CASE REPORT

Graded Epidural Anesthesia with Real-Time Hemodynamic Monitoring for Cesarean Delivery in Severe Mitral Stenosis: A Case Report

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Abstract

This case report highlights the successful management of a high-risk obstetric patient with severe rheumatic mitral stenosis (MS) and acute decompensated heart failure (ADHF) using graded epidural anesthesia guided by real-time hemodynamic monitoring. A 34-year-old woman, in her second pregnancy following a previous abortion, presented at 34 weeks and 5 days of gestation with progressive dyspnea and orthopnea. Echocardiography confirmed severe MS accompanied by pulmonary hypertension and preserved left ventricular systolic function. After multidisciplinary optimization, an elective cesarean delivery was performed under graded epidural anesthesia with incremental dosing of lidocaine and ropivacaine. Beat-to-beat cardiac output monitoring using the MostCare™ PRAM (Pressure Recording Analytical Method) system guided vasopressor titration with phenylephrine, maintaining hemodynamic stability. The patient remained hemodynamically stable throughout the intraoperative and postoperative periods, with no pulmonary edema or arrhythmias, and was discharged on postoperative day four. This case demonstrates that graded epidural anesthesia, when combined with advanced hemodynamic monitoring and collaborative care, represents a safe and effective alternative to general anesthesia in parturients with severe valvular heart disease.

Keywords: Cesarean section, Graded epidural anesthesia, Hemodynamic monitoring, Mitral stenosis, Rheumatic heart disease

Anestesi Epidural Bertahap dengan Pemantauan Hemodinamik *Real-Time* pada Seksio Sesarea dengan Stenosis Mitral Berat: Laporan Kasus

Abstrak

Laporan kasus ini menggambarkan keberhasilan penatalaksanaan pasien obstetri berisiko tinggi dengan stenosis mitral (MS) berat akibat penyakit jantung rematik dan gagal jantung dekompensasi akut (ADHF) menggunakan anestesi epidural bertahap yang dipandu oleh pemantauan hemodinamik *real-time*. Seorang wanita berusia 34 tahun pada kehamilan kedua dengan riwayat abortus datang pada usia kehamilan 34 minggu 5 hari dengan keluhan sesak progresif dan ortopnea. Ekokardiografi menunjukkan MS berat disertai hipertensi pulmonal dengan fungsi sistolik ventrikel kiri yang masih terjaga. Setelah dilakukan optimalisasi multidisiplin, pasien menjalani operasi seksio sesarea elektif dengan anestesi epidural bertahap melalui titrasi dosis lidokain dan ropivakain. Pemantauan curah jantung *beat-to-beat* dengan sistem *MostCare™ PRAM* (*Pressure Recording Analytical Method*) memandu pemberian vasopresor fenilefrin untuk menjaga stabilitas hemodinamik. Pasien tetap stabil selama operasi dan periode pascaoperasi tanpa edema paru atau aritmia, dan dipulangkan pada hari keempat pascaoperasi. Kasus ini menunjukkan bahwa anestesi epidural bertahap, bila dikombinasikan dengan pemantauan hemodinamik canggih dan kerja sama multidisiplin, dapat menjadi alternatif yang aman dan efektif terhadap anestesi umum pada pasien obstetri dengan penyakit katup jantung berat.

Kata kunci: Penyakit jantung rematik, Stenosis mitral, Anestesi epidural bertahap, Pemantauan hemodinamik, Seksio sesarea

Introduction

Rheumatic heart disease (RHD) remains a major contributor to maternal morbidity and mortality in low- and middle-income countries, where limited access to cardiac intervention leads to high-risk pregnancies with complex valvular lesions.[1] Severe MS poses a particularly critical challenge. The normal physiological changes of pregnancy—especially a 40–50% increase in cardiac output

and plasma volume—can unmask or exacerbate underlying MS, predisposing patients to ADHF, pulmonary hypertension, and arrhythmias.[2,3] Up to half of pregnant women with severe MS experience symptomatic heart failure by the third trimester, with mortality rates reported as high as 10–50% in those with New York Heart Association (NYHA) class III–IV or mWHO class IV disease.[1,2]

