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Perioperative Considerations for ASD Device Closure in the First Trimester: A Case of Secundum ASD with Bidirectional Shunt

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A B S T R A C T

Introduction: Atrial septal defect (ASD) closure during pregnancy is a complex procedure requiring careful consideration of maternal and fetal risks. This case report highlights the perioperative management of a secundum ASD with a bidirectional shunt in a patient during her first trimester. **Case presentation:** A 31-year-old woman, G3P2A0, presented at approximately 10-11 weeks gestation with a recently diagnosed large secundum ASD and pulmonary hypertension. She was on Sildenafil and Bisoprolol. Due to the potential risks associated with an unrepaired ASD during pregnancy, the decision was made to proceed with percutaneous ASD closure. General anesthesia was administered with meticulous hemodynamic monitoring. The procedure was successful, and the patient recovered without complications. **Conclusion:** ASD closure during the first trimester can be safely performed with careful planning and execution. Multidisciplinary collaboration and vigilant monitoring are crucial for optimal maternal and fetal outcomes.

1. Introduction

Atrial septal defect (ASD) is a congenital heart anomaly characterized by an abnormal opening in the interatrial septum, permitting blood flow between the left and right atria. This anomalous communication disrupts the normal circulatory pattern, potentially leading to a cascade of hemodynamic perturbations and long-term sequelae. ASDs are classified based on their anatomical location and embryological origin, with the secundum ASD being the most prevalent type, accounting for approximately 70% of all cases. Secundum ASDs typically involve a defect in the fossa ovalis region of the interatrial septum, resulting from incomplete closure of the foramen ovale after birth. The clinical presentation of ASDs is variable, ranging from asymptomatic individuals to those with overt symptoms of heart failure, arrhythmias, and exercise intolerance. The natural history of unrepaired ASDs is associated with an increased risk of complications, including pulmonary hypertension, right ventricular dysfunction, atrial fibrillation, and stroke. The hemodynamic consequences of ASDs are primarily determined by the size of the defect, the direction and magnitude of the shunt, and the presence of associated cardiac anomalies.[1,2]

Pregnancy represents a unique physiological challenge for women with ASDs, as the maternal cardiovascular system undergoes significant adaptations to accommodate the growing fetus. These adaptations include increases in blood volume, cardiac output, and heart rate, as well as decreases in systemic vascular resistance and pulmonary vascular resistance. These changes can exacerbate the hemodynamic burden imposed by an ASD, potentially leading to right heart volume overload, pulmonary hypertension, and congestive heart failure. The presence of an ASD during pregnancy has been associated with an increased risk of maternal and fetal complications. Maternal complications include arrhythmias, thromboembolic events, and heart failure, while fetal complications include preterm birth, fetal growth restriction, and neonatal morbidity. The magnitude of these risks is influenced by several factors, including the size and type of ASD, the presence of associated cardiac anomalies, and the functional capacity of the right ventricle.[3,4]

The management of ASD in pregnancy requires a multidisciplinary approach involving cardiologists, obstetricians, and anesthesiologists. The decision to intervene during pregnancy depends on the severity of symptoms, the presence of complications, and the gestational age at presentation. In asymptomatic patients with small ASDs and no evidence of pulmonary hypertension, conservative management with close monitoring may be appropriate. However, in symptomatic patients or those with large ASDs and/or pulmonary hypertension, intervention may be necessary to mitigate the risks to both mother and fetus. Percutaneous ASD device closure has emerged as a safe and effective alternative to open-heart surgery for eligible patients. This minimally invasive procedure involves the transcatheter deployment of a device to occlude the ASD, thereby restoring normal interatrial septal anatomy and physiology. Device closure offers several advantages over surgery, including reduced morbidity, shorter hospital stays, and faster recovery times.[5,6]

Anesthetic management for ASD device closure during pregnancy presents unique challenges due to the altered maternal physiology and the potential impact on the fetus. The choice of anesthesia depends on several factors, including the patient's clinical status, the gestational age, and the anticipated complexity of the procedure. General anesthesia offers several advantages, including controlled ventilation, airway protection, and hemodynamic stability. However, it also carries risks, such as maternal hypotension, fetal hypoxia, and potential teratogenic effects of anesthetic agents. Regional anesthesia, such as spinal or epidural anesthesia, may be considered in selected cases, but its use is limited by concerns about hemodynamic instability and the potential for neurological complications. Regardless of the anesthetic technique chosen, meticulous hemodynamic monitoring is essential during ASD closure in pregnant patients. The goal is to maintain adequate maternal blood pressure and cardiac output to ensure optimal uteroplacental perfusion and fetal oxygenation. Invasive arterial blood pressure monitoring allows for continuous real-time assessment of maternal hemodynamics and facilitates prompt intervention in case of hypotension or other complications.[7,8]

