

Assessment of Coronary Reserve Preservation in Pregnant Women with Mitral Stenosis

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ABSTRACT

Pregnant women with mitral stenosis (MS) face significant risks, with maternal mortality rates reaching 5%, increasing to 17% in cases of atrial fibrillation. This study aimed to develop a multifactorial scale for assessing coronary reserve preservation in pregnant women with atrioventricular orifice stenosis. A cohort of 124 pregnant women aged 17–32 years, at gestational ages of 12–38 weeks, underwent comprehensive evaluations. Assessments included respiratory rate, heart rate, blood pressure, oxygen saturation, echocardiographic parameters (ejection fraction, cardiac index, stroke volume), and functional tests such as the breath-holding test, six-minute step test, and nitroglycerin challenge. Prognostic scores were calculated to classify coronary reserves into preserved, reduced, severely reduced, and depleted categories. The findings revealed that the severity of mitral stenosis, cardiac index, ejection fraction, and functional test outcomes were critical predictors of coronary reserve status. Patients with critical mitral stenosis and severe hemodynamic impairments demonstrated sharply reduced reserves, highlighting the need for early, individualized interventions. This methodology supports evidence-based clinical decision-making, optimizing obstetric and anesthetic strategies, and improving maternal and fetal outcomes. Incorporating this scale into practice provides a cost-effective tool for stratifying cardiovascular risk in high-risk pregnancies.

ARTICLE HISTORY

Received 28 November 2024

Accepted 20 January 2025

KEYWORDS: Mitral stenosis, coronary reserve, pregnancy, risk stratification, cardiovascular assessment

Volume 3 issue 1 (2025)

Introduction

Pregnant women and postpartum patients suffering from mitral stenosis (MS) are at particularly high risk of mortality, reaching 5%. If atrial fibrillation develops in a pregnant woman with MS, the risk of death increases to 17%. The functionality of the cardiovascular system in such patients determines the specific obstetric management during delivery and the anesthetic support required during the optimal gestational period. The severity of MS and the resulting pathological changes in circulation, which intensify as pregnancy progresses, are key factors limiting the hemodynamic reserves of the maternal body [1,2,3,8].

Mitral stenosis is one of the most common valvular heart diseases encountered during pregnancy, often due to rheumatic heart disease, which remains prevalent in developing countries. The physiological changes during pregnancy, such as increased blood volume, cardiac output, and heart rate, further strain an already compromised cardiovascular system. This exacerbates the risks associated with mitral stenosis, including pulmonary congestion, reduced cardiac output, and systemic hypoperfusion, which can lead to adverse outcomes for both the mother and the fetus. Consequently, managing pregnant women with MS requires a multidisciplinary approach, involving cardiologists, obstetricians, anesthesiologists, and neonatologists, to ensure maternal and fetal safety.

Anesthetic management during surgical interventions in patients with concomitant cardiovascular diseases remains one of the most challenging and unresolved problems in modern anesthesiology. The complexity arises from the need to balance the maternal hemodynamic stability while ensuring adequate oxygen delivery to the fetus. This issue is particularly critical in pregnant women, where the risk of adverse outcomes is especially high and depends on the optimal collaboration among obstetricians, cardiologists, and anesthesiologists, as well as the severity and nature of cardiovascular dysfunction.

It is evident that such patients require an individualized approach to anesthetic care, with the primary objective being to ensure the safety of delivery and maintain hemodynamic stability throughout the entire labor and immediate postpartum (postoperative) period. Pre-delivery evaluation of the cardiovascular system, particularly the degree of coronary reserve preservation, plays a significant role in achieving these objectives [3,6,7,8,11]. The concept of coronary reserve refers to the heart's ability to increase blood flow to meet the metabolic demands of tissues, particularly under stress. In pregnant women with MS, compromised coronary reserves exacerbate the hemodynamic challenges and pose a significant risk of cardiac decompensation during labor and delivery.

The selection of pregnant and postpartum women with MS for participation in clinical studies was carried out

strictly in accordance with the protocols and recommendations approved by the Ministry of Health of Uzbekistan. Only patients who consciously and voluntarily agreed to participate were included in the studies. To ensure the "homogeneity" of participants and balance among the study groups, inclusion and exclusion criteria were developed. Exclusion criteria included the presence of oncological, neurological, neurosurgical, or psychiatric disorders [7,8,10,11]. These criteria ensured that the findings of the study were directly attributable to the effects of mitral stenosis and its management during pregnancy, without confounding factors.

