

CASE REPORT

Anesthetic Management for Atrial Septal Defect (ASD) Closure in a Patient with Bidirectional Shunt and Pulmonary Hypertension

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ABSTRACT

Background: ASD bidirectional shunt occurs when flow moves between left and right depending on the higher pressure, either systemic vascular resistance (SVR) or pulmonary vascular resistance (PVR). The anesthetic management aimed to control factors that could increase PVR while retaining SVR within normal or slightly elevated ranges in order to maintain left to right shunting.

Case Illustration: We reported a 39-year-old female patient with history of dyspnea and chest discomfort. She was diagnosed with ASD bidirectional shunt, pulmonary hypertension (PH), and scheduled for defect closure. She had history of routine medication in previous hospital since 2017 due to cardiac abnormalities. Over 4 years of treatment, symptoms improved, but limitations remained during strenuous activities. Due to the mean pulmonary pressure exceeded 50% of mean systemic pressure, an intentional ASD creation was performed. It is not a routine procedure; however, it serves as a “way out” if there was severe left ventricular dysfunction. The main principle of anesthetic management is to minimize shunting from right to left so that desaturation does not occur. Preload, heart rate and contractility should be maintained. Attention and intervention were promptly administered for any identified post-surgical issues, including PH crisis or right ventricular dysfunction. PH management was conducted during perioperative period and the patient was successfully extubated at 17 hours post-surgery.

Conclusion: Perioperative management of bidirectional shunt ASD with PH requires to maintain the left-to-right shunt and control factors that could increase PVR while retaining SVR within normal or slightly increased.

Keywords: Anesthetic management; Atrial septal defect; Pulmonary hypertension.



INTRODUCTION

Atrial septal defect (ASD) results from incomplete closure of the septum between the right and left atria. It has an incidence rate of 56 per 100,000 live births, contributing around 10% of adult congenital heart diseases¹. Bidirectional shunt occurs when flow moves between left and right based on higher pressure, either systemic vascular resistance (SVR) or pulmonary vascular resistance (PVR)².

Preoperatively, assessing defect size, valve condition, and ventricular function is vital for anesthetic preparation³. Intraoperatively, maintaining left-to-right shunt flow is crucial to prevent systemic desaturation⁴. Postoperatively, early mitigation is necessary in cases of PH crisis or Right Ventricle (RV) dysfunction⁵.

CASE ILLUSTRATION

A 39-year-old female patient with a history of dyspnea and chest discomfort was admitted to the hospital. Over 4 years of treatment, symptoms were improved, as they are only getting worsened during strenuous activities. She received sildenafil 20 mg/8 hour and beraprost 20 mcg/24 hour, orally. The preoperative clinical condition was quite good with oxygen supplementation and laboratory results are within normal limits. Echocardiography and choroangiography results supported the presence of secundum ASD, bidirectional shunt, high low-flow resistance, and pulmonary arterial hypertension (nonreactive oxygen test). Chest X-Ray revealed the oligemic lungs, suggesting the condition of severe pulmonary hypertension (**Figure 1**).



Figure 1. Chest X-Ray

She was scheduled for ASD closure and mitral valve repair with invasive monitoring.

Initial hemodynamic parameters showed systolic and diastolic pressure of 110-140 mmHg and 55-80 mmHg respectively, heart rate (HR) 70-80 beats per minute (bpm), oxygen saturation (SpO₂) 92-100%, respiratory rate (RR) 24 times/minute, central venous pressure (CVP) 15-18 mmHg. Electrocardiography (ECG) showed normal sinus rhythm with HR 70 bpm. We used invasive monitoring tools (artery line, central venous catheter, and side port) intraoperatively.

Premedication began with the administration of 2 mg of midazolam and 50 mcg of fentanyl, intravenously. Further, 150 mcg of fentanyl was injected as a blunting agent for intubation. For induction, sevoflurane at 2 vol% was utilized, and 50 mg of rocuronium was administered as a muscle relaxant. Initial hemodynamic parameters showed a stable condition with oxygen saturation (SpO₂) between 92-100% (preoperative room-air SpO₂ showed 85%). During the maintenance phase of anesthesia, sevoflurane 0.8-1.5 vol%, fentanyl 4 mcg/kg/hour, milrinone 0.375 – 0.5 mcg/kg/minute,