Performing ASD device closure during the first trimester poses additional challenges due to the heightened vulnerability of the developing fetus to teratogenic agents and the potential impact of the procedure on early organogenesis. The first trimester is a critical period of fetal development, during which exposure to certain medications or radiation can have detrimental effects on the fetus. Furthermore, the maternal physiology in the first trimester is characterized by significant hormonal fluctuations and hemodynamic changes, which can influence the response to anesthesia and the overall perioperative course. Careful consideration must be given to the choice of anesthetic agents, the management of hemodynamics, and the postoperative care to minimize the risks to both mother and fetus. This case report describes the perioperative management of a pregnant woman with a secundum ASD and a bidirectional shunt who underwent successful percutaneous device closure during her first trimester. The patient presented with mild symptoms and pulmonary hypertension, necessitating intervention to mitigate the

risks associated with an unrepaired ASD during pregnancy.[9,10] The case highlights the importance of a multidisciplinary approach involving cardiologists, obstetricians, and anesthesiologists in the management of such complex cases. Careful planning, meticulous execution, and vigilant monitoring are crucial for achieving optimal maternal and fetal outcomes.

2. Case Presentation

A 31-year-old woman, gravida 3, para 2, presented to the cardiology clinic with a positive pregnancy test at approximately 10-11 weeks gestation. She had been recently diagnosed with a large secundum atrial septal defect (ASD) and pulmonary hypertension, a condition she was unaware of until six years prior. The patient expressed concerns about the potential impact of her newly diagnosed heart condition on her pregnancy and even contemplated terminating the pregnancy. Her medical history was notable for two prior uncomplicated pregnancies and deliveries. She had been under the care of a cardiologist and was on a medication regimen of Sildenafil and Bisoprolol to manage her pulmonary hypertension. The patient was referred to the anesthesiology department for a comprehensive evaluation and discussion of the potential risks and benefits of ASD closure during pregnancy.

A thorough physical examination revealed a woman with a body mass index (BMI) of 17.78 kg/m², calculated from her weight of 40 kg and height of 150 cm. Her vital signs were within normal limits, with a blood pressure of 120/80 mmHg, a heart rate of 106 beats per minute, and a respiratory rate of 18 breaths per minute. However, her oxygen saturation was notably low at 83-87% on room air, indicative of impaired oxygenation likely related to her underlying cardiac condition. Cardiac auscultation revealed a normal first heart sound (S1) and a widely fixed split-second heart sound (S2), a classic finding associated with ASDs. This abnormal splitting of S2 occurs due to delayed closure of the pulmonic valve, resulting from increased right ventricular stroke volume and prolonged right ventricular ejection time in the presence of a left-to-right shunt. Laboratory investigations showed a hemoglobin level of 15.5 g/dL, a hematocrit of 46%, and a white blood cell count of 11,050/uL. Her platelet count was 232,000/uL, and other laboratory parameters were within normal limits. These findings suggested no significant hematological abnormalities or underlying infections.

The patient's echocardiogram demonstrated a large secundum ASD with a bidirectional shunt, predominantly left-to-right, measuring 1.5 cm to 2.07 cm. There was evidence of right atrial and right ventricular dilation, indicative of chronic volume overload due to the left-to-right shunt. The echocardiogram also revealed a high probability of pulmonary hypertension, a serious complication associated with ASDs that can significantly impact maternal and fetal outcomes during pregnancy. Chest radiography further corroborated the echocardiographic findings, showing an enlarged cardiac silhouette suggestive of cardiomegaly, a common manifestation of right heart volume overload in patients with ASDs.

The patient's case was discussed in a multidisciplinary team meeting involving cardiologists, obstetricians, and anesthesiologists. The potential risks and benefits of ASD closure during pregnancy were carefully weighed. The presence of pulmonary hypertension and the large size of the ASD raised concerns about potential maternal and fetal complications if the defect remained uncorrected. The team acknowledged the potential risks associated with any intervention during pregnancy, particularly in the first trimester, a critical period of fetal development. However, the potential benefits of ASD closure in mitigating the risks of right heart failure, arrhythmias, and paradoxical embolism were deemed to outweigh the risks of the procedure. After extensive discussions and informed consent, the decision was made to proceed with percutaneous ASD device closure. The patient was reassured about the safety and efficacy of the procedure and the meticulous care that would be taken to ensure the well-being of both her and her fetus.

The patient continued her Sildenafil regimen until the day before the procedure. This medication, a phosphodiesterase-5 inhibitor, helps to dilate the

pulmonary blood vessels and reduce pulmonary vascular resistance, thereby improving right ventricular function and decreasing the risk of pulmonary hypertensive crisis during the procedure. On the day of the procedure, the patient was kept nil per os (NPO) for six hours to minimize the risk of aspiration during anesthesia. Intravenous access was established, and standard monitoring, including electrocardiogram (ECG), pulse oximetry, and noninvasive blood pressure monitoring, was initiated. The anesthetic plan involved general anesthesia with endotracheal intubation. This approach was chosen to ensure adequate oxygenation and ventilation, maintain hemodynamic stability, and facilitate transesophageal echocardiographic guidance during the procedure. The anesthetic agents were carefully selected to minimize potential fetal exposure and adverse effects.

