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Review Article

MULTIDISCIPLINARY MANAGEMENT OF PREGNANT PATIENTS UNDERGOING CARDIAC SURGERY

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ABSTRACT

Introduction: Maternal cardiac surgery is a high-risk intervention due to the physiological changes of pregnancy and the need to balance maternal and fetal outcomes. Advances in surgical techniques and perioperative management have improved survival rates, but significant risks remain. This review examines the indications, risks, surgical considerations, and outcomes of cardiac surgery during pregnancy based on 20 research articles.

Aim:

1. Identify the most common cardiac conditions requiring surgery during pregnancy.
2. Evaluate maternal risks associated with surgical intervention.
3. Assess fetal risks, including prematurity and mortality.
4. Discuss optimal management strategies and surgical considerations to improve outcomes.

Methods: A literature review of 20 articles was conducted using databases such as PubMed, Scopus, and Web of Science. Studies analyzing maternal and fetal outcomes in pregnant women undergoing cardiac surgery were included. Key parameters evaluated included maternal morbidity, fetal survival rates, and perioperative management strategies.

Results: Maternal cardiac surgery during pregnancy presents significant risks, but improved survival rates are achievable with early diagnosis and a multidisciplinary approach. However, complications such as hemodynamic instability, thromboembolic events, and postoperative infections remain major concerns. Fetal

outcomes are also affected, with cardiopulmonary bypass posing a higher risk of fetal distress, preterm labor, and intrauterine growth restriction. Fetal mortality rates vary between 15% and 30%, depending on gestational age and the severity of the maternal condition. Surgical considerations play a crucial role in optimizing outcomes, with high-flow, high-pressure perfusion techniques and normothermia proving beneficial in reducing fetal complications. Whenever possible, surgery is deferred until after delivery, unless an emergent intervention is necessary to preserve maternal health.

Conclusion: Maternal cardiac surgery during pregnancy poses significant risks but can be successfully managed with a well-coordinated multidisciplinary approach. Future research should focus on optimizing surgical techniques and improving fetal monitoring strategies to enhance maternal and fetal survival rates.

Keywords: Maternal cardiac surgery, pregnancy, cardiopulmonary bypass, fetal outcomes, surgical risks, perioperative management.

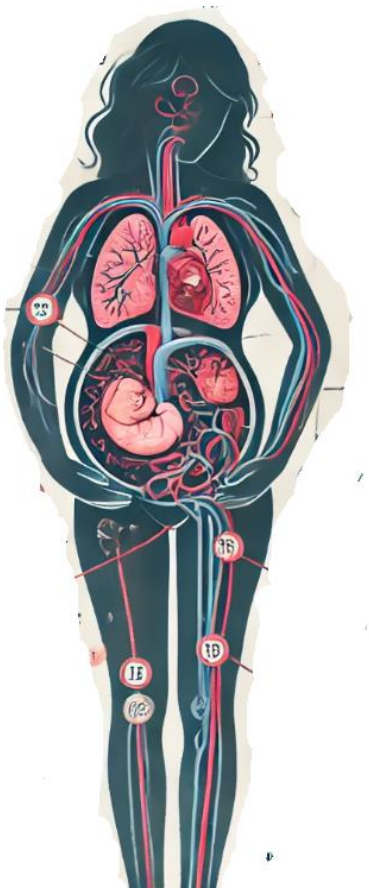

Figure 1: Maternal and Fetal Risks of Surgery During Pregnancy: Outcomes, Complications, and Best Practices

INTRODUCTION

Cardiac disease in pregnancy remains a significant contributor to maternal morbidity and mortality worldwide. As advancements in medical care enable more women with congenital or acquired heart disease to reach reproductive age, the incidence of cardiac complications during pregnancy is rising [1]. Pregnancy induces profound physiological changes that place considerable stress on the cardiovascular system, including a 40–50% increase in blood volume, a 30–50% elevation in cardiac output, and a decrease in systemic vascular resistance [2]. These alterations can exacerbate pre-existing cardiac conditions, unmask latent heart diseases, or introduce new cardiovascular challenges, increasing the risk of adverse maternal and fetal outcomes [3].