Currently, there are several effective invasive and non-invasive methods for assessing coronary reserve. These include transesophageal Doppler echocardiography, gas chromatography, X-ray densitometry, and radionuclide scintigraphy, among others [3,8]. However, these techniques are complex and costly, making them unsuitable for routine diagnostic practice. At the same time, commonly accepted criteria used to characterize the functional state of the cardiovascular system are not always sufficiently informative when considered in isolation. This highlights the need for simple, cost-effective, and reliable methods to evaluate coronary reserve preservation in pregnant women with MS, ensuring timely interventions to prevent complications.

In addition to the physiological and clinical aspects, the social and economic implications of managing pregnant women with MS are substantial. The high cost of advanced diagnostic tools, the need for specialized care, and the potential for long-term maternal and neonatal morbidity emphasize the importance of developing preventive strategies and evidence-based management protocols. Moreover, educating healthcare professionals about the early recognition of mitral stenosis and the importance of preconception counseling in women with known cardiovascular conditions is critical in reducing the burden of this condition during pregnancy.

Thus, the study of coronary reserve preservation in pregnant women with mitral stenosis is not only clinically significant but also essential for shaping public health policies and improving maternal and neonatal outcomes. Addressing this issue requires a comprehensive approach that integrates advanced medical technologies, multidisciplinary collaboration, and patient-centered care.

In an epoch characterized by swift technological evolution, digitization has become an essential foundation of economic advancement. Through the assimilation of digital technologies into financial frameworks, communication networks, and commercial operations, societies have transformed their economic practices. This metamorphic process promotes efficiency, spurs innovation, and enhances global competitiveness. Nevertheless, in conjunction with these advantages, digitization poses significant challenges, particularly in

relation to economic security, encompassing vulnerabilities to cyber threats, data breaches, and financial misconduct [1, 7, 10].

In this study we aimed to develop a multifactorial scale for the prenatal assessment of the degree of preservation of coronary reserves in pregnant women with atrioventricular orifice stenosis.

Materials and methods

This study utilized established multifactorial scales designed to assess the preservation of coronary reserves in patients with heart failure. These scales were adapted and calculated using a simplified algebraic model of constructive logic. A cohort of 124 pregnant women, aged 17 to 32 years, with gestational ages ranging from 12 to 38 weeks, was included in the study. All participants exhibited either varying degrees of atrioventricular orifice stenosis or combined mitral valve defects, with stenosis being the predominant feature.

During the prenatal preparation period, a comprehensive assessment of vital parameters was conducted. This included measurements of respiratory rate, heart rate, blood pressure, and oxygen saturation, as part of routine monitoring of essential physiological systems. Echocardiography was employed to evaluate central hemodynamics, capturing key parameters such as ejection fraction, stroke volume index, cardiac index, stroke volume output, cardiac output, reserve coefficient, total peripheral vascular resistance, and left ventricular power index.

To further evaluate the functional capacity of the cardiovascular system, a series of standardized functional tests were administered. These tests included a breath-holding test, a six-minute step test, and a nitroglycerin challenge, focusing on changes in the left ventricular power index. The diagnostic and prognostic significance of various factors was systematically analyzed, including vital signs, central hemodynamic parameters, results of functional tests, and the degree of mitral stenosis and heart failure severity.

The collected data were processed using a heterogeneous sequence recognition procedure for identifying pathological processes. Informative features were systematically selected and ranked based on the Kullback information measure within the framework of the constructive logic model. This rigorous methodological approach allowed for the integration and evaluation of multifactorial data, forming the basis for a precise and reliable assessment of coronary reserve preservation in pregnant women with complex cardiovascular conditions.

Results and Discussion

The study identified the most informative factors for assessing the preservation of coronary reserves in pregnant women with mitral stenosis. The most significant factors

included the breath-holding test, nitroglycerin test, six-minute step test, ejection fraction (EF), cardiac index (CI), and the severity of mitral stenosis. These factors were

systematically evaluated and represented using prognostic scores, as shown in Table 1.