Upon arrival in the catheterization laboratory, invasive arterial blood pressure monitoring was established to allow for continuous, real-time assessment of the patient's hemodynamic status. The patient's vital signs remained stable, with a blood pressure of 110/83 mmHg, a heart rate of 73 beats per minute, and an oxygen saturation of 89% on 3 liters per minute of supplemental oxygen via nasal cannula. General anesthesia was induced with intravenous midazolam, sufentanil, and ketamine. These agents provide anxiolysis, analgesia, and amnesia, respectively, while minimizing the potential for maternal hypotension and fetal depression. Atracurium was administered to facilitate endotracheal intubation with a 7.0 mm endotracheal tube. The patient's oxygen saturation improved to 98% after intubation, indicating adequate ventilation and oxygenation. Anesthesia was maintained with sevoflurane, a volatile anesthetic agent with rapid onset and offset, allowing for precise control of anesthetic depth and facilitating prompt emergence from anesthesia. The patient's vital signs were closely monitored throughout the procedure, with particular attention to blood pressure, heart rate, oxygen saturation, and end-tidal carbon dioxide ($ETCO_2$) levels. The ASD closure procedure was performed under fluoroscopic and transesophageal echocardiographic guidance. A catheter was inserted through the right femoral vein and advanced to the right atrium. The ASD was crossed, and a sizing balloon was used to determine the appropriate device size. A 24 mm Amplatzer Septal Occluder device was successfully deployed, resulting in complete closure of the ASD. Throughout the procedure, the patient's hemodynamic status remained stable, with no significant fluctuations in blood pressure or heart rate. The mean arterial pressure (MAP) was maintained above 65 mmHg, ensuring adequate uteroplacental perfusion and fetal oxygenation. The total fluid administered during the procedure was 1000 mL, consisting of 500 mL of crystalloid and 500 mL of colloid, to maintain intravascular volume and support cardiac output.

Following the procedure, the patient was transferred to the intensive care unit (ICU) for close monitoring. She remained hemodynamically stable and was extubated shortly after arrival in the ICU. Her respiratory status was satisfactory, with a respiratory rate of 20 breaths per minute and an oxygen saturation of 99% on a non-rebreathing mask at 10 liters per minute. Her blood pressure was 109/69 mmHg, and her heart rate was 91 beats per minute. Urine output was adequate at 1100 cc over 13 hours, suggesting adequate renal perfusion. Postoperative transthoracic echocardiography confirmed the successful placement of the device and the absence of any residual shunt. The patient's left ventricular ejection fraction was 62.3%, indicating normal cardiac function. The patient received postoperative medications, including cefazolin for antibiotic prophylaxis, metamizole for analgesia, ranitidine for stress ulcer prophylaxis, milrinone for inotropic support, and furosemide for diuresis. These medications were carefully selected and dosed to minimize potential adverse effects on the fetus while ensuring adequate maternal care. The patient's recovery was uneventful, and she was discharged home on postoperative day two with instructions for close follow-up with her cardiologist and obstetrician.

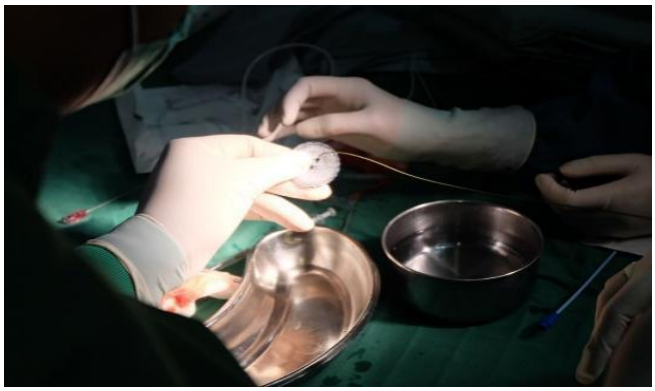

Figure 1. Device ASD closure.

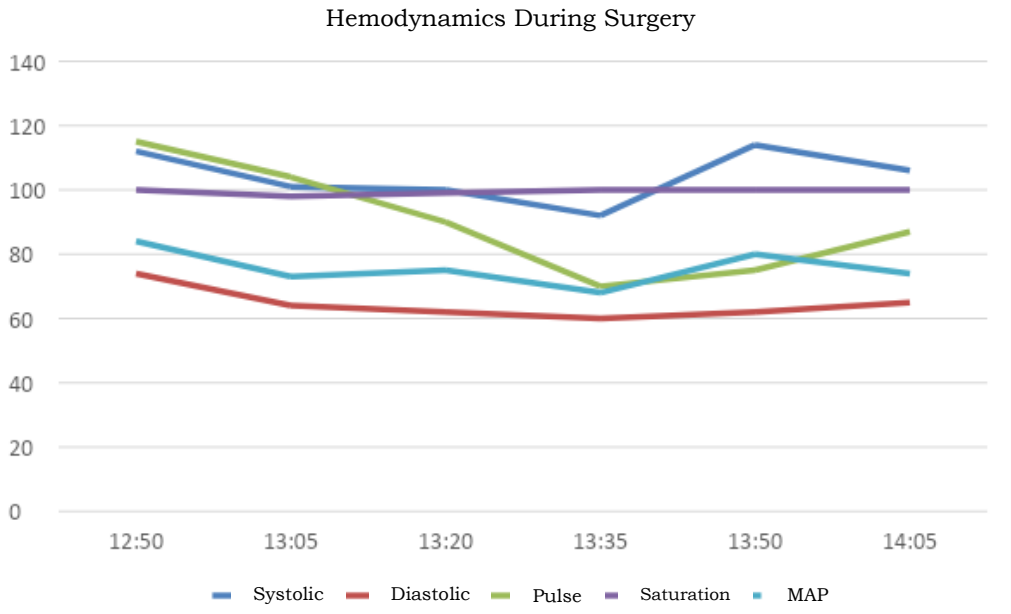

Figure 2. Hemodynamics during surgery.