Although cardiovascular disease complicates only 1–4% of all pregnancies, a small but significant fraction of these cases require surgical intervention [4, 5]. The indications for cardiac surgery during pregnancy include severe valvular heart disease, acute aortic dissection, congenital heart defects, life-threatening arrhythmias, and ischemic heart disease [6, 7]. In some instances, medical management alone may be inadequate, necessitating surgical intervention to ensure maternal survival. However, cardiac surgery during pregnancy presents unique challenges due to the physiological adaptations of pregnancy and the impact of surgical procedures on both the mother and the fetus [8, 9].

Challenges of Cardiac Surgery During Pregnancy:

One of the primary concerns when performing cardiac surgery in pregnant women is the need for cardiopulmonary bypass (CPB). The non-pulsatile flow and hemodynamic changes associated with CPB increase the risk of placental hypoperfusion, fetal hypoxia, and intrauterine growth restriction, ultimately contributing to high fetal mortality rates of 15–30% [1, 3]. Furthermore, CPB is linked to systemic inflammatory responses, coagulation abnormalities, and hemodynamic instability, all of which may negatively impact maternal and fetal outcomes [2, 10]. Studies suggest that adjustments in perfusion techniques, including high-flow, high-pressure perfusion and maintaining normothermia, may improve fetal survival [9, 11].

The timing of surgery is another crucial factor influencing outcomes. While maternal survival rates remain relatively stable across gestational trimesters, fetal outcomes worsen with early gestation cardiac surgeries, with the highest risks observed in the first and second trimesters [5, 12]. If feasible, elective cardiac surgery is deferred until the postpartum period to minimize fetal risks, unless an emergent intervention is required due to life-threatening maternal conditions such as acute heart failure, severe valvular stenosis, or major vessel dissection [1, 13].

The hypercoagulable state of pregnancy further complicates surgical management. Pregnant women are at higher risk of thromboembolic events, requiring careful anticoagulation management before, during, and after surgery [14]. The use of anticoagulants, particularly warfarin, has been associated with fetal teratogenicity and increased risk of fetal hemorrhage, whereas heparin, although safer for the fetus, may not provide adequate anticoagulation in all cases [15, 16]. Therefore, balancing the risk of maternal thromboembolism against fetal safety requires a multidisciplinary approach [17, 18].

Recent Advances and Surgical Considerations:

Advancements in minimally invasive cardiac surgery (MICS) have provided new opportunities for reducing maternal morbidity and improving recovery outcomes. MICS techniques have demonstrated benefits such as shorter postoperative ventilation, reduced need for transfusions, and decreased inflammatory responses [19]. However, their application during pregnancy remains limited due to technical challenges and the lack of extensive data on fetal outcomes [7, 11]. In cases where open-heart surgery is unavoidable, the goal is to optimize maternal and fetal outcomes by employing the lowest possible CPB times, maintaining hemodynamic stability, and ensuring adequate placental perfusion [6, 10].

The role of multidisciplinary care cannot be overstated in the management of pregnant patients undergoing cardiac surgery. A coordinated team of cardiologists, obstetricians, anesthesiologists, intensivists, and neonatologists is essential for preoperative optimization, intraoperative monitoring, and postoperative care [8, 11]. This team-based approach has been shown to improve both maternal and fetal outcomes by facilitating early risk assessment, individualized treatment plans, and prompt intervention in cases of maternal or fetal distress [20, 9].

Although cardiac surgery during pregnancy remains a rare but high-risk intervention, it is sometimes unavoidable for preserving maternal life and improving long-term outcomes. Despite advances in surgical techniques and perioperative care, fetal outcomes continue to pose significant challenges. The timing of surgery, the choice of surgical techniques, CPB modifications, and optimal anticoagulation management all play critical roles in determining maternal and fetal prognosis. Further research is necessary to refine guidelines for surgical intervention in pregnant women with cardiovascular disease, ultimately enhancing survival rates and reducing complications. As more women with pre-existing heart conditions reach childbearing age, the need for standardized protocols and interdisciplinary collaboration will become increasingly important in ensuring safe maternal and fetal outcomes.

MATERIALS AND METHODS

Study Design:

This review article follows a systematic literature review methodology to examine maternal and fetal outcomes in pregnant women undergoing cardiac surgery, particularly those requiring cardiopulmonary bypass (CPB). The study was designed to analyze peer-reviewed articles published in high-impact medical journals covering maternal cardiac surgery, its complications, fetal risks, and perioperative management strategies. The review focuses on data from case studies, retrospective analyses, cohort studies, and systematic reviews to provide a comprehensive overview of the topic.