and intermittent injection of rocuronium 10 mg/30 minutes were administered. The patient was mechanically ventilated in volume control mode with a tidal volume, FiO₂, RR, positive end-expiratory pressure (PEEP), Inspiratory:Expiratory (I:E) ratio, and end-tidal CO₂ (etCO₂) of 400 mL, 50-70%, 14 times/minute, 5 mmHg, 1:2, and 30-35 mmHg, respectively. Preoperative transesophageal echocardiography (TEE) examination confirmed a secundum ASD, bidirectional shunt (predominantly left to right), measuring 3.77 – 4.24 cm in diameter. Moderate mitral regurgitation (MR) with vena contracta of 0.35-0.4 cm. The mitral valve (MV) annulus reached 3.6 cm, and there was moderate tricuspid regurgitation (TR) with TR V_{max} at 228 cm/s and TR Max PG at 21 mmHg. Other observations included tricuspid valve (TV) annulus, left ventricular outflow tract (LVOT) diameter, LVOT velocity time integral (VTI), LVOT stroke volume (SV), Ao:PA ratio, ejection fraction (EF), and tricuspid annular plane systolic excursion (TAPSE) of 3.7 cm, 1.75 cm, 24 cm, 57.8 ml, 1, 65%, and 19 mm, respectively. Direct puncture to the main pulmonary artery revealed mPAP of 55

mmHg, which is 61% of the MAP of 89 mmHg.

The procedures performed included defect closure with a patch, MV repair, TV repair (DeVega procedure), and an intentional ASD creation. Continuous milrinone infusion was initiated at the commencement of surgery with a dose of 0.375-0.5 mcg/kg/minute. The rewarming and separation process from cardiopulmonary bypass (CPB) machine proceeded smoothly with continuous dobutamine support at 2.5 mcg/kg/minute. The durations of CPB, cross-clamp, and ischemia were 90, 75, and 68 minutes, respectively.

Postoperatively, TEE examination confirmed the ASD creation (**Figure 2**) with diameter of 0.686 cm, left-to-right shunt. Mild MR was still present with a vena contracta measuring 0.248 cm, but there was no TR after the TV repair. Good contractility was observed with EF 78%, Tricuspid Annular Plane Systolic Excursion (TAPSE) 12 mm, and Qp:Qs ratio 2.06. Additionally, hemodynamics showed blood pressure 110/65 mmHg, HR 85 bpm, SpO₂ 100%, ECG in sinus rhythm, and Central Venous Pressure (CVP) 13 mmHg. Drug support included dobutamine 2.5 mcg/kg/minute and milrinone 0.375 mcg/kg/minute.

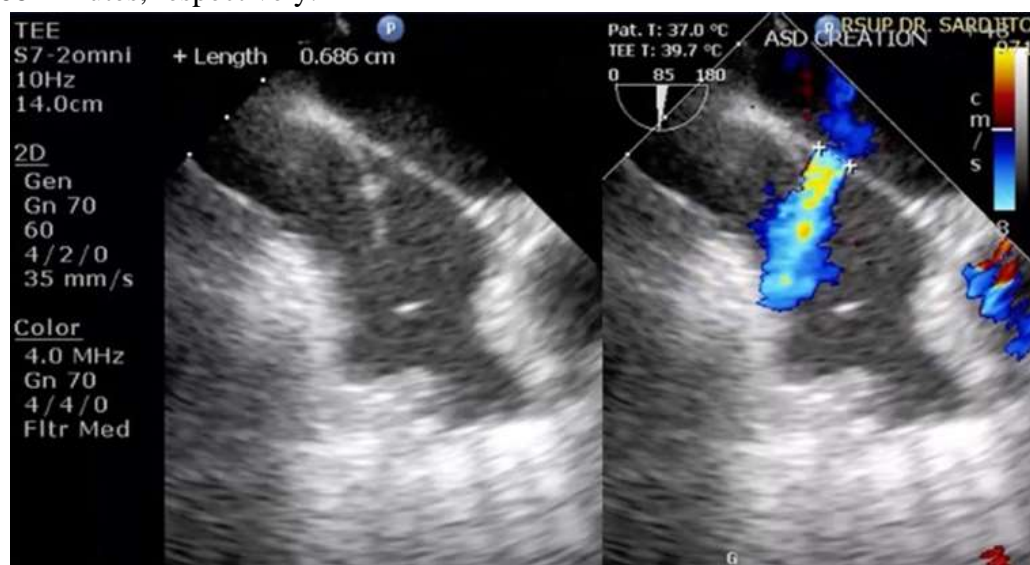


Figure 2. TEE Post ASD Creation

Before transferring the patient to ICU, a Swan-Ganz Catheter was inserted into the sideport. Upon arrival at the ICU, hemodynamics parameters

indicated systolic blood pressure ranging from 130-153 mmHg, diastolic blood pressure between 46-62 mmHg, Heart Rate (HR) of 70-76 bpm, CVP at