3. Discussion

The successful management of the presented case serves as a poignant reminder of the multifaceted challenges inherent in performing ASD device closure during the first trimester of pregnancy. This critical period, characterized by rapid fetal development and profound maternal physiological adaptations, necessitates a nuanced and meticulous approach to ensure the well-being of both mother and child. The first trimester, encompassing the initial 12 weeks of gestation, is a time of remarkable transformation and heightened vulnerability. It is during this phase that the foundational structures of the fetus are laid down, and any disruption to this intricate process can have far-reaching consequences. The developing embryo is particularly susceptible to the teratogenic effects of certain medications, radiation exposure, and even maternal physiological stress. Concurrent with fetal development, the maternal body undergoes a series of profound physiological adaptations to accommodate the growing fetus. These adaptations involve intricate hormonal interplay and extensive remodeling of the cardiovascular, respiratory, and hematological systems. The maternal heart, in particular, experiences significant changes, including increases in blood volume, cardiac output, and heart rate, as well as

decreases in systemic vascular resistance. These adaptations, while essential for supporting fetal growth and development, can also exacerbate the hemodynamic challenges posed by an ASD. An ASD, even in its asymptomatic state, introduces an abnormal communication between the left and right atria, disrupting the normal flow of blood through the heart. This can lead to a left-to-right shunt, where oxygenated blood from the left atrium flows into the right atrium, increasing the volume of blood that the right ventricle must pump to the lungs. In the context of pregnancy, the increased blood volume and cardiac output can further amplify this right ventricular volume overload, potentially leading to right heart dilation, dysfunction, and ultimately, heart failure. Furthermore, the presence of a bidirectional shunt, as observed in our patient, raises the specter of paradoxical embolism. This phenomenon occurs when a thrombus, originating in the venous circulation, traverses the ASD and enters the systemic arterial circulation, potentially causing stroke or other thromboembolic events. Pregnancy itself is associated with a hypercoagulable state, further increasing the risk of thromboembolism in patients with ASDs. Pulmonary hypertension, another significant concern in this case, adds another layer of complexity to the management of ASD in pregnancy. This condition, characterized by elevated blood pressure in the pulmonary arteries, can impair right ventricular function and lead to right heart failure. Pregnancy can exacerbate pulmonary hypertension due to the increased blood volume and cardiac output, potentially precipitating a life-threatening crisis. The confluence of these factors underscores the imperative of early intervention in pregnant women with significant ASDs, particularly in the presence of pulmonary hypertension. While delaying the procedure until later in pregnancy might seem tempting, it carries the risk of progressive hemodynamic deterioration and potential complications as the pregnancy advances. The enlarging uterus can also pose technical challenges for device closure in the later stages of pregnancy. Early intervention, ideally in the first trimester, aims to mitigate these risks and optimize maternal and fetal outcomes. By addressing the ASD early on, the hemodynamic burden on the right heart can be alleviated, reducing the risk of right heart failure and pulmonary hypertensive crisis. Moreover, early closure of the ASD minimizes the duration of exposure to the risk of paradoxical embolism, thereby safeguarding both maternal and fetal well-being. The decision to proceed with ASD device closure in early pregnancy is not without its challenges. The first trimester is a critical period of fetal development, and any intervention carries the potential for adverse effects on the fetus. The use of radiation during the procedure, although minimal, raises concerns about potential teratogenicity. Additionally, the maternal physiological changes in early pregnancy can influence the response to anesthesia and the overall perioperative course. Therefore, a meticulous risk-benefit assessment is essential before embarking on ASD closure in the first trimester. The size and type of ASD, the presence of associated complications, the severity of symptoms, and the patient's overall health status must all be carefully considered. A multidisciplinary team approach, involving cardiologists, obstetricians, and anesthesiologists, is crucial for ensuring that the decision to intervene is made in the best interests of both mother and child. Anesthetic management for ASD device closure in early pregnancy presents a unique set of challenges. The choice of anesthesia must balance the need for maternal hemodynamic stability and fetal safety. General anesthesia, while offering advantages such as controlled ventilation and airway protection, also carries risks, including maternal hypotension, fetal hypoxia, and potential teratogenic effects of anesthetic agents. Regional anesthesia techniques, such as spinal or epidural anesthesia, may be considered in selected cases, but their use is limited by concerns about hemodynamic instability and the potential for neurological complications. In our patient, general anesthesia was deemed the most appropriate approach due to the presence of pulmonary hypertension and the need for transesophageal echocardiographic guidance. The anesthetic agents were carefully selected to minimize potential fetal exposure and adverse effects. Meticulous hemodynamic monitoring was employed throughout the perioperative period to ensure maternal and fetal well-being. Postoperative care following ASD device