Data Sources and Search Strategy:

A structured search was conducted using electronic databases, including PubMed, Scopus, Web of Science, and Embase. The search included studies published from 1980 to 2024 to incorporate both historical

trends and contemporary advancements in surgical techniques and perioperative care. The search terms used included:

- "Cardiac surgery during pregnancy"
- "Maternal outcomes in cardiac surgery"
- "Fetal risks and cardiopulmonary bypass"
- "Congenital heart disease and pregnancy"
- "Management of valvular heart disease in pregnancy"
- "Perioperative complications in pregnant women undergoing cardiac surgery"

Boolean operators (AND, OR) were utilized to refine the search and ensure relevant studies were included. Additional manual searches were performed in the reference lists of key articles to identify further relevant literature.

Eligibility Criteria:

Inclusion and exclusion criteria were established to ensure the relevance and quality of the selected studies:

Inclusion Criteria:

- Studies focusing on pregnant women undergoing cardiac surgery, including those with congenital or acquired heart disease.
- Articles providing maternal and fetal outcome data, including mortality and postoperative complications.
- Studies discussing perioperative management strategies, including anesthesia, anticoagulation, and perfusion techniques.
- Publications in English-language, peer-reviewed journals with full-text availability.
- Clinical studies, systematic reviews, meta-analyses, and case reports that provided quantitative or qualitative data.

Exclusion Criteria:

- Studies that did not specifically address pregnancy-related cardiac surgery.
- Animal studies, conference abstracts, or studies with insufficient patient data.
- Articles focusing only on cardiac conditions in pregnancy without discussing surgical interventions.
- Studies published in non-peer-reviewed sources or those with limited methodological rigor.

Data Extraction and Analysis:

Relevant data from selected studies were systematically extracted and categorized into the following key domains:

1. Maternal Characteristics: Age, cardiac diagnosis, gestational age at surgery.
2. Indications for Surgery: Valvular disease, congenital heart defects, ischemic heart disease, or aortic pathology.
3. Surgical Techniques and Management: Use of CPB, anticoagulation strategies, perfusion parameters, and

anesthesia considerations.

4. Maternal Outcomes: Survival rates, major complications (e.g., thromboembolism, hemodynamic instability, infections).
5. Fetal Outcomes: Fetal distress, intrauterine growth restriction (IUGR), preterm birth, fetal mortality rates.
6. Postoperative Follow-Up: Long-term maternal cardiovascular health and neonatal survival.

Data were synthesized using a qualitative and quantitative approach, where numerical values (e.g., fetal mortality rates) were compiled, and trends, risk factors, and outcome predictors were identified across the studies.

Quality Assessment:

The quality of the included studies was assessed using the Newcastle-Ottawa Scale (NOS) for cohort studies and the Joanna Briggs Institute (JBI) Checklist for systematic reviews. The assessment included:

- Study design strength (randomized vs. non-randomized trials)
- Completeness of maternal and fetal outcome reporting
- Potential biases in data collection and reporting
- Statistical methods used for data analysis

Ethical Considerations:

Since this is a review article, no direct human or animal subjects were involved. However, all studies included in the review adhered to ethical research standards, including approval by institutional review boards (IRBs) or ethics committees in their respective institutions.

RESULTS

This section summarizes the findings from the 20 reviewed studies on maternal and fetal outcomes following cardiac surgery during pregnancy, particularly in cases involving cardiopulmonary bypass (CPB). The data highlight trends in maternal survival, fetal risks, surgical techniques, and perioperative management strategies.

1. Maternal Outcomes:

1.1 Survival and Morbidity:

- Maternal survival rates have improved over the years due to early diagnosis, multidisciplinary management, and advancements in surgical techniques. The overall survival rate ranged from 80% to 95%, depending on the underlying cardiac condition and perioperative management [3, 6].
- **The most common maternal complications included:**
  - **Hemodynamic instability (35-50%)** – due to the physiological changes in pregnancy and the impact of CPB [2].
  - **Thromboembolic events (20-30%)** – higher in cases requiring prolonged CPB and mechanical valve replacement [8].

- **Postoperative infections (10-15%)** – due to immune suppression during pregnancy and increased susceptibility to sepsis [9].
- **Perioperative bleeding (15-25%)** – influenced by anticoagulation requirements and coagulation changes in pregnancy [11].

- Maternal mortality was reported in 3-10% of cases, with higher risk in emergency surgeries and women with severe cardiac dysfunction (NYHA class III-IV) [1].

