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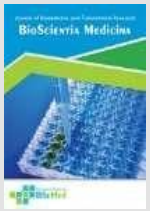

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Ultrasound-Guided Neuraxial Precision in a High-Risk Adolescent Parturient: Navigating Anesthetic Management in the Confluence of Nephrotic Syndrome, Diastolic Heart Failure, and Anasarca

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A B S T R A C T

Background: Anesthetic management for cesarean delivery in parturients with concurrent nephrotic syndrome and decompensated heart failure presents a profound clinical challenge. Severe anasarca can obliterate anatomical landmarks, while complex cardiorenal pathophysiology creates a state of extreme hemodynamic fragility. This case report describes a systematic, ultrasound-guided approach to overcome these obstacles. **Case presentation:** A 15-year-old primigravida at 33 weeks gestation, with new-onset nephrotic syndrome and decompensated heart failure (NYHA Class III), required an emergency cesarean section. Clinical examination revealed severe anasarca, rendering lumbar spinal landmarks impalpable. A systematic pre-procedural lumbar ultrasound examination was performed using a low-frequency curvilinear transducer. This allowed for precise identification of the L3-L4 interspace and an accurate skin-to-dura depth measurement of 4.6 cm. A single-attempt subarachnoid block was successfully performed with a reduced dose (10 mg) of hyperbaric bupivacaine. An adequate T4 sensory block was achieved for surgery. The patient remained remarkably hemodynamically stable throughout the procedure, with no episodes of hypotension requiring vasopressor support. A healthy infant was delivered, and both maternal and neonatal outcomes were excellent. **Conclusion:** This case demonstrates that a systematic pre-procedural ultrasound protocol is an indispensable tool for enhancing the safety and success of neuraxial anesthesia in high-risk obstetric patients. By enabling precise anatomical localization and informed dose reduction, it mitigates procedural risk and supports hemodynamic stability in the face of distorted anatomy and severe cardiorenal comorbidities.

1. Introduction

The practice of obstetric anesthesia exists at a delicate intersection of two lives, where maternal physiology is profoundly altered to support the developing fetus.[1] The introduction of severe, pre-existing, or newly acquired systemic disease transforms this delicate balance into a high-stakes clinical scenario fraught with peril. The confluence of pregnancy with complex multi-system pathologies, such as nephrotic syndrome and chronic heart failure, presents one of the most formidable challenges to the modern anesthesiologist.[2] Cesarean delivery in such patients mandates a meticulously crafted anesthetic plan that not only provides effective surgical anesthesia but also rigorously defends maternal hemodynamic stability to ensure both maternal and fetal well-being.[3]

Nephrotic syndrome, a renal disorder characterized by massive proteinuria, hypoalbuminemia, peripheral edema, and hyperlipidemia, introduces a triad of distinct anesthetic challenges.[4] Firstly, the profound hypoalbuminemia fundamentally alters the pharmacokinetics of highly protein-bound anesthetic agents, creating a risk of exaggerated drug effects and potential toxicity from a standard dose. Secondly, the syndrome induces a significant hypercoagulable state through the urinary loss of anticoagulant proteins and a reactive hepatic synthesis of procoagulant factors, thereby increasing the risk of catastrophic thromboembolic events, a risk that is magnified in the context of neuraxial anesthesia. Thirdly, and most visibly, the severe generalized edema, or anasarca, resulting from plummeting plasma oncotic pressure can completely obscure the anatomical landmarks of the lumbar spine, rendering the traditional palpation-based technique for neuraxial blockade unreliable and dangerous. Repeated, traumatic attempts at needle placement in a hypercoagulative patient with obscured anatomy significantly elevate the risk of complications such as post-dural puncture headache (PDPH), nerve injury, and the devastating formation of a spinal or epidural hematoma.[5,6]

Concurrently, the presence of chronic heart failure, particularly heart failure with preserved ejection fraction (HFpEF), characterized by diastolic dysfunction, superimposes a layer of extreme hemodynamic fragility.[7] Parturients with diastolic dysfunction possess a stiff, non-compliant left ventricle that is exquisitely sensitive to fluctuations in preload and afterload. The ventricle requires high filling pressures to achieve adequate end-diastolic volume, making the patient critically dependent on venous return. The sympatholysis induced by neuraxial anesthesia causes profound venodilation and arterial vasodilation, leading to a precipitous drop in both preload and afterload.[8] In a heart with impaired diastolic filling, this sudden decrease in preload can lead to a sharp fall in cardiac output and severe hypotension, while injudicious fluid administration to correct this hypotension can rapidly overwhelm the non-compliant ventricle, precipitating acute pulmonary edema. This narrow physiological window demands an anesthetic technique that is not just effective, but exceptionally precise, controlled, and minimally disruptive to the patient's tenuous cardiovascular equilibrium.[9]

In recent decades, the field of regional anesthesia has undergone a paradigm shift, moving away from "blind," palpation-based techniques towards a more precise, image-guided science. Lumbar spine ultrasonography has emerged as a transformative technology, allowing clinicians to visualize the neuraxial anatomy before the needle ever touches the skin.[10] This capability is especially crucial in patients where landmarks are impalpable due to obesity or edema. Two primary approaches exist: real-time ultrasound guidance, where the needle is visualized as it advances, and pre-procedural mapping, which involves a systematic scan to identify the optimal interspace, measure the depth to the target, and mark the skin for a subsequent "blind" but highly informed needle insertion. By providing a clear roadmap of the underlying sonoanatomy, pre-procedural ultrasound has been demonstrated to significantly increase first-attempt success rates, reduce the number of needle passes, decrease procedural time, and lower complication rates.

