

CASE REPORT

Graded Epidural Anesthesia for Emergency Cesarean Section in Severe Tricuspid Regurgitation, Pulmonary Hypertension, and Neurofibromatosis Type 1: A Case Report

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ABSTRACT

Background. Severe tricuspid regurgitation with pulmonary hypertension makes right ventricular perfusion depend on systemic pressure, and a sudden fall in vascular resistance during anesthesia may cause collapse. Neurofibromatosis type 1 adds neuraxial and airway risks.

Objective. To describe the anesthetic management and hemodynamic course of an emergency Cesarean delivery under a graded epidural in a parturient with these three conditions.

Methods. A 37-year-old woman (G2P1A0, 34 weeks, NYHA class IV) had severe functional tricuspid regurgitation (regurgitant volume 112 mL), echocardiographically estimated pulmonary hypertension (systolic about 79 mmHg, mean about 50 mmHg) and neurofibromatosis type 1. A lumbar epidural catheter was placed (L1–L2), and 0.375% levobupivacaine with fentanyl 50 µg was given in 3 mL aliquots every 5 minutes (12 mL). Crystalloid was limited to 300 mL, with titrated phenylephrine and slow oxytocin. The CARE guideline was followed.

Results. A T6 block without motor block was reached in 20 minutes. Mean arterial pressure stayed at 70–78 mmHg (–2.8% to +8.3%), heart rate fell from 112 to 94 bpm (–16.1%) and oxygen saturation rose from 92% to 98%. A neonate of 2300 g was delivered (Apgar 6, 7 and 8 at 1, 5 and 10 minutes). There was no cardiovascular collapse or airway intervention. She was discharged on day 6.

Conclusion. A slowly titrated epidural was followed by stable hemodynamics and an uneventful recovery. One case cannot show that it protected the right ventricle, because right ventricular pressures and vascular resistances were not measured.

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1. Introduction

Cardiac disease complicates 1% to 4% of pregnancies and is a leading cause of maternal death.¹ Pulmonary hypertension carries a particular risk. In the European Registry of Pregnancy and Cardiac Disease, 151 women with pulmonary hypertension were followed; maternal death within one week of delivery occurred in 3.3%, and mortality was highest in idiopathic pulmonary arterial hypertension.² Outcomes in women with pulmonary hypertension and the risk of a pulmonary hypertension crisis at Cesarean delivery have also been studied.^{3,4} Current guidelines treat pulmonary hypertension in pregnancy as a high-risk condition that needs specialist care.⁵

The right ventricle is a thin-walled, compliant chamber suited to a low-resistance pulmonary circuit. When pulmonary vascular resistance is high, it dilates and its function falls.^{6,7} Functional tricuspid regurgitation follows dilatation of the annulus and adds volume overload.^{8,9} Right ventricular coronary perfusion then depends on the gradient between aortic pressure and right ventricular

pressure, so a sudden fall in systemic vascular resistance can cause right ventricular ischemia.^{10,11} The balance between the right ventricle and the pulmonary artery (ventriculo-arterial coupling) is a recognized determinant of outcome.^{12,13}

Neurofibromatosis type 1 is an autosomal dominant disorder with a variable phenotype.¹⁴ It may involve the vasculature¹⁵ and the airway,¹⁶ and spinal neurofibromas may distort the epidural space. General anesthesia and single-shot spinal anesthesia are usually avoided in severe pulmonary hypertension because of vasodilation, positive-pressure ventilation and the pulmonary pressor response to laryngoscopy. Graded epidural anesthesia has been reported in atrial septal defect with pulmonary hypertension,¹⁷ in mitral stenosis¹⁸ and in Eisenmenger syndrome,¹⁹ and in a parturient with severe tricuspid regurgitation, pulmonary hypertension and systemic lupus erythematosus.²⁰ Neuraxial technique does not remove the risk: refractory cardiac arrest during epidural anesthesia in supra-systemic pulmonary hypertension has been described.^{21,22}

This report describes the anesthetic management and hemodynamic course of an emergency Cesarean delivery

under a graded epidural in a parturient with severe functional tricuspid regurgitation, pulmonary hypertension and neurofibromatosis type 1.

2. Methods

2.1. Report design and reporting guideline

This is a single case report. It follows the CARE guideline for case reports.²³

2.2. Setting

The patient was managed at Dr. Moewardi Regional General Hospital, Surakarta, Indonesia, a tertiary referral academic hospital. Care took place in the emergency obstetric unit, the operating theater and the intensive care unit (ICU).

2.3. Patient information and case selection

The patient was a 37-year-old woman (gravida 2, para 1, abortus 0) at 34 weeks plus 2 days of gestation. She came to the emergency obstetric triage unit with rapidly worsening dyspnea. She was in New York Heart Association (NYHA) class IV, with severe orthopnea, dyspnea at rest and a persistent dry cough. Extensive cutaneous neurofibromas covered the trunk, abdomen, cervical spine and neck, consistent with neurofibromatosis type 1. The case was selected because severe functional tricuspid regurgitation, pulmonary hypertension and neurofibromatosis type 1 coexisted in a parturient who needed an emergency Cesarean delivery.

2.4. Case timeline

The course is shown in Table 1 using relative time. T0 is the baseline before the first epidural dose, and times are minutes from T0. Percentage change ($\Delta\%$) is calculated against T0 as $[(T_n - T_0) / T_0] \times 100$. Rate-pressure product (RPP) is heart rate $\times$ systolic pressure.

2.5. Clinical findings and diagnostic assessment

On admission, respiratory rate was 24 breaths/min and peripheral oxygen saturation (SpO_2) ranged from 90% to 96% on oxygen 10 L/min through a non-rebreather mask. Auscultation showed a diastolic murmur at the apex, an audible third heart sound (S3) and bilateral inspiratory crackles over the lower lung zones. Airway assessment gave Mallampati class III with pharyngeal tissue thickening and mucosal edema. The results of laboratory tests, radiography, electrocardiography and echocardiography are given in Table 2.