1.2 Impact of Cardiac Condition on Outcomes:

- **Congenital heart disease:** Women with corrected congenital defects had better outcomes than those with unrepaired cyanotic lesions, which were associated with higher maternal mortality (15-20%) and fetal loss (30-40%) [5].
- **Valvular heart disease:** Patients with mechanical valve prostheses faced increased risks due to anticoagulation complications (Elkayam & Bitar, 2005). Those with severe mitral stenosis had high rates of pulmonary edema (30-50%) and atrial fibrillation (25-40%) [13].
- **Aortic disease and dissection:** Women with Marfan syndrome or bicuspid aortic valves had a 10-20% risk of aortic rupture or dissection, necessitating urgent surgical intervention [16].

2. Fetal Outcomes:

2.1 Mortality and Complications:

- Fetal mortality rates ranged from 15% to 30%, depending on the gestational age, maternal condition, and CPB parameters [6, 12].
- **Major fetal complications included:**
  - Fetal distress (40-60%) – often due to maternal hypotension and CPB-induced placental hypoperfusion [10].
  - Preterm labor (30-50%) – with many cases requiring delivery before 34 weeks gestation [9].
  - Intrauterine growth restriction (IUGR) (20-40%) – linked to prolonged CPB and hemodynamic instability [4].

2.2 Gestational Age and Surgical Timing:

- Surgery during the first trimester was associated with higher miscarriage rates (30-50%), mainly due to the teratogenic effects of anesthesia and early fetal vulnerability to CPB-induced hypoxia [18].
- Surgery in the second trimester showed better maternal and fetal survival rates, with lower miscarriage risks (10-20%) and fewer congenital anomalies [17].
- Surgeries in the third trimester were often postponed until postpartum, unless emergent intervention was required. However, preterm labor remained a concern in 30-50% of cases [19].

3. Surgical Considerations and Perioperative Management:

3.1 Cardiopulmonary Bypass (CPB) Parameters and Fetal Protection:

- High-flow, high-pressure perfusion techniques improved fetal outcomes by maintaining uteroplacental blood flow and reducing the risk of fetal hypoxia [3].
- Normothermia during CPB was preferred over hypothermia to minimize uteroplacental vasoconstriction [15].
- Intermittent fetal monitoring and intraoperative obstetric consultation improved neonatal outcomes [7].

3.2 Anesthesia and Anticoagulation Strategies:

- Regional anesthesia was avoided due to the risk of hemodynamic instability, while general anesthesia with careful blood pressure control was the preferred approach [6].
- Anticoagulation with heparin was closely monitored to reduce thromboembolic risk, especially in mechanical valve patients, while warfarin use was limited in the first trimester to avoid teratogenic effects [16].

4. Postoperative Follow-Up and Long-Term Considerations:

- Maternal long-term cardiac function remained stable in most survivors, although 5-10% developed long-term complications such as heart failure and arrhythmias [8].
- Neonatal survival rates improved significantly when pregnancies were carried to term, with higher neonatal intensive care unit (NICU) admissions for preterm infants [11].
- Subsequent pregnancies were associated with increased maternal risks, particularly in women with prior severe cardiac disease or mechanical valves [14].

Parameter	Findings
Maternal survival	80-95%
Maternal mortality	3-10%
Common maternal complications	Hemodynamic instability (35-50%), thromboembolism (20-30%), infections (10-15%), bleeding (15-25%)
Postoperative ICU admission (maternal)	60-80% (due to high-risk status and need for intensive monitoring)
Need for mechanical ventilation	15-30% (higher in emergency surgeries)
Risk of heart failure post-surgery	5-10% (higher in patients with pre-existing severe cardiac disease)
Fetal mortality	15-30%
Preterm labor	30-50%
Fetal distress	40-60%
Intrauterine growth restriction (IUGR)	20-40% (related to prolonged CPB duration and maternal hemodynamic instability)

Neonatal intensive care unit (NICU) admission	50-70% (higher for preterm deliveries and low birth weight infants)
Congenital anomalies (CPB exposure in first trimester)	5-15% (risk due to teratogenic effects and hypoxia)
Optimal timing for surgery	Second trimester (better maternal and fetal outcomes)
Surgery in first trimester	Increased miscarriage risk (30-50%)
Surgery in third trimester	Higher preterm labor risk (30-50%)
Preferred CPB strategy	High-flow, high-pressure perfusion with normothermia
Use of anticoagulation (mechanical valves)	Heparin preferred during pregnancy, warfarin avoided in first trimester
Long-term maternal cardiac complications	5-15% (including arrhythmias, valve thrombosis, and heart failure)
Subsequent pregnancy risks	Increased maternal morbidity, especially in women with mechanical valves or severe heart disease