closure in early pregnancy focuses on maintaining hemodynamic stability, preventing thromboembolic events, and monitoring fetal development. Close observation in the intensive care unit, serial echocardiograms, and appropriate anticoagulation therapy are essential components of postoperative management. The patient's recovery in this case was uneventful, highlighting the safety and efficacy of percutaneous ASD device closure in the first trimester when performed with meticulous planning and execution. The successful outcome underscores the importance of a multidisciplinary team approach and the value of early intervention in mitigating the risks associated with ASDs in pregnancy. The complexity of ASD closure in early pregnancy necessitates a nuanced and individualized approach. By carefully weighing the risks and benefits, selecting appropriate anesthetic techniques, and employing meticulous monitoring, we can ensure the best possible outcomes for both mother and child. This case serves as a testament to the advancements in medical science and the power of collaborative care in navigating the challenges of complex medical conditions during pregnancy.[11,12]

The presence of a large secundum ASD coupled with a bidirectional shunt and pulmonary hypertension in a pregnant woman, as exemplified in the presented case, introduces a complex interplay of physiological challenges that can significantly impact both maternal and fetal well-being. The intricacies of this scenario necessitate a comprehensive understanding of the pathophysiological implications and the potential risks associated with delayed intervention. The hallmark of an ASD, particularly one with a left-to-right shunt, is the increased volume load on the right heart. Oxygenated blood from the left atrium shunts into the right atrium, leading to increased blood flow through the right ventricle and pulmonary circulation. Pregnancy, with its associated increase in blood volume and cardiac output, further amplifies this volume overload, placing significant strain on the right ventricle. This can lead to right ventricular dilation, hypertrophy, and ultimately, right heart failure. Symptoms of right heart failure may include fatigue, dyspnea, peripheral edema, and ascites. In severe cases, it can progress to cardiogenic shock and maternal mortality. ASDs, especially those with right atrial enlargement, predispose individuals to atrial arrhythmias, most notably atrial fibrillation and flutter. Pregnancy, with its associated hormonal and autonomic changes, can further increase the risk of arrhythmias. Atrial fibrillation can lead to hemodynamic instability, thromboembolic events, and decreased cardiac output, compromising both maternal and fetal well-being. The presence of a bidirectional shunt in ASD creates a pathway for paradoxical embolism, a phenomenon where a thrombus from the venous circulation crosses the ASD and enters the systemic arterial circulation. This can lead to devastating consequences, such as stroke, myocardial infarction, or even pulmonary embolism. Pregnancy itself is a hypercoagulable state, further increasing the risk of thromboembolism in patients with ASDs. Pulmonary hypertension, a condition characterized by elevated blood pressure in the pulmonary arteries, is a serious complication associated with ASDs. It can significantly impair right ventricular function and lead to right heart failure. Pregnancy can exacerbate pulmonary hypertension due to the increased blood volume and cardiac output, potentially precipitating a life-threatening crisis. Symptoms of pulmonary hypertension may include dyspnea, fatigue, chest pain, and syncope. The hemodynamic instability and potential complications associated with ASDs in pregnancy can increase the risk of preterm birth. Premature infants are at a higher risk of respiratory distress syndrome, intraventricular hemorrhage, necrotizing enterocolitis, and other complications that can impact their long-term health and development. Inadequate uteroplacental perfusion due to maternal cardiac dysfunction can lead to fetal growth restriction. This can result in low birth weight, developmental delays, and increased neonatal morbidity and mortality. Infants born to mothers with ASDs may experience a range of complications, including respiratory distress, hypoglycemia, and feeding difficulties. The presence of pulmonary hypertension in the mother can also lead to persistent pulmonary hypertension of the newborn, a serious condition that requires intensive neonatal care. The decision to intervene with ASD closure during pregnancy hinges on

a delicate balance between the risks of the procedure and the potential consequences of delaying intervention. While the first trimester is a period of heightened fetal vulnerability, early intervention offers several advantages. Early closure of the ASD can alleviate the hemodynamic burden on the right heart, reducing the risk of right heart failure, arrhythmias, and pulmonary hypertensive crisis as the pregnancy progresses. This can significantly improve maternal well-being and reduce the risk of maternal mortality. Early intervention also minimizes the duration of fetal exposure to the risks associated with an unrepaired ASD, such as paradoxical embolism and uteroplacental insufficiency. This can potentially improve fetal growth and development and reduce the risk of neonatal complications. Performing the procedure in the first trimester, before significant uterine enlargement, can facilitate technical aspects of the procedure and reduce the risk of complications. While delaying intervention until later in pregnancy might seem appealing, it carries the risk of further hemodynamic deterioration and potential complications as the pregnancy progresses. The increased blood volume and cardiac output in the later stages of pregnancy can exacerbate the hemodynamic burden on the right heart, potentially leading to decompensation and maternal mortality. Furthermore, performing the procedure in the later stages of pregnancy can be technically challenging due to the enlarged uterus and altered anatomical relationships. This can increase the risk of procedural complications and compromise the success of the intervention. The management of ASD in pregnancy necessitates a collaborative approach involving cardiologists, obstetricians, and anesthesiologists. Careful pre-procedural planning, meticulous execution, and vigilant monitoring are essential for ensuring the best possible outcomes for both mother and child. The decision to intervene with ASD closure during pregnancy should be made on an individual basis, taking into account the specific characteristics of the ASD, the presence of associated complications, the severity of symptoms, and the patient's overall health status. A comprehensive risk-benefit assessment, coupled with open communication and shared decision-making, is crucial for optimizing maternal and fetal well-being.[13,14]