Pulmonary pressures were estimated by Doppler echocardiography. The peak tricuspid regurgitant velocity gave a pressure gradient of $4v^2 = 64.3$ mmHg; adding an assumed right atrial pressure of 15 mmHg gives a systolic pulmonary arterial pressure (sPAP) of about 79 mmHg, and mean pulmonary arterial pressure (mPAP) was estimated as $0.61 \times sPAP + 2$, about 50 mmHg. Right ventricular end-diastolic pressure (RVEDP) was not measured; it was estimated at 18–20 mmHg. Right ventricular coronary perfusion pressure (CPP_{RV}) was calculated as mean arterial pressure (MAP) – estimated RVEDP. The diagnosis of neurofibromatosis type 1 was clinical.

2.6. Therapeutic intervention

General anesthesia and single-shot spinal anesthesia were judged hazardous because of the severe right-heart disease

and a predicted difficult airway, and a graded lumbar epidural was chosen. The patient lay in the left lateral position and received continuous oxygen. Under aseptic conditions the epidural space was identified at L1–L2 with an 18-gauge Tuohy needle by loss of resistance to air at a depth of 5.5 cm. The catheter was advanced 4.5 cm (tip about T11–T12). After a negative test dose of 3 mL of 1.5% lidocaine with 1:200,000 epinephrine, 0.375% levobupivacaine with fentanyl 50 μ g was given in 3 mL aliquots every 5 minutes to a total of 12 mL (levobupivacaine 45 mg).

Sensory level was checked on both sides every 3 minutes by pinprick and cold testing, and motor block was graded with the modified Bromage scale. Phenylephrine was given as 50 μ g intravenous boluses. Intravenous crystalloid was limited to 300 mL for the whole operation to avoid right ventricular volume overload. After delivery of the neonate, oxytocin 10 IU in 100 mL of normal saline was infused over 30 minutes, and rapid boluses were avoided.

After surgery the patient went to the ICU for monitoring and fluid management. Intravenous furosemide 20 mg every 12 hours was started to offset the autotransfusion from the uterus.

2.7. Outcome measures and follow-up

The outcomes were MAP, heart rate, SpO_2 and RPP at each milestone, the sensory level and Bromage score, blood loss and fluid balance, the neonatal Apgar scores, the ICU course and the date of discharge. Follow-up lasted until hospital discharge.

2.8. Ethics and consent

The report was approved by CMHC Research Center Ethics Committee, Indonesia (reference no. 2026/2841) and followed the Declaration of Helsinki. Written informed consent for publication was obtained from the patient and her legal guardian.

3. Results

3.1. Presentation and baseline findings

On admission (Tables 1 and 2) the patient was tachycardic at 112 bpm, with blood pressure 100/58 mmHg (MAP 72 mmHg) and SpO_2 92%. Hemoglobin was 13.5 g/dL, leukocytes 12,700 / μ L (1.27×10^{10} /L), creatinine 0.8 mg/dL (70.7 μ mol/L), blood urea nitrogen 16 mg/dL (5.71 mmol/L) and sodium 138 mmol/L. Serum potassium was 2.8 mmol/L (reference 3.5–5.0).

The chest radiograph showed cardiomegaly (cardiothoracic ratio 60%), bilateral pulmonary venous congestion and interstitial haziness in the lower perihilar zones. The electrocardiogram showed sinus tachycardia at 112 bpm, right axis deviation (QRS axis $+120^\circ$) and right ventricular hypertrophy, with tall R waves in V1 (R/S ratio > 1.0), ST-segment depression and T-wave inversion in V1 to V3. Echocardiography showed marked dilatation of the right atrium and right ventricle, with a right ventricular end-diastolic dimension larger than the left ventricular dimension and flattening of the interventricular septum in systole and diastole. Tricuspid regurgitation was severe and functional: peak velocity 4.01 m/s, gradient 64.3 mmHg, regurgitant volume 112 mL and effective regurgitant orifice area 0.58 cm^2 . Estimated sPAP was about 79 mmHg and mPAP about 50 mmHg. Left ventricular ejection fraction was 85%, with an underfilled cavity.

Table 1. Clinical timeline of the case from admission to discharge, with the hemodynamic values at each milestone. Time is relative to T0, the baseline before the first epidural dose.