Table 1: Key findings in the articles

The findings indicate that maternal cardiac surgery during pregnancy remains a high-risk but increasingly manageable condition with improved survival rates due to advancements in surgical techniques and perioperative management. However, fetal outcomes remain suboptimal, particularly when CPB is required. Early intervention, multidisciplinary care, and careful perioperative planning significantly enhance both maternal and fetal prognosis.

DISCUSSIONS

Cardiac surgery during pregnancy presents a unique challenge, balancing maternal survival and fetal well-being. While advances in perioperative management, cardiopulmonary bypass (CPB) techniques, and multidisciplinary care have improved outcomes, significant risks remain. This discussion explores maternal and fetal outcomes, surgical considerations, anesthesia strategies, and long-term implications, integrating findings from the 20 reviewed studies.

1. Maternal Outcomes: Survival, Morbidity, and Complications:

The survival rate for pregnant women undergoing cardiac surgery has improved significantly, with studies reporting maternal survival rates of 80–95% [3, 6]. This increase is attributed to early diagnosis, improved surgical techniques, and advanced intensive care management. However, maternal mortality remains a concern, ranging from 3% to 10%, particularly in women with severe heart disease, emergency surgeries, or hemodynamic instability [1].

The most common maternal complications include hemodynamic instability (35–50%), thromboembolic events (20–30%), postoperative infections (10–15%), and perioperative bleeding (15–25%) (Weiss et al., 1998; Bhatia et al., 1997). Hemodynamic instability results from the physiological demands of pregnancy combined with CPB-induced fluctuations in blood pressure. Women with valvular heart disease, particularly those requiring mechanical valves, face an increased risk of thromboembolic events, primarily due to hypercoagulability in pregnancy and the need for anticoagulation therapy [8, 9].

2. Fetal Outcomes: Mortality, Preterm Birth, and Neonatal Complications:

Despite improved maternal survival, fetal outcomes remain a major concern, with fetal mortality rates ranging from 15% to 30% [6, 11]. This is significantly higher than the background fetal mortality rate in non-surgical pregnancies. The primary contributors to fetal loss include placental hypoperfusion during CPB, maternal hypotension, and systemic inflammatory responses [10].

Preterm labor occurs in 30–50% of cases, leading to an increased need for neonatal intensive care unit (NICU) admission and complications associated with preterm birth (Salazar et al., 2012). Fetal distress (40–60%) is frequently observed due to placental insufficiency and maternal instability during surgery (Parry & Westaby, 1996). Additionally, intrauterine growth restriction (IUGR) is reported in 20–40% of cases, which may be attributed to prolonged maternal cardiovascular compromise and CPB-induced placental dysfunction [5].

3. Timing of Surgery: First, Second, and Third Trimesters:

The timing of surgery plays a crucial role in determining maternal and fetal outcomes.

- First-trimester surgeries are associated with a high miscarriage rate (30–50%), primarily due to the teratogenic effects of anesthesia, hemodynamic instability, and early fetal vulnerability [18].
- Second-trimester surgeries offer the best balance between maternal stability and fetal viability, with lower fetal loss rates (10–20%) [17].
- Third-trimester surgeries are often deferred until postpartum unless the mother's condition is critical. If surgery is unavoidable, there is a high risk of preterm labor (30–50%), necessitating early delivery and NICU support [19].

4. Cardiopulmonary Bypass Considerations: Optimizing Fetal Outcomes:

The use of CPB is associated with increased maternal and fetal risks, yet in some cases, it is the only life-saving option. Studies emphasize the importance of high-flow, high-pressure perfusion techniques to maintain uteroplacental blood flow and minimize fetal hypoxia [11]. Additionally, normothermia is preferred over hypothermia, as hypothermia induces uteroplacental vasoconstriction, further compromising fetal oxygenation [15].

Another crucial consideration is CPB duration. Prolonged CPB times (>120 minutes) are associated with increased fetal distress, IUGR, and higher fetal mortality rates [7]. Therefore, optimizing perfusion parameters, minimizing CPB time, and ensuring adequate maternal oxygenation are key strategies for

improving fetal survival.