Table 1. Multifactorial Criteria for Assessing Coronary Reserve Preservation in Pregnant Women with Mitral Stenosis

Most Informative Factors	Prognostic Score
Degree of atrioventricular orifice stenosis	
I – Mild ($>2.9 \text{ cm}^2$)	0.5
II – Moderately expressed ($2.9\text{--}2.0 \text{ cm}^2$)	1
III – Expressed ($1.9\text{--}1.1 \text{ cm}^2$)	3
IV – Critical ($<1 \text{ cm}^2$)	5
Cardiac index, $\text{L}/\text{m}^2/\text{min}$	
2.8–2.5	1
2.4–2.0	2
<2.0	5
Ejection fraction	
60.0–55.0	1
54.0–50.0	2
<50.0	5
Breath-holding test, seconds	
30.0–20.0	1
19.0–10.0	2
<10.0	3
Not possible to perform	5
Nitroglycerin test (based on changes in LVPI)	
LVPI increases	1
LVPI remains unchanged	2
LVPI decreases	5
Six-minute step test, meters	
301–400	1
300–250	2
249–150	4
Not possible to perform due to severity of condition	5
Maximum total score: 30. Coronary reserves are <i>preserved</i> with 6–9 points, <i>reduced</i> with 10–17 points, <i>severely reduced</i> with 18–24 points, and <i>depleted</i> with 25–30 points.	

Table 1 provides multifactorial criteria for assessing coronary reserves in this group of patients. Prognostic scores were calculated for each parameter based on the degree of their deviation. For example, the severity of atrioventricular orifice stenosis ranged from mild ($>2.9 \text{ cm}^2$, 0.5 points) to critical ($<1 \text{ cm}^2$, 5 points), allowing for precise categorization of stenosis severity. Similarly, cardiac index and ejection fraction were scored according to their values, with lower values indicating more severe cardiovascular impairment.

Functional tests such as the breath-holding test, six-minute step test, and nitroglycerin test were also evaluated using clear criteria. For instance, the inability to perform the step test due to the severity of the patient's condition corresponded to 5 points, indicating a significant reduction in coronary reserves. Similarly, a decrease in the left ventricular power index (LVPI) during the nitroglycerin test

was the most unfavorable outcome (5 points), while an increase in LVPI indicated preserved reserves (1 point).

The maximum total prognostic score was 30. Based on the results, a classification system for coronary reserve status was proposed: scores of 6–9 indicated complete preservation of coronary reserves; scores of 10–17 reflected moderate reserve reduction; scores of 18–24 indicated a sharp decline in reserves; and scores of 25–30 represented reserve depletion.

The analysis revealed that most patients with critical mitral stenosis (Grade IV) and significant reductions in cardiac index ($>2.0 \text{ L}/\text{m}^2/\text{min}$) had prognostic scores ranging from 18 to 30, signifying a sharp decline or depletion of coronary reserves. These findings highlight the importance of early diagnosis and more intensive therapeutic interventions in this patient group.

The calculated diagnostic strength of each factor, expressed in points, allows for an effective evaluation of

coronary reserves in pregnant women with mitral stenosis. This facilitates timely clinical decision-making and reduces the risk of perinatal complications.

Conclusions

This methodology enables the calculation of an individualized cardiovascular reserve in patients with mitral stenosis. The assessment of coronary reserve preservation provides a scientifically grounded basis for determining obstetric surgical strategies, anesthetic management, and prenatal pharmacological preparation tailored to each specific case. By integrating multifactorial data, the approach ensures a comprehensive evaluation of the patient's cardiovascular condition, which is critical for optimizing clinical outcomes.

The application of this method allows for a more accurate risk stratification, helping to identify patients at higher risk of perinatal complications. It facilitates early intervention planning, including the choice of surgical delivery techniques and the customization of anesthetic protocols to minimize cardiovascular stress during labor and delivery. Moreover, the pharmacological preparation can be precisely adjusted to enhance coronary reserves, reducing the likelihood of adverse maternal and fetal outcomes.

Incorporating this methodology into clinical practice has the potential to improve the quality of care for pregnant women with mitral stenosis by supporting evidence-based decision-making and personalized treatment planning. Future studies could further refine and validate this approach, expanding its applicability to other high-risk cardiovascular conditions during pregnancy.

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