Time point	Clinical event	Key findings	Intervention
Admission	Emergency triage; NYHA class IV; neurofibromas on trunk and neck	RR 24/min; SpO ₂ 90–96% on oxygen 10 L/min; K ⁺ 2.8 mmol/L	Oxygen by non-rebreather mask; ICU and obstetric assessment
T0 (0 min)	Baseline before the first epidural dose	HR 112; BP 100/58; MAP 72; SpO ₂ 92%; RPP 11,200	Catheter at L1–L2 after a negative test dose
5 min	First 3 mL aliquot; sensory level L2–L3	HR 110; SBP 98*; MAP 70; SpO ₂ 93%; RPP 10,780; Δ% HR –1.8, MAP –2.8, SpO ₂ +1.1	Levobupivacaine 11.25 mg cumulative
10 min	Second aliquot; T12–L1	HR 106; SBP 100*; MAP 72; SpO ₂ 95%; RPP 10,600; Δ% HR –5.4, MAP 0.0, SpO ₂ +3.3	6 mL (22.5 mg) cumulative
15 min	Third aliquot; T8–T10	HR 102; SBP 104*; MAP 75; SpO ₂ 96%; RPP 10,608; Δ% HR –8.9, MAP +4.2, SpO ₂ +4.3	9 mL (33.75 mg); phenylephrine 50 μg
20 min	Fourth aliquot; T6 reached; Bromage 0	HR 99; SBP 107*; MAP 77; SpO ₂ 97%; RPP 10,593; Δ% HR –11.6, MAP +6.9, SpO ₂ +5.4	12 mL (45 mg) with fentanyl 50 μg in total
25 min	Surgical incision (Pfannenstiel)	HR 98; SBP 108*; MAP 78; SpO ₂ 97%; RPP 10,584; Δ% HR –12.5, MAP +8.3, SpO ₂ +5.4	No further local anesthetic
35 min	Delivery of the neonate (2300 g)	HR 105; SBP 102*; MAP 74; SpO ₂ 97%; RPP 10,710; Δ% HR –6.3, MAP +2.8, SpO ₂ +5.4	Oxytocin 10 IU in 100 mL over 30 min
40 min	Delivery of the placenta	HR 101; SBP 105*; MAP 75; SpO ₂ 98%; RPP 10,605; Δ% HR –9.8, MAP +4.2, SpO ₂ +6.5	Crystalloid limited to 300 mL in total
48 min	Peritoneal closure	HR 96; SBP 107*; MAP 76; SpO ₂ 98%; RPP 10,272; Δ% HR –14.3, MAP +5.6, SpO ₂ +6.5	—
55 min	Skin closure	HR 94; SBP 106*; MAP 76; SpO ₂ 98%; RPP 9,964; Δ% HR –16.1, MAP +5.6, SpO ₂ +6.5; blood loss 300 mL	Transfer to ICU
Postpartum hours 0–24	ICU	Net fluid balance –850 mL; oxygen weaned to room air by hour 18, SpO ₂ 98%	Furosemide 20 mg IV every 12 hours
Postoperative day 2	Step-down cardiac ward	Dyspnea, orthopnea and crackles resolved	—
Postoperative day 6	Hospital discharge	Full functional recovery	—

Notes: BP, blood pressure (SBP/DBP, mmHg); MAP, mean arterial pressure (mmHg); HR, heart rate (bpm); RPP, rate-pressure product (SBP × HR, bpm·mmHg); Δ%, percentage change from T0 [(Tn – T0)/T0 × 100]; SpO₂, peripheral oxygen saturation; NYHA, New York Heart Association; ICU, intensive care unit; RR, respiratory rate. * SBP is derived as RPP ÷ HR.

Table 2. Baseline findings on admission.

Parameter	Observed value	Reference or classification
Age; obstetric history	37 years; gravida 2, para 1, abortus 0	—
Gestational age	34 weeks + 2 days	Term 37–40 weeks
NYHA class	IV (symptoms at rest)	Class I (asymptomatic)
Symptoms	Severe dyspnea, orthopnea, dry cough	None
Cardiac auscultation	Diastolic murmur at the apex; S3	Normal S1–S2, no murmur
Pulmonary auscultation	Bilateral basal crackles (lower third of lung fields)	Clear bilaterally
Skin	Multiple neurofibromas over neck, trunk and spine	Normal
Airway	Mallampati class III; pharyngeal tissue thickening and mucosal edema	Class I–II
Hemoglobin	13.5 g/dL	11.0–14.0 g/dL
Leukocytes	12,700 /μL (1.27×10^{10} /L)	4,500–11,000 /μL (non-pregnant)
Potassium	2.8 mmol/L	3.5–5.0 mmol/L
Sodium	138 mmol/L	135–145 mmol/L
Creatinine; blood urea nitrogen	0.8 mg/dL (70.7 μmol/L); 16 mg/dL (5.71 mmol/L)	0.5–0.9 mg/dL; 7–20 mg/dL
Chest radiograph	Cardiothoracic ratio 60%; bilateral pulmonary venous congestion	< 50%
Electrocardiogram	Sinus tachycardia 112 bpm; axis +120°; right ventricular hypertrophy	Sinus rhythm; axis 0° to +90°
Right heart size	Severe right atrial and right ventricular dilatation; septal flattening	Normal dimensions
Tricuspid regurgitation	Severe, functional; regurgitant volume 112 mL; EROA 0.58 cm ²	Trace or none (< 10 mL)
Peak tricuspid regurgitant velocity	4.01 m/s (gradient 64.3 mmHg)	< 2.8 m/s
Pulmonary artery pressure (Doppler estimate)	sPAP about 79 mmHg; mPAP about 50 mmHg	mPAP ≤ 20 mmHg; sPAP ≤ 35 mmHg
Left ventricular ejection fraction	85%	55–70%

Notes: EROA, effective regurgitant orifice area; mPAP, mean pulmonary arterial pressure; NYHA, New York Heart Association; sPAP, systolic pulmonary arterial pressure; S3, third heart sound. Pulmonary pressures are Doppler estimates (sPAP = $4v^2$ + assumed right atrial pressure of 15 mmHg; mPAP = $0.61 \times$ sPAP + 2).

3.2. Diagnostic findings

Neurofibromatous nodules lay along the lumbar and lower thoracic spine, and the midline was located by palpation

and ultrasonography. The epidural space was found at L1–L2 at the first attempt, without paresthesia, vascular puncture or dural puncture, and the catheter passed without resistance. The sensory block rose in steps with

each 3 mL aliquot (Figure 1A): L2–L3 at 5 minutes, T12–L1 at 10 minutes, T8–T10 at 15 minutes and T6 at 20 minutes.

Motor function in the lower limbs was preserved (modified Bromage score 0).