This case report presents the detailed anesthetic management of a critically ill adolescent primigravida with severe anasarca secondary to newly diagnosed nephrotic syndrome and decompensated diastolic heart failure, a "zero-landmark" scenario. The aim of this report is to describe the successful and safe administration of a single-attempt, hemodynamically stable subarachnoid block facilitated by a systematic pre-procedural ultrasound examination. The novelty of this report lies in its detailed description of a systematic imaging protocol as a safe and effective solution in a patient archetype where traditional techniques are rendered obsolete and dangerous, thereby providing a methodological blueprint for managing similar high-stakes obstetric emergencies.

2. Case Presentation

This case report was prepared in accordance with the CARE (CAse REport) guidelines. Written informed consent was obtained from the patient and her legal guardian for the publication of this case report and any accompanying images. Patient data has been fully anonymized to protect privacy. A 15-year-old, G1P0A0, Indonesian female at 33 weeks and 6 days of gestation was transferred to our tertiary care center for the management of progressive dyspnea and severe generalized edema. Her symptoms began approximately six weeks prior to admission with mild pedal edema, which rapidly progressed to anasarca. This was accompanied by orthopnea and paroxysmal nocturnal dyspnea, which severely limited her activity to minimal exertion, consistent with New York Heart Association (NYHA) Class III functional status. Her past medical history was unremarkable, with no prior history of hypertension, diabetes, renal disease, or cardiac abnormalities. Her prenatal care had been routine and uncomplicated until the recent, rapid onset of symptoms (Table 1).

On admission to the obstetric high-dependency unit, physical examination revealed a conscious but visibly distressed young woman. Her weight was 68 kg and her height was 150 cm. Her pre-pregnancy Body Mass Index (BMI) was 22.2 kg/m², which had increased to an admission BMI of 30.2 kg/m² due to massive fluid retention. Her vital signs were: blood pressure 133/87 mmHg, heart rate 94 beats per minute, respiratory rate 22 breaths per minute, and an oxygen saturation of 96% while receiving 6 L/min of oxygen via a simple face mask.

The cardiovascular examination was notable for an elevated jugular venous pressure, estimated at 10 cm H_2O. Her heart rhythm was a regular tachycardia with an audible S3 gallop, and a Grade II/VI holosystolic murmur was best heard at the cardiac apex. Her extremities exhibited 4+ pitting edema extending bilaterally to the thighs and sacral region. The lumbar region, critical for neuraxial anesthesia, was characterized by massive, taut, non-pitting edema that completely obliterated all bony prominences; the spinous processes and iliac crests were entirely impalpable. Airway assessment revealed a Mallampati Class III view, a thyromental distance of 6.5 cm, and normal neck mobility, suggesting a potentially challenging airway should general anesthesia be required. Obstetric examination confirmed a singleton pregnancy with a fundal height corresponding to the gestational age.

The patient underwent a comprehensive diagnostic evaluation to determine the etiology of her multi-system presentation. The differential diagnoses considered included pre-eclampsia with severe features, peripartum cardiomyopathy, and autoimmune diseases such as systemic lupus erythematosus with renal involvement. Laboratory investigations were significant for a constellation of findings confirming a diagnosis of nephrotic syndrome. A 24-hour urine collection quantified massive proteinuria at 8.2 g/day (normal <0.15 g/day). Blood work revealed severe hypoalbuminemia (1.9 g/dL) and marked dyslipidemia. Coagulation studies indicated a prothrombotic state with a significantly elevated fibrinogen level of 650 mg/dL. The patient also had normocytic, normochromic anemia. A comprehensive summary of the key laboratory and diagnostic findings is presented in Table 1. To evaluate her cardiac status, N-terminal pro-B-type natriuretic peptide (NT-proBNP) was measured and found to be profoundly elevated at 2100 pg/mL (normal <125 pg/mL), consistent with significant cardiac strain and volume overload. A transthoracic echocardiogram (TTE) was performed, which demonstrated a structurally normal heart with concentric left ventricular hypertrophy. The left ventricular ejection fraction (LVEF) was preserved at 57%. However, there was definitive evidence of Grade II diastolic dysfunction, characterized by an E/A ratio of 1.6 and an elevated E/e' ratio of 15. The TTE also revealed a severely dilated left atrium and moderate functional mitral regurgitation. A chest radiograph showed cardiomegaly, cephalization of pulmonary vessels, and small bilateral pleural effusions, confirming pulmonary venous congestion.

Table 1. Clinical Findings on Admission

A comprehensive summary of the patient's key diagnostic data.

PARAMETER	PATIENT'S VALUE	NORMAL RANGE
General Profile		
Age (years)	15	-
Gestational Age (weeks+days)	33+6	-
BMI (kg/m²)	30.2	18.5-24.9
Blood Pressure (mmHg)	133/87	<140/90
Heart Rate (bpm)	94	60-100
Hematology		
Hemoglobin (g/dL)	7.7	12.0-16.0
White Blood Cell (WBC) (/µL)	17,600	4,500-11,000
Renal & Metabolism		
Serum Albumin (g/dL)	1.9	3.5-5.0
24-hr Urine Protein (g/day)	8.2	<0.15
Total Cholesterol (mg/dL)	340	<200
Fibrinogen (mg/dL)	650	200-400
Cardiac Assessment		
NT-proBNP (pg/mL)	2100	<125
LVEF (%)	57	55-70
Diastolic Function Grade	Grade II	Normal (Grade 0)
E/e' Ratio	15	<14

Following this comprehensive