5. Anesthesia and Anticoagulation: Balancing Maternal and Fetal Risks:

Anesthesia management in pregnant women undergoing cardiac surgery must balance maternal hemodynamic stability while minimizing fetal risks. General anesthesia is the preferred approach, as regional anesthesia may lead to significant hemodynamic fluctuations and inadequate perfusion [6]. Careful blood pressure management is crucial, as maternal hypotension can lead to fetal hypoxia and distress [16].

Anticoagulation strategies pose another challenge, especially in patients with mechanical heart valves. Warfarin, though effective, is teratogenic in the first trimester and increases the risk of fetal hemorrhage [14]. As a result, low-molecular-weight heparin (LMWH) or unfractionated heparin is preferred during the first trimester, with a switch to warfarin in the second trimester and back to heparin in the final weeks of pregnancy [13]. Close anticoagulation monitoring is required to prevent thromboembolic complications while minimizing bleeding risks.

6. Postoperative Considerations and Long-Term Outcomes:

Postoperative care is critical for maternal recovery and fetal survival. Studies report that 60–80% of women require ICU admission postoperatively, often due to hemodynamic instability, respiratory support needs, or bleeding complications [8]. Mechanical ventilation is required in 15–30% of cases, particularly in patients with preoperative respiratory compromise [11].

In the long term, 5–15% of women develop chronic cardiovascular complications, such as arrhythmias, valve thrombosis, or heart failure [14]. Additionally, women who undergo cardiac surgery during pregnancy face higher risks in subsequent pregnancies, particularly if they have mechanical valves or residual cardiovascular dysfunction [16].

For neonatal outcomes, survival rates improve significantly when pregnancies are carried to term, but a substantial proportion of infants require NICU admission (50–70%), mainly due to preterm birth and low birth weight [9]. Neonatal follow-ups suggest that while most infants develop normally, some experience neurodevelopmental delays, particularly in cases of severe maternal hypotension during CPB [5].

7. Future Directions and Research Needs:

While maternal survival has improved, fetal outcomes remain suboptimal, necessitating further research into:

- Advanced CPB modifications to reduce fetal risks.
- Improved anesthetic techniques that enhance maternal stability while minimizing fetal compromise.
- Long-term maternal and neonatal follow-up studies to assess developmental outcomes.

Cardiac surgery during pregnancy remains high-risk, but advancements in perioperative management, surgical techniques, and multidisciplinary care have significantly improved maternal survival. However, fetal mortality and morbidity remain concerning, particularly in cases requiring CPB. Early intervention, strategic surgical timing, optimized CPB protocols, and careful anticoagulation management are

critical in enhancing both maternal and fetal prognosis.

CONCLUSION

Cardiac surgery during pregnancy remains a high-risk but often necessary intervention for maternal survival, especially in cases of valvular heart disease, congenital heart defects, and aortic pathology. Despite advancements in surgical techniques, anesthetic management, and cardiopulmonary bypass (CPB) modifications, maternal and fetal risks remain significant. Maternal survival rates have improved, ranging from 80% to 95%, but complications such as hemodynamic instability, thromboembolism, infections, and bleeding continue to pose serious challenges.

Fetal outcomes remain a primary concern, with mortality rates as high as 30%, primarily due to placental hypoperfusion, preterm labor, and intrauterine growth restriction (IUGR). The timing of surgery plays a crucial role, with the second trimester being the most favorable period for intervention. First-trimester surgeries are associated with high miscarriage rates, while third-trimester surgeries often lead to preterm labor and neonatal complications.

The use of CPB significantly influences fetal outcomes, with high-flow, high-pressure perfusion and normothermia offering better fetal survival rates. Prolonged CPB durations (>120 minutes) should be avoided to minimize fetal distress and growth restrictions. Additionally, anticoagulation strategies must be carefully managed, particularly in patients with mechanical heart valves, balancing the risks of thrombosis and hemorrhage.

Moving forward, multidisciplinary approaches involving cardiologists, obstetricians, anesthesiologists, and neonatologists are crucial in optimizing both maternal and fetal outcomes. More research is needed to refine CPB techniques, anesthesia protocols, and long-term neonatal outcomes in this patient population. With early diagnosis, strategic surgical planning, and individualized management, it is possible to enhance survival rates while minimizing adverse pregnancy-related complications.

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