11-12 mmHg, and oxygen saturation at 100%. Mechanical ventilation was applied in PSIMV mode, with RR of 16 x/m, PEEP at 5 mmHg, PC of 12, FiO₂ of 50%, I:E ratio of 1:2, and tidal volume output of 320-330 mL. The minute volume ranged from 4.4-4.6 L, with RR of 16 x/min, and SpO₂ at 100%. Therapeutic interventions in the ICU included the intravenous administration of gelofusin, cefazoline, fentanyl, midazolam, dobutamine,

milrinone, omeprazole, and paracetamol at 50 mL/hour, 1g/12 hours, 0.5 mcg/kg/hour, 0.1 mg/kg/hour, 2.5 mcg/kg/minute, 0.375 mcg/kg/minute, 40 mg/24 hours, and 1g/8 hours, respectively.

During ICU treatment, a stable condition was maintained with hemodynamic parameters showing a MAP of 70-90 mmHg and an mPAP of 37-43 mmHg (**Figure 3**).

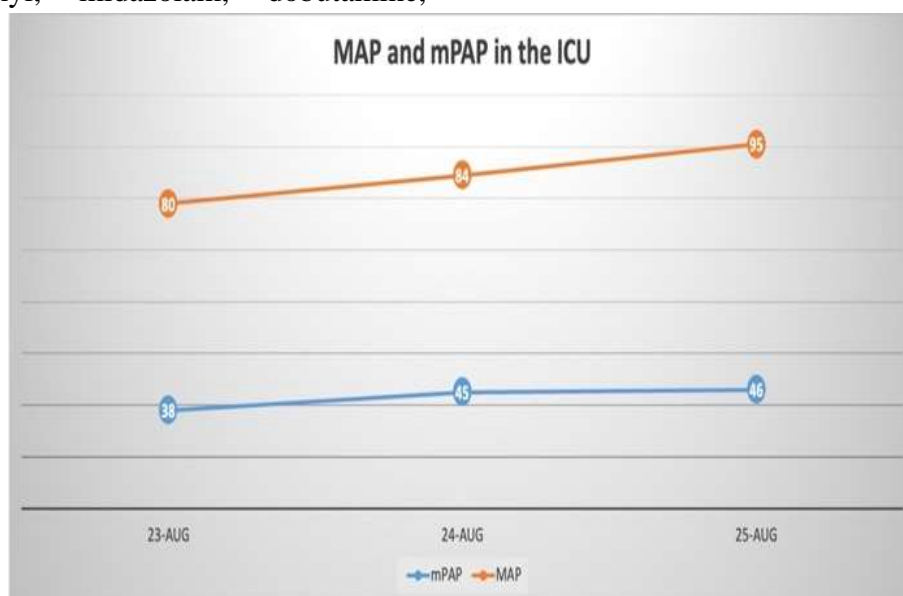


Figure 3. MAP and mPAP in ICU

Weaning process began approximately 13 hours after surgery and progressed to spontaneous mode with FiO₂ of 40%, PS of 8 cmH₂O, and PEEP of 5 cmH₂O. Extubation was successfully done 4 hours later, continuing milrinone administration and introducing oral sildenafil at a dose

of 20 mg every 8 hours.

At 10 hours post-extubation, an NRM was used at 8 L/min with RR of 20-22 breaths/min and SpO₂ between 98-100%. During this period, PA pressure ranged from 48-50 mmHg and patient experienced chest discomfort so the milrinone dosage was increased to

0.5 mcg/kg/min, sildenafil dosage was adjusted, and iloprost nebulizer was administered every 8 hours. At 24 hours, milrinone dosage was reduced to 0.375 mcg/kg/min for 60 minutes, followed by a cessation time of 60 minutes. Iloprost and sildenafil were continued, and the patient was transferred to an intermediate care unit at 27 hours post-extubation.