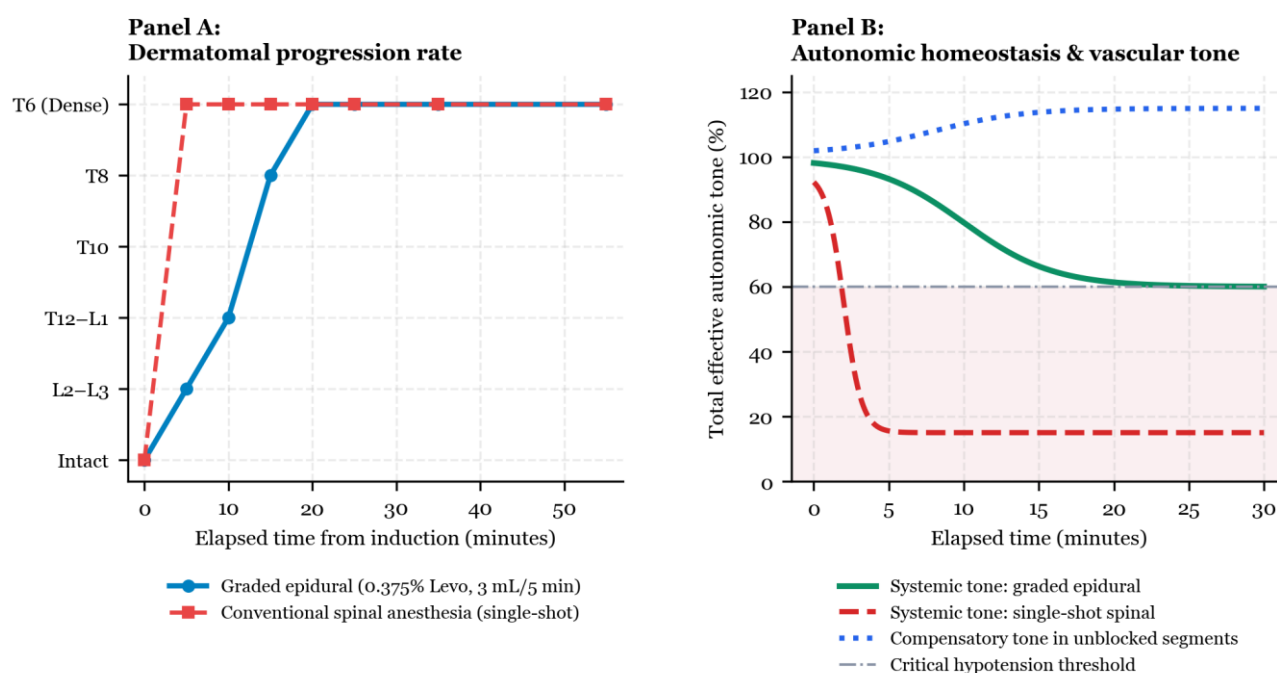


Figure 1. Sensory dermatomal progression and autonomic tone. (A) Dermatome level over time with the graded epidural (observed) and a conventional single-shot spinal (schematic comparison; not patient data). (B) Autonomic tone over 30 minutes for the graded epidural, a single-shot spinal and unblocked segments, relative to the critical hypotension threshold (schematic model curves; not measured). Epidural: 0.375% levobupivacaine, 3 mL every 5 minutes.

3.3. Treatment course and outcome

Table 1 and Figures 2 and 3 show the hemodynamic course. At baseline (T0), heart rate was 112 bpm, MAP 72 mmHg, SpO₂ 92% and RPP 11,200 bpm·mmHg. After the first aliquot (5 minutes) heart rate was 110 bpm ($\Delta\%$ -1.8%), MAP 70 mmHg ($\Delta\%$ -2.8%) and SpO₂ 93% ($\Delta\%$ +1.1%). At 15 minutes, after the third aliquot, a phenylephrine bolus of 50 μ g was given; MAP was 75 mmHg ($\Delta\%$ +4.2%), heart rate 102 bpm ($\Delta\%$ -8.9%) and SpO₂ 96% ($\Delta\%$ +4.3%).

At incision (25 minutes), heart rate was 98 bpm ($\Delta\%$ -12.5%), MAP 78 mmHg ($\Delta\%$ +8.3%), SpO₂ 97% ($\Delta\%$

+5.4%) and RPP 10,584 bpm·mmHg. The neonate was delivered at 35 minutes; heart rate rose from 98 to 105 bpm ($\Delta\%$ against T0 -6.3%) and MAP was 74 mmHg ($\Delta\%$ +2.8%) as the slow oxytocin infusion began. At skin closure (55 minutes) heart rate was 94 bpm ($\Delta\%$ -16.1%), MAP 76 mmHg ($\Delta\%$ +5.6%), SpO₂ 98% ($\Delta\%$ +6.5%) and RPP 9,964 bpm·mmHg, 11.0% below baseline. MAP stayed within 9% of baseline, with no value below 65 mmHg and no hypertensive episode. With the estimated RVEDP of 18–20 mmHg, the estimated CPP_{RV} was about 50–60 mmHg.