The selection of an appropriate anesthetic technique for ASD closure during pregnancy is a critical decision that necessitates a meticulous evaluation of both maternal and fetal safety considerations. The physiological changes associated with pregnancy, coupled with the hemodynamic alterations induced by the ASD and potential comorbidities such as pulmonary hypertension, create a complex anesthetic landscape that demands careful navigation. The choice between general and regional anesthesia for ASD closure in pregnancy is often a subject of intense debate and deliberation. Each approach presents its own set of advantages and disadvantages, and the optimal choice hinges on a multitude of factors, including the patient's clinical status, the gestational age, the anticipated complexity of the procedure, and the expertise of the anesthesia team. General anesthesia, characterized by the induction of a state of unconsciousness and loss of sensation, offers several distinct advantages in the context of ASD closure during pregnancy. It provides a controlled airway, ensuring adequate oxygenation and ventilation, which is particularly crucial in patients with pulmonary hypertension or other respiratory comorbidities. General anesthesia also facilitates hemodynamic stability, allowing for precise control of blood pressure and cardiac output, essential for maintaining uteroplacental perfusion and fetal oxygenation. Moreover, it enables the use of transesophageal echocardiography, a valuable imaging modality for guiding device placement and assessing procedural success. However, general anesthesia is not without its risks. Maternal hypotension, a common complication of general anesthesia, can compromise uteroplacental blood flow and lead to fetal hypoxia. The potential teratogenic effects of anesthetic agents, particularly in the first trimester, are also a concern, although the available evidence suggests that the risk is minimal with judicious agent selection and careful dosing. Additionally, general anesthesia requires endotracheal intubation, which carries a small risk of airway trauma and aspiration. Regional anesthesia techniques, such as spinal or epidural anesthesia, involve the injection

of local anesthetics around the spinal cord or nerve roots, resulting in a loss of sensation in a specific region of the body. These techniques offer the advantage of avoiding the potential risks associated with general anesthesia, such as maternal hypotension and fetal exposure to anesthetic agents. However, the use of regional anesthesia for ASD closure during pregnancy is limited by several factors. Hemodynamic instability, a potential complication of regional anesthesia, can compromise uteroplacental perfusion and fetal oxygenation. Additionally, the potential for neurological complications, although rare, is a concern. Moreover, regional anesthesia may not provide adequate analgesia for the duration of the procedure, necessitating supplemental sedation or conversion to general anesthesia. In the presented case, general anesthesia was deemed the most appropriate approach due to the patient's pulmonary hypertension and the need for transesophageal echocardiographic guidance. The presence of pulmonary hypertension necessitated meticulous control of hemodynamics and ventilation, which is best achieved with general anesthesia. Transesophageal echocardiography, essential for guiding device placement and assessing procedural success, is also more readily facilitated under general anesthesia. The selection of anesthetic agents for ASD closure during pregnancy requires a delicate balance between efficacy and safety. The ideal agents should provide adequate hypnosis, analgesia, and muscle relaxation while minimizing potential adverse effects on the mother and fetus. A benzodiazepine with anxiolytic, sedative, and amnestic properties, midazolam is commonly used for premedication and induction of anesthesia. It has a rapid onset and short duration of action, making it suitable for procedures of relatively short duration. Midazolam crosses the placenta but has minimal effects on the fetus when used in standard doses. A potent synthetic opioid analgesic, sufentanil provides excellent pain relief with minimal hemodynamic effects. It has a rapid onset and short duration of action, making it ideal for intraoperative analgesia. Sufentanil crosses the placenta but has minimal effects on the fetus when used in appropriate doses. A dissociative anesthetic agent with analgesic, amnestic, and bronchodilatory properties, ketamine is often used for induction and maintenance of anesthesia in patients with compromised cardiovascular function or respiratory disease. Although not specifically categorized by the FDA for pregnancy, ketamine has been used safely in pregnant patients, with limited evidence of adverse fetal effects. A non-depolarizing neuromuscular blocking agent, atracurium provides muscle relaxation, facilitating endotracheal intubation and surgical access. It has a relatively short duration of action and is metabolized by Hofmann elimination and ester hydrolysis, making it suitable for use in patients with renal or hepatic impairment. Atracurium crosses the placenta minimally and has no known teratogenic effects. Meticulous hemodynamic monitoring is paramount during ASD closure in pregnant patients. The physiological changes associated with pregnancy, coupled with the hemodynamic alterations induced by the ASD and potential comorbidities such as pulmonary hypertension, can lead to significant fluctuations in blood pressure and cardiac output. Invasive arterial blood pressure monitoring allows for continuous, real-time assessment of the patient's hemodynamic status. This enables the anesthesia team to promptly detect and respond to any changes in blood pressure, heart rate, or oxygen saturation, ensuring optimal uteroplacental perfusion and fetal oxygenation. The goal of hemodynamic management is to maintain adequate maternal blood pressure and cardiac output while avoiding excessive increases in right ventricular afterload. This can be achieved through a combination of fluid management, vasopressor support, and inotropic agents, tailored to the individual patient's needs and the specific challenges posed by the ASD and pregnancy.[15,16]