Anesthetic management in these patients requires a careful balance between maintaining maternal hemodynamic stability and ensuring uteroplacental perfusion. While general anesthesia allows controlled airway management, it carries significant risks in fixed cardiac output states—particularly due to tachycardia, increased pulmonary vascular resistance, and myocardial depression.[4] Conversely, neuraxial anesthesia, especially graded epidural, offers theoretical advantages by minimizing sympathetic surges and avoiding volatile anesthetics; however, it remains controversial in severe MS due to potential precipitous decreases in preload and afterload.[5,6]

Recent case series and case reports have demonstrated that carefully titrated graded epidural anesthesia, combined with real-time hemodynamic monitoring and judicious vasopressor use, can be safely implemented in high-risk obstetric patients with severe valvular disease.[7–10] Hemodynamic monitoring technologies such as MostCare™ PRAM enable continuous assessment of cardiac output and systemic vascular resistance, guiding precise pharmacologic and fluid management.[11] Integration of these technologies, within a multidisciplinary approach involving anesthesiology, cardiology, and obstetrics, aligns with recent international guidelines emphasizing individualized, physiology-based care.[1,3,4]

This case report presents a 34-year-old pregnant woman with severe rheumatic MS and ADHF who successfully underwent cesarean delivery under graded epidural anesthesia guided by beat-to-beat cardiac output monitoring. The case highlights the feasibility and safety of this approach in a mWHO class IV patient and contributes to the growing body of evidence supporting neuroaxial anesthesia with hemodynamic guidance as a viable alternative to general anesthesia in critically ill parturients with valvular heart disease.

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Case Presentation

A 34-year-old woman in her second pregnancy after a previous abortion, at 34 weeks and 5 days of gestation was referred for elective cesarean delivery due to severe rheumatic MS and ADHF. She presented with progressively worsening exertional dyspnea and orthopnea, requiring three pillows at night. There was no chest pain, palpitations, or fever. Her medical history included RHD with severe MS (Wilkins score 7, valve area < 1 cm²), pulmonary hypertension, paroxysmal atrial fibrillation, and mild tricuspid regurgitation. She was categorized as mWHO class IV, NYHA class III, and ASA physical status III. Her comorbidities included mild anemia (Hb 8.7 g/dL) and well-controlled bronchial asthma.

On admission, she appeared tachypneic with a respiratory rate of 24/min, heart rate 92 bpm, and blood pressure 109/66 mmHg. Oxygen saturation was 98% on 3 L/min via nasal cannula. Echocardiography demonstrated

marked left atrial enlargement, a left ventricular ejection fraction of 54.4% consistent with low-normal systolic function, and diastolic dysfunction attributable to severe rheumatic mitral stenosis with a valve area of less than 1.0 cm². Estimated pulmonary artery pressures were in the moderate range, reflecting clinically significant pulmonary hypertension. These findings were consistent with fixed cardiac output physiology and highlighted the need for meticulous perioperative hemodynamic control. Chest X-ray showed mild pulmonary congestion. Arterial blood gas analysis revealed mild respiratory alkalosis, while spirometry indicated a moderate restrictive pattern ($FEV_1 \approx$ 70% predicted).
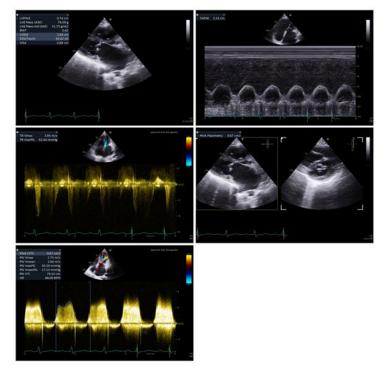

Figure 1. Echocardiography showed LA and LV dilation, reduced EF (54.38%), uncoordinated septal wall motion, severe mitral stenosis (MS), mild tricuspid regurgitation, high probability of pulmonary hypertension, and undetermined diastolic function due to severe MS.

A multidisciplinary team consisting of cardiology, obstetrics, pulmonology, and anesthesiology, planned an elective cesarean section after preoperative optimization. The patient received bisoprolol 2.5 mg daily, furosemide 40 mg IV on the morning of surgery, benzathine penicillin G for rheumatic prophylaxis, and antenatal corticosteroids for fetal lung maturity.