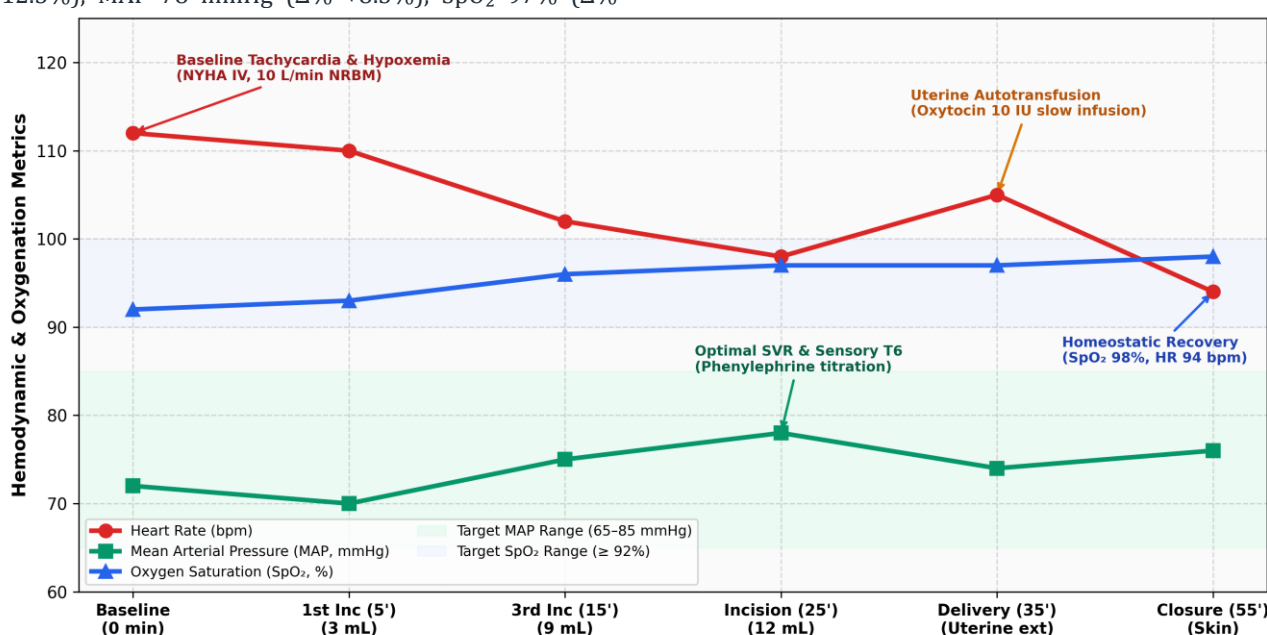


Figure 2. Serial heart rate, mean arterial pressure and oxygen saturation at the graded epidural milestones, from baseline (0 minutes) to skin closure (55 minutes). Shaded bands show the authors' target ranges (MAP 65–85 mmHg; SpO₂ $\geq$ 92%).

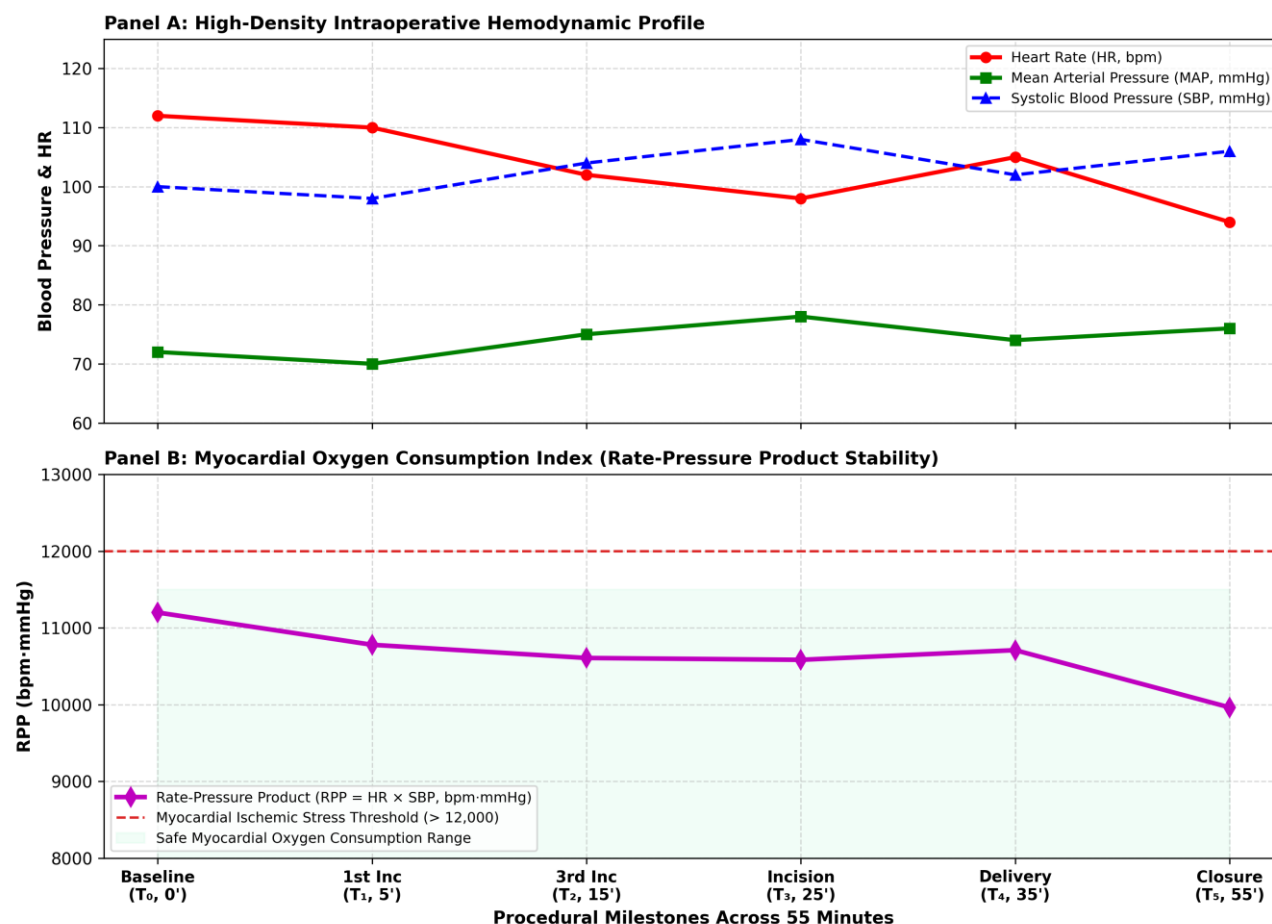


Figure 3. Heart rate, mean arterial pressure, systolic blood pressure and rate-pressure product (RPP = heart rate × systolic pressure) at each milestone.