Percutaneous ASD device closure, while minimally invasive compared to open-heart surgery, remains a technically intricate procedure demanding a high level of expertise in interventional cardiology and echocardiography. The presence of a bidirectional shunt and pulmonary hypertension, as observed in the presented case, introduces additional layers of complexity that necessitate meticulous planning, precise execution, and vigilant monitoring. The success of ASD device closure hinges, in part, on careful patient

selection. Not all patients with ASDs are suitable candidates for percutaneous closure. Factors such as the size and location of the defect, the presence of associated cardiac anomalies, and the patient's overall health status must be carefully evaluated to determine eligibility. In the context of pregnancy, additional considerations come into play. The potential impact of the procedure on fetal development, the altered maternal physiology, and the risks associated with anesthesia must all be factored into the decision-making process. A multidisciplinary team approach, involving cardiologists, obstetricians, and anesthesiologists, is crucial for ensuring that the decision to proceed with device closure is made in the best interests of both mother and child. Meticulous pre-procedural planning is essential for optimizing outcomes in ASD device closure. This involves a comprehensive assessment of the patient's cardiac anatomy and physiology, including detailed echocardiographic evaluation and, in some cases, cardiac catheterization. The size and location of the ASD, the presence and severity of any associated shunts, and the functional capacity of the right ventricle must all be carefully evaluated. In pregnant patients, additional considerations include the gestational age, the presence of fetal anomalies, and the maternal hemodynamic status. The potential impact of the procedure on fetal development and the risks associated with anesthesia must be thoroughly discussed with the patient and her family. Advanced imaging modalities play a pivotal role in guiding ASD device closure. Transesophageal echocardiography (TEE), in particular, offers real-time visualization of the interatrial septum and the ASD, allowing for precise assessment of shunt severity and guidance of device deployment. TEE also enables the identification of any associated cardiac anomalies, such as patent foramen ovale or atrial septal aneurysm, which may influence the choice of device or procedural approach. Fluoroscopy, another essential imaging modality, provides real-time visualization of the catheter and device during the procedure. It allows for accurate positioning of the device within the ASD and confirmation of successful deployment. Fluoroscopy also aids in the detection of potential complications, such as device embolization or cardiac perforation. The choice of device is a critical determinant of successful ASD closure. Several devices are available, each with its own unique characteristics and suitability for different types of ASDs. The Amplatzer Septal Occluder, used in the presented case, is a widely used device with a proven track record of safety and efficacy in both adult and pediatric populations. The Amplatzer device's self-centering design and wide range of sizes make it suitable for a variety of ASDs, including those with complex anatomy or associated complications. Its two discs, connected by a short waist, are designed to conform to the shape of the ASD and provide secure closure. The device is typically deployed through a transcatheter approach, minimizing the invasiveness of the procedure. The ASD device closure procedure involves a series of carefully orchestrated steps, each requiring precision and expertise. The procedure typically begins with obtaining vascular access, usually through the femoral vein. A sheath is inserted into the vein, through which catheters and other instruments can be advanced to the heart. A diagnostic catheter is advanced to the right atrium, and hemodynamic measurements are obtained to assess the severity of the shunt and the presence of any associated pulmonary hypertension. TEE is performed to visualize the ASD, assess shunt severity, and guide device deployment. The size and location of the ASD are carefully measured to determine the appropriate device size. The selected device is loaded onto a delivery catheter and advanced through the sheath to the right atrium. Under fluoroscopic and TEE guidance, the device is positioned across the ASD and deployed. Once deployed, the device is carefully assessed for proper positioning and stability. TEE and fluoroscopy are used to confirm complete closure of the ASD and the absence of any residual shunts or complications. The catheters and sheath are removed, and hemostasis is achieved at the puncture site. The patient is then transferred to a recovery area for observation. The anesthesiologist plays a crucial role in ensuring the safety and well-being of the patient during ASD device closure. They are responsible for administering anesthesia, monitoring vital signs, and managing any complications that may arise. In the context of

pregnancy, the anesthesiologist must also consider the potential impact of anesthesia and the procedure on the fetus.[17,18]