DISCUSSION

Induction of general anesthesia in patients with ASD and PH presents a potential risk of hemodynamic disturbances. PH management must be tailored to individual clinical status as shown by the algorithm from ESC/ERS guideline (**Figure 4**)⁶. General measures are needed to optimize the care of patients with PH throughout the course of the disease. Recommended actions include standardized exercise training, psychosocial support, immunization against diseases, diuretic treatment in patients with signs of RV failure and fluid retention, correction of iron status for patients with iron-deficiency anemia, and long-term oxygen therapy for patients with low blood oxygen pressure. Actions

that may be considered include iron repletion in non-anemic iron deficiency patient and anticoagulation administration on an individual basis. It is not recommended to give ACEis, ARBs, ARNIs, SGLT-2is, beta-blockers, or ivabradine unless required by comorbidities.

Patients who are also accompanied by cardiopulmonary comorbidities respond less well to PH medication and also have higher mortality risk than patients without such conditions do. Treatment recommendations for patients with cardiopulmonary comorbidities and PAH are difficult to implement due to a lack of strong evidence, and patients should be counseled accordingly. When it comes to helping guide therapeutic decision-making, risk stratification is not very helpful because there is a lack of information regarding treatment strategies for these patients. For most of these individuals, initial monotherapy is advised, with PDE5i being the most often prescribed medication based on registry data. Individualized decisions on additional treatment should be made in conjunction with the PH center and nearby physicians.

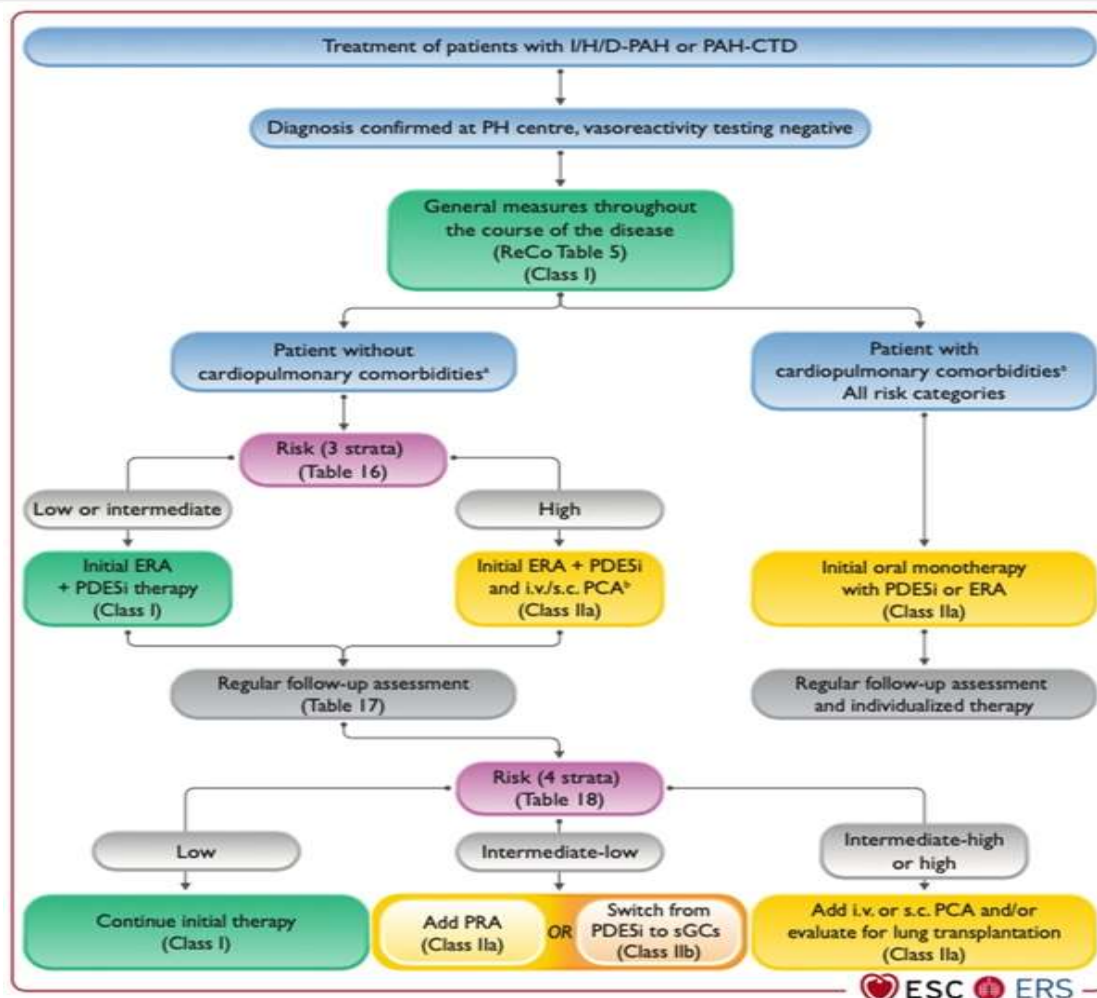


Figure 4. Algorithm for PH management from ESC/ERS Guidelines⁶.