Skin closure was 55 minutes after baseline, about 30 minutes after incision, through a Pfannenstiel incision. Blood loss was 300 mL and crystalloid 300 mL. The neonate was a male of 2300 g with a crown-heel length of 46 cm. Apgar scores were 6, 7 and 8 at 1, 5 and 10 minutes, and he needed no bag-mask ventilation or intubation.

The patient went to the ICU. Bedside echocardiography in the first 24 hours showed preserved right ventricular forward flow, non-progressive tricuspid regurgitation and less plethora of the inferior vena cava. Net fluid balance was -850 mL over 24 hours with furosemide. Dyspnea, orthopnea and crackles resolved, and oxygen was weaned from 10 L/min to room air by postpartum hour 18, with SpO₂ 98%. She moved to the step-down cardiac ward on postoperative day 2 and was discharged on day 6 with full functional recovery.

4. Discussion

4.1. Principal lesson of the case

In a parturient with severe functional tricuspid regurgitation, estimated pulmonary hypertension and neurofibromatosis type 1, an emergency Cesarean delivery under a slowly titrated epidural was followed by stable blood pressure, a fall in heart rate and an uneventful recovery. The case shows that this approach can be

delivered with fluid restriction, small phenylephrine doses and a slow oxytocin infusion. It does not show that it is better than other options.

4.2. Comparison with the published literature

Graded epidural anesthesia has been reported for other cardiac lesions in pregnancy (Table 3). Wicaksana et al. used 0.5% levobupivacaine titrated to T6 in a woman with an atrial septal defect and moderate pulmonary hypertension, with arterial and central venous monitoring and no vasopressor.¹⁷ Kurniady et al. used lidocaine and ropivacaine in severe mitral stenosis and guided phenylephrine with beat-to-beat cardiac output monitoring.¹⁸ Dewi et al. needed staged inodilator and vasopressor support in severe tricuspid regurgitation with pulmonary hypertension and lupus.²⁰ Arul et al. described graded epidural block in Eisenmenger syndrome.¹⁹ Low-dose combined spinal-epidural anesthesia has been used for Cesarean delivery in corrected transposition with severe pulmonary stenosis,²⁴ and graded epidural anesthesia in a patient with a low ejection fraction outside obstetrics.²⁵ Our patient is consistent with these reports in the slow titration and the fluid and vasopressor strategy. She differs in the neurofibromatosis, in the predicted difficult airway, and in not needing inodilators.

Table 3. Published reports of graded epidural anesthesia in cardiac disease in pregnancy, and the present case.

Report	Patient	Anesthetic technique	Hemodynamic management	Outcome
Present case	37-year-old, 34 weeks; severe TR, PH, NF1	Graded lumbar epidural; 0.375% levobupivacaine with fentanyl, 3 mL every 5 min (12 mL)	Crystalloid 300 mL; phenylephrine; slow oxytocin	Mother and neonate (2300 g) survived; discharge day 6
Wicaksana 2025 ¹⁷	28-year-old primigravida, 37+2 weeks; large secundum ASD, moderate PH (sPAP 50.2 mmHg)	Graded lumbar epidural; 0.5% levobupivacaine to T6	Arterial and central venous lines; no vasopressor needed	Uneventful ICU course; neonatal outcome not given in the abstract
Kurniady 2025 ¹⁸	34-year-old, 34+5 weeks; severe rheumatic MS, PH, acute heart failure	Graded epidural; lidocaine and ropivacaine	Cardiac output monitoring (MostCare PRAM); phenylephrine titration	Stable; no pulmonary edema or arrhythmia; discharge day 4
Dewi 2026 ²⁰	30-year-old, 37+1 weeks; SLE, severe TR, probable PH, PFO with right-to-left shunt	Graded epidural; 0.5% levobupivacaine	Norepinephrine, milrinone, dobutamine, furosemide; fluid restriction	Neonate in good condition; vasoactive support weaned by day 2; ward day 3
Arul 2025 ¹⁹	Eisenmenger syndrome	Graded epidural block	-	-
Soomro 2026 ²¹	Supra-systemic PH, Cesarean section	Epidural anesthesia	Refractory cardiac arrest; rescued by VA ECMO	See report
Sliwa 2016 ²	151 women with PH (74% PH from left heart disease)	Not reported in the abstract	—	Maternal death within 1 week in 5 (3.3%); highest in idiopathic PAH (3 of 7)

Notes: ASD, atrial septal defect; ECMO, extracorporeal membrane oxygenation; MS, mitral stenosis; NF1, neurofibromatosis type 1; PAH, pulmonary arterial hypertension; PFO, patent foramen ovale; PH, pulmonary hypertension; SLE, systemic lupus erythematosus; TR, tricuspid regurgitation. Details are taken from the published abstracts.

In the European registry, 3.3% of 151 women with pulmonary hypertension died within a week of delivery, and 74% of the group had pulmonary hypertension from left heart disease.² The second point matters here, because an apical diastolic murmur with an S3 raises the possibility of left-sided valve disease, which was not excluded in our patient. Neuraxial anesthesia is not risk free: refractory cardiac arrest during epidural anesthesia for Cesarean section in supra-systemic pulmonary hypertension was rescued only by venoarterial extracorporeal membrane oxygenation.²¹ A plan for ECMO support may therefore be needed. This report adds a step-by-step record of a graded epidural in a patient who combined these three conditions, and the neurofibromatosis-specific reasoning about the airway and the epidural space.