A graded epidural anesthesia technique was selected because it provides a controlled and physiologically gentle approach to sympathetic blockade, which is essential in patients with severe MS and fixed cardiac output physiology. Unlike single-shot spinal anesthesia, which produces a rapid and dense block that can suddenly reduce systemic vascular resistance and venous return, a graded epidural permits slow titration of segmental anesthesia. This allows the anesthesiologist to monitor the hemodynamic response after each dosing increment and adjust therapy accordingly. The stepwise onset of epidural anesthesia is aligned with current European Society of Cardiology (ESC), American College of Cardiology (ACC/AHA), and SOAP guidance, which recommend avoiding abrupt reductions in preload and afterload in high-risk valvular lesions. By selecting a graded technique, the team minimized the risks of acute hypotension, tachyarrhythmias, and pulmonary edema while still achieving adequate anesthesia for cesarean

delivery. Under aseptic conditions, an epidural catheter was placed at the L1–L2 interspace, with the tip directed to T9–T10. MostCare™ PRAM monitoring was used to obtain beat-to-beat measurements of cardiac output, stroke volume, and systemic vascular resistance, enabling titrated management.

In this patient with severe MS and ADHF, clearly defined hemodynamic targets were established prior to initiating neuraxial anesthesia. The primary objectives included maintaining a heart rate between 60 and 70 beats per minute to prolong diastolic filling time and reduce the transmitral gradient, preserving a mean arterial pressure of approximately 70–80 mmHg to ensure adequate coronary perfusion, and avoiding abrupt decreases in preload that might precipitate pulmonary congestion. Particular attention was also given to preventing increases in pulmonary vascular resistance, as this could worsen right ventricular strain and aggravate pulmonary hypertension. These goals served as the physiologic framework for anesthetic decision-making throughout the procedure and guided both fluid administration and vasopressor therapy.
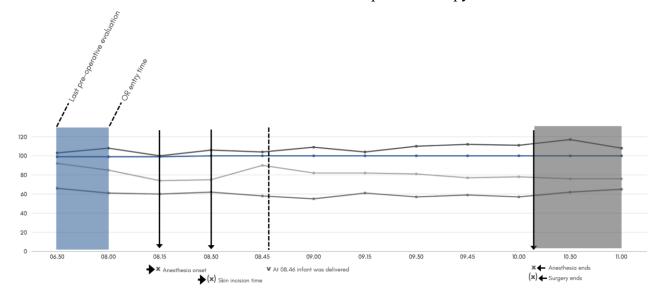

Figure 2. Intraoperative Hemodynamic Monitoring Timeline and Key Events

Incremental dosing was initiated with lidocaine 2% (6 mL) followed by ropivacaine 0.5% (8 mL), attaining a sensory block level of T6–L1. The selection of lidocaine and ropivacaine for the epidural regimen was based on their complementary pharmacologic profiles and safety considerations in patients with compromised cardiac function. Lidocaine 2% was used initially due to its rapid onset and predictable spread, allowing early assessment of block adequacy. Ropivacaine 0.5% was subsequently administered to provide more stable sensory anesthesia with minimal motor blockade and reduced cardiotoxicity compared with bupivacaine. Delivering these agents in small, carefully titrated aliquots allowed the anesthetic level to advance progressively while enabling real-time evaluation of cardiac output, systemic vascular resistance, and stroke volume trends on PRAM monitoring. This incremental dosing strategy helped maintain preload and afterload within the targeted physiologic range and reduced the likelihood of sudden hemodynamic deterioration. A phenylephrine infusion (25 µg/min, titrated) was administered to maintain systolic blood pressure $\geq$ 90 mmHg. Hemodynamics remained stable (BP 82–108/62–73 mmHg, HR 63–78 bpm, SpO$_2$ 99–100%). A male infant weighing 2270 g was delivered with Apgar scores of 7 and 9 at one and five minutes, respectively. Estimated blood

loss was 500 mL, and urine output was 1 L during the procedure.

Real-time hemodynamic monitoring with the MostCare™ PRAM system provided continuous measurements of cardiac output, stroke volume, systemic vascular resistance, and ventricular contractility indices. These data allowed early detection of subtle downward trends in cardiac output or stroke volume during the incremental epidural dosing. Any reduction exceeding approximately 10% from baseline prompted temporary cessation of further neuraxial dosing and adjustment of the phenylephrine infusion to restore vascular resistance and support forward flow. This dynamic, physiology-guided approach ensured that the anesthetic block progressed in a hemodynamically safe manner and allowed precise titration of vasopressor support based on objective beat-to-beat hemodynamic data rather than intermittent noninvasive measurements alone.

