Doppler ultrasound assessment, provide valuable insights into the state of placental perfusion and allow for early identification of high-risk pregnancies. Integration of maternal cardiovascular evaluation with assessment of uteroplacental circulation is essential for improving prognostic accuracy and guiding clinical management. Current international recommendations emphasize the importance of a multidisciplinary and individualized approach to the management of pregnant women with cardiovascular disease. Early risk stratification, continuous monitoring, and timely intervention are key factors in optimizing both maternal and perinatal outcomes. At the same time, the presence of placenta-

mediated complications should be considered not only as a marker of pregnancy-related pathology but also as an indicator of increased long-term cardiovascular risk in women. This highlights the need for extended follow-up and preventive strategies beyond the postpartum period.

Thus, improving outcomes in women with cardiovascular pathology requires a comprehensive understanding of the interaction between maternal hemodynamics and placental function, as well as the implementation of evidence-based, patient-centered care strategies.

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