4.3. Pathophysiological or mechanistic interpretation

What was observed is stable MAP (70–78 mmHg), a fall in heart rate from 112 to 94 bpm, a fall in RPP of 11.0% and a rise in SpO₂ from 92% to 98%. MAP stayed above the 65 mmHg threshold commonly used in intraoperative management.²⁶ Everything below is inferred. Right ventricular perfusion depends on the gradient between

aortic and right ventricular pressure,^{10,11} and with the estimated RVEDP, MAP above 70 mmHg gave an estimated CPP_{RV} of at least about 50 mmHg. A block that rises over 20 minutes may allow vasoconstriction in unblocked segments, and small phenylephrine doses may have added to it. Limited fluid may have avoided further right ventricular dilatation and worsening regurgitation,^{6,8,9} and a slow oxytocin infusion avoided vasodilation. Figures 4 and 5 summarize this proposed sequence; they are schematic, and SVR, PVR and their ratio were not measured.

Other explanations are as likely. Heart rate and RPP may have fallen because dyspnea and anxiety eased and oxygenation improved, as much as through the block. RPP reflects global, mainly left ventricular work, and right ventricular oxygen demand was not measured. Doppler estimates of pulmonary pressure are unreliable in severe tricuspid regurgitation, and the values here are estimates.²⁷ General anesthesia was avoided mainly because of the predicted difficult airway and the effects of intubation and positive-pressure ventilation on a failing right ventricle.¹⁰

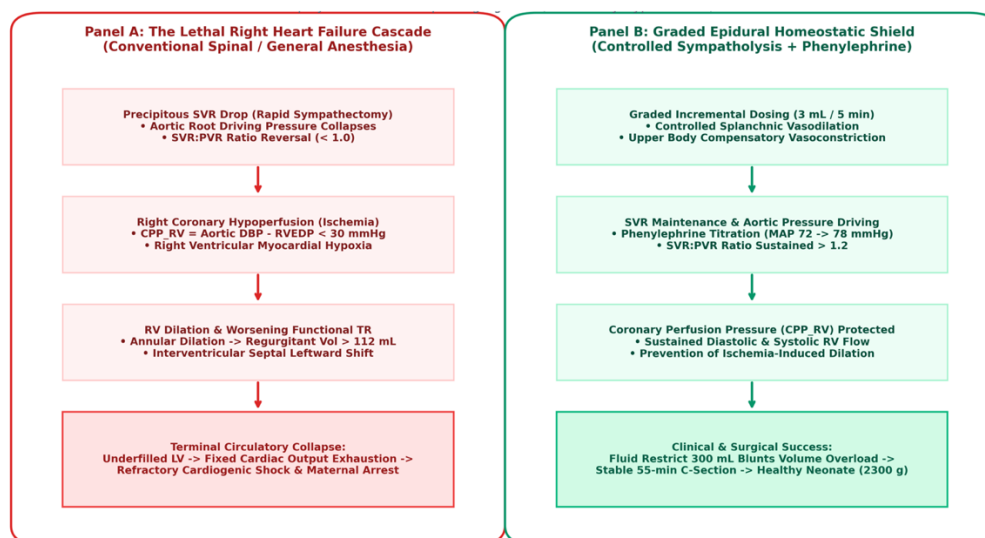


Figure 4. Schematic of right ventricular-pulmonary coupling and coronary perfusion: the proposed cascade after a precipitous fall in systemic vascular resistance (panel A) and the proposed protective sequence with a graded epidural (panel B). Schematic only: SVR:PVR ratio and CPP_{RV} were not measured (CPP_{RV} is estimated as MAP – RVEDP). PH, pulmonary hypertension; SVR, systemic vascular resistance; PVR, pulmonary vascular resistance; CPP_{RV}, right ventricular coronary perfusion pressure; RVEDP, right ventricular end-diastolic pressure; TR, tricuspid regurgitation.

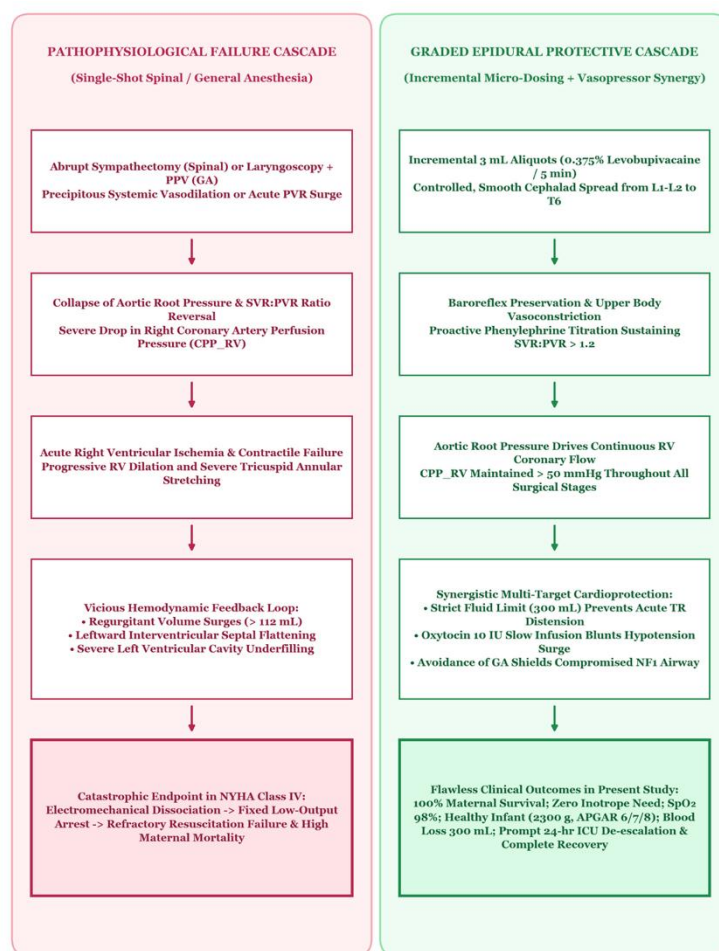


Figure 5. Proposed mechanistic cascade: single-shot spinal or general anesthesia compared with a graded epidural protocol. Schematic only; the SVR:PVR ratio was not measured. PPV, positive-pressure ventilation; GA, general anesthesia; PVR, pulmonary vascular resistance; SVR, systemic vascular resistance; CPP_{RV}, right ventricular coronary perfusion pressure; RV, right ventricular; NF1, neurofibromatosis type 1; NYHA, New York Heart Association.