The postoperative analgesic regimen was designed to maintain hemodynamic stability by preventing pain-induced sympathetic surges and tachycardia, both of which can critically worsen transmitral gradients in severe MS. A low-dose epidural regimen using dilute bupivacaine combined with intermittent low-dose morphine provided effective analgesia while avoiding the respiratory depression and hypercapnia that may occur with systemic opioids and potentially exacerbate pulmonary hypertension. This technique ensured stable postoperative heart rate and afterload conditions, supporting safe recovery and minimizing the risk of pulmonary edema during the vulnerable early postpartum period, when abrupt fluid shifts commonly occur.

The patient was monitored in a high-dependency unit for 48 hours. Analgesia was provided via epidural Bupivacaine 0.0625% + Morphine 0.5 mg q12h, supplemented with Paracetamol 1 g IV q8h. Furosemide 20 mg IV was administered post-delivery to prevent volume overload. No pulmonary edema or arrhythmias occurred. She was discharged in stable condition on postoperative day 4 with a plan for percutaneous balloon mitral valvotomy.

Discussion

Pregnancy induces significant cardiovascular adaptations, including increased blood volume and cardiac output, which may precipitate heart failure in women with severe MS.[1,2,4] These patients have fixed cardiac output and limited ability to tolerate tachycardia or decreased afterload. The goal of anesthesia is therefore to maintain controlled heart rate, stable preload, and adequate SVR.

General anesthesia may provoke sympathetic surges, tachycardia, and myocardial depression, increasing maternal and fetal risk.[4,6] Conversely, graded epidural anesthesia, when performed cautiously, provides controlled sympathetic blockade and gradual hemodynamic change.[5–7] Previous studies have reported improved outcomes with the use of incremental epidural techniques in patients with MS during pregnancy.[7,8] The present case contributes to this evidence by incorporating real-time cardiac output monitoring via the MostCare™ PRAM system, allowing physiology-guided titration of vasopressors and fluids.[11]

Phenylephrine, a pure α-agonist, was selected for vasopressor support due to its ability to maintain SVR without increasing heart rate, consistent with SOAP and ESC recommendations.[1,3,4] Controlled fluid administration and postoperative diuresis minimized pulmonary congestion risk, while beta-blockade optimized diastolic filling.[1,3,4,9]

Our findings align with recent literature demonstrating that hemodynamic-guided graded epidural anesthesia can be safely employed in mWHO class IV patients with

valvular disease.[7–10] The main strengths of this case include integration of advanced monitoring and a multidisciplinary perioperative approach. Limitations include single-case nature and short follow-up period.

The present case underscores the importance of adhering to strict hemodynamic goals during anesthetic management of severe mitral stenosis in pregnancy. Maintaining controlled heart rate, stable preload, and adequate afterload is essential to prevent hemodynamic collapse in fixed cardiac output states. The combination of graded epidural anesthesia and PRAM-guided monitoring provided a controlled and adaptable environment in which sympathetic blockade developed gradually and cardiovascular responses were immediately visible. This approach allowed early correction of minor hemodynamic deviations, prevented abrupt decreases in systemic vascular resistance, and minimized the need for large vasopressor boluses. The real-time insight into cardiovascular performance further supported individualized anesthetic management and reduced the risk of peripartum decompensation, reinforcing the feasibility of neuraxial anesthesia even in mWHO class IV patients when applied with careful physiologic guidance.

Graded epidural anesthesia guided by real-time cardiac output monitoring and multidisciplinary planning, can be safely applied in pregnant patients with severe mitral stenosis and acute heart failure. Key management principles include incremental dosing, maintenance of SVR with phenylephrine, and strict fluid control. This physiology-based approach supports the evolving paradigm of precision, hemodynamic-guided anesthesia for high-risk obstetric cardiac disease.

Declaration of Patient Consent
The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published, and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

Conflicts of Interest
The authors report no conflict of interest.

Data Availability Statement
De-identified patient data from this case report will be made available upon reasonable request to the corresponding author following publication, subject to institutional data-sharing policies and ethics approval.

Author's Contributions
All authors contributed significantly to the conception and design of the study, data collection, analysis, and interpretation of the results. All authors participated in writing and critically revising the manuscript for important intellectual content, approved the final version to be published, and are accountable for all aspects of the research.

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