The combination of benzodiazepines, opioids, and muscle relaxants in this case proved to be effective in maintaining hemodynamic stability. While benzodiazepines, opioids, and general anesthetic agents (volatile anesthetics, propofol, barbiturates, and etomidate) can moderately decrease SVR, careful management is essential to minimize this response and maintain an optimal SVR. In the reported case, rocuronium was used because this drug has lower

histamine-releasing potential and lesser impact on increasing PVR compared to other muscle relaxants, such as atracurium and mivacurium⁷. Additionally, ketamine was intentionally avoided due to its ability to trigger sympathetic stimulation. The combination of ketamine and propofol could be an alternative, but the joint administration required close hemodynamic monitoring to prevent the initiation of variable responses. To assess pulmonary artery pressure, Swan-

Ganz Catheter insertion was performed. The associated risks and benefits of this procedure need to be carefully considered as it is capable of causing transient ventricular arrhythmias, bleeding, and even pulmonary artery rupture⁸.

Intraoperatively, the anesthetic approach for patients with chronic bidirectional shunts aims to ensure hemodynamic stability without exacerbating right-to-left shunting. This requires paying diligent attention to preload, SVR, PVR, HR, and contractility. Optimizing preload is important to maintain right ventricular function, as a decrease in preload can lead to reduced left ventricular filling and a subsequent decline in systemic flow. However, overly aggressive volume administration tends to impart negative effects. The target for SVR is to retain this parameter within the normal range, which can be achieved by managing the depth of anesthesia and providing adequate analgesia. A sharp decline in SVR is liable to compromise right ventricle (RV) coronary perfusion, potentially leading to ischemia and hemodynamic collapse. Consequently, continuous monitoring and treatment with systemic vasoconstrictors are

crucial⁹.

Postoperative complications in patients with ASD and PH, particularly subjected to defect closure, often include RV failure, which is the most common cause of death within the first 72 hours after surgery¹⁰. Another one is the PH crisis, a condition characterized by increased PA pressure with a ratio of PAP to MAP $> 75\%$, elevated central venous pressure exceeding 20%, above 20% decrease in MAP, oxygen saturation below 90%, and signs of low cardiac output syndrome¹¹.

A recommended postoperative mechanical ventilation strategy, referred to as the “right ventricular protective strategy” for managing PH crisis, comprises delivering 6-8 mL/kg tidal volume, with peak plateau pressure, driving pressure, and PEEP maintained below 27 cmH₂O, 18 cmH₂O, and 7 cmH₂O, respectively. This approach emphasizes avoiding intrinsic PEEP and ensuring controlled hypercapnia ($\text{PaCO}_2 < 48 \text{ mmHg}$)⁷.

The administration of sildenafil before and after surgery has been found to effectively control pulmonary hypertension in those subjected to congenital heart surgery. Additionally, dobutamine, acting through β_1 receptors,

can increase contractility and reduce PVR and SVR. Adequate postoperative pain management is crucial, as pain tends to trigger sympathetic activation, elevate oxygen demand, and increase PVR, potentially exacerbating PH and leading to right heart failure. While opioids are frequently used for postoperative pain control, caution should be exercised to avoid administering large doses, which can instigate an acute decrease in sympathetic tone, resulting in hypotension and compromised RV contractility. To prevent PH exacerbation, non-opioid pain management approaches, such as regional blocks or epidural anesthesia, local anesthetic injections, acetaminophen, or ketorolac, may be applied⁹.

CONSLUSION

The preoperative assessment of ASD should include characteristics of symptoms, valve and ventricular function using trans-esophageal echocardiography. Careful intraoperative preservation of normal shunt flow is critical to prevent systemic desaturation. Post operative care management involves maintaining appropriate PVR and SVR based on

subjective symptoms and objective pressure data. This case underscores the importance of tailored perioperative strategies and vigilant monitoring in ensuring optimal outcomes for patients undergoing anesthesia in the context of ASD with shunt and pulmonary hypertension.

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