4.4. Implications for practice

In a similar patient, a graded epidural can be considered when general anesthesia is hazardous, provided the team can monitor closely, titrate a vasopressor, limit fluid and plan intensive care. Arterial pressure monitoring, a ready plan for extracorporeal support and early cardiology input

are sensible additions. Avoiding rapid oxytocin boluses and planning diuresis after delivery are supported by the physiology described here but not by comparative data. These steps are summarized in Figure 6. The transferability of the advice is limited to patients with similar anatomy and resources.

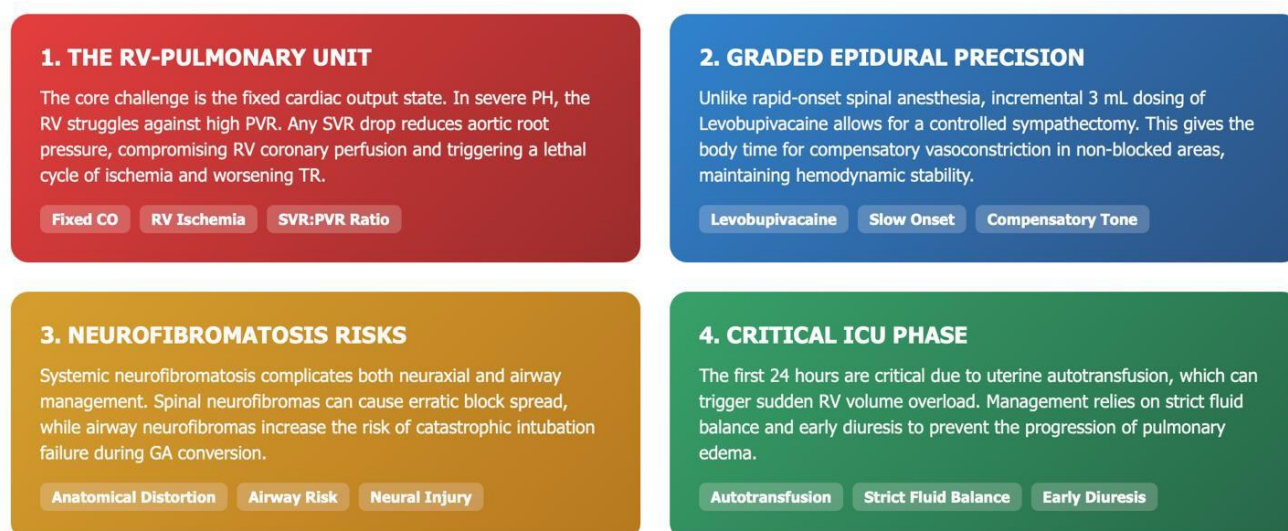


Figure 6. Conceptual framework: four domains of management in the parturient with severe right-heart disease and neurofibromatosis type 1. RV, right ventricle; PH, pulmonary hypertension; PVR, pulmonary vascular resistance; SVR, systemic vascular resistance; TR, tricuspid regurgitation; CO, cardiac output; GA, general anesthesia.

4.5. Strengths

The record is complete and timed, derived values reproduce from the measured ones, the dermatomal ascent is documented step by step, and ethics approval and written consent are stated.

4.6. Limitations

This is a single case without a comparator, and it cannot establish causation, prevalence or effect. Pulmonary hypertension was not confirmed by right heart catheterization, and RVEDP, SVR, PVR and CPP_{RV} were estimated or not measured. No pulmonary artery catheter or transesophageal echocardiography was used, and right ventricular function was not quantified; echocardiographic assessment of right ventricular function is itself variable in practice.²⁷ A left-sided cause of pulmonary hypertension was not excluded, spinal imaging in neurofibromatosis was not reported, and follow-up ended at discharge.

4.7. Recommendations for future work

Prospective multicenter registries of parturients with severe pulmonary hypertension and right-heart disease, with standardized echocardiographic and invasive monitoring and recording of anesthetic technique, would be needed to test whether a graded epidural lowers complications compared with other techniques.

5. Conclusion

This report describes a graded epidural for emergency Cesarean delivery in a parturient with severe tricuspid regurgitation, pulmonary hypertension and neurofibromatosis type 1. With restricted fluid, small phenylephrine doses and a slow oxytocin infusion, the course was hemodynamically stable and both mother and neonate survived. The report claims no more than one case supports. A slowly titrated epidural can be considered in similar patients when general anesthesia is hazardous, but its advantage over other techniques needs to be tested in larger prospective series.

6. Declarations

Ethical approval and consent to participate. This case report was approved by the CMHC Research Center Ethics Committee, Indonesia, under reference number 2026/2841 issued in 2026. The report followed the Declaration of Helsinki.

Consent for publication. Written informed consent for publication of this case and the accompanying data was obtained from the patient and her legal guardian. A copy of the signed consent form is available for review by the editorial office.

Availability of data and materials. All data generated and analyzed are contained within the article and its tables. De-identified physiological data are available from the corresponding author on reasonable request.

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