The immediate postoperative period following ASD device closure during pregnancy is a critical phase that demands meticulous attention to detail and a proactive approach to management. The primary objectives of postoperative care are to maintain hemodynamic stability, prevent thromboembolic events, and closely monitor fetal well-being. The successful recovery of the patient in the presented case underscores the importance of comprehensive postoperative management and vigilant follow-up in ensuring optimal maternal and fetal outcomes. Maintaining hemodynamic stability is paramount in the postoperative period following ASD device closure. The sudden closure of the ASD can lead to changes in intracardiac pressures and flows, potentially resulting in hemodynamic fluctuations. Additionally, the residual effects of anesthesia and the potential for bleeding or other complications can further impact the patient's hemodynamic status. Close monitoring in the intensive care unit (ICU) allows for continuous assessment of vital signs, including blood pressure, heart rate, and oxygen saturation. Invasive arterial blood pressure monitoring may be continued in the immediate postoperative period to provide real-time data and facilitate prompt intervention in case of hypotension or other hemodynamic disturbances. Fluid management is a critical aspect of postoperative care. Careful titration of intravenous fluids is necessary to maintain adequate intravascular volume and support cardiac output while avoiding fluid overload, which can exacerbate right heart strain in patients with residual pulmonary hypertension. Inotropic and vasopressor support may be required in some cases to maintain adequate blood pressure and cardiac output. These agents should be used judiciously, with careful titration to avoid adverse effects on the mother or fetus. The presence of a foreign body, such as an ASD closure device, in the heart increases the risk of thromboembolic events. Thrombus formation on the device can lead to device embolization, stroke, or other thromboembolic complications. Anticoagulation therapy is therefore essential in the postoperative period to prevent device thrombosis and maintain the patency of the systemic and pulmonary circulation. The choice of anticoagulant and the duration of therapy depend on various factors, including the type of device used, the patient's risk factors for thromboembolism, and the gestational age. Unfractionated heparin or low-molecular-weight heparin are commonly used in the immediate postoperative period, followed by a transition to warfarin or direct oral anticoagulants (DOACs) once the patient is stable and discharged home. The use of anticoagulants during pregnancy requires careful consideration of the potential risks and benefits. While essential for preventing thromboembolic events, anticoagulants also carry the risk of bleeding complications, both for the mother and the fetus. Close monitoring of coagulation parameters and regular follow-up with a hematologist are crucial for ensuring the safe and effective use of anticoagulants during pregnancy. Monitoring fetal well-being is a critical component of postoperative care following ASD device closure during pregnancy. The potential impact of the procedure and anesthesia on the fetus must be carefully assessed. Serial ultrasounds are performed to evaluate fetal growth and development, assess amniotic fluid volume, and monitor fetal heart rate and movements. In the first trimester, particular attention is paid to the assessment of fetal anatomy and the detection of any potential structural anomalies. The use of radiation during the procedure, although minimal, raises concerns about potential teratogenicity. Close collaboration between the cardiologist, obstetrician, and anesthesiologist is essential for ensuring comprehensive fetal surveillance and timely intervention in case of any concerns. Serial echocardiograms are performed in the postoperative period to assess the function of the ASD closure device and monitor the patient's cardiac status. Transthoracic echocardiography (TTE) is typically performed initially, followed by transesophageal echocardiography (TEE) if there are any concerns about device stability or residual shunting. TTE and TEE provide valuable information about the position and integrity of the device, the presence or absence of residual shunts, and the function of the right and left ventricles. These imaging modalities also allow for the assessment of any

potential complications, such as device embolization, cardiac perforation, or new-onset arrhythmias. Once the patient is hemodynamically stable, has adequate pain control, and demonstrates satisfactory fetal well-being, she can be discharged home with appropriate instructions and follow-up plans. Close collaboration between the cardiologist and obstetrician is essential for ensuring continuity of care and monitoring the patient's cardiac status and fetal development throughout the remainder of the pregnancy. The patient is typically advised to avoid strenuous activity and to report any symptoms such as chest pain, palpitations, or shortness of breath. Regular follow-up visits are scheduled to monitor blood pressure, heart rate, and oxygen saturation, as well as to assess fetal growth and development. Anticoagulation therapy is continued as per the recommendations of the cardiologist and hematologist. Regular blood tests are performed to monitor coagulation parameters and adjust medication dosages as needed. Patient education and empowerment are integral components of postoperative care and long-term follow-up. The patient should be provided with comprehensive information about her condition, the ASD closure procedure, and the potential risks and complications. She should also be educated about the importance of medication adherence, lifestyle modifications, and regular follow-up visits. Empowering the patient to actively participate in her care can improve adherence to treatment plans and enhance overall outcomes. Open communication and shared decision-making between the patient and her healthcare team are crucial for ensuring that the patient feels informed, supported, and confident in managing her health during pregnancy and beyond.[19,20]

4. Conclusion

This case report underscores the feasibility and safety of percutaneous ASD device closure during the first trimester of pregnancy, even in the presence of complex anatomical and physiological challenges. Early intervention can effectively mitigate the risks associated with an unrepaired ASD, safeguarding both maternal and fetal well-being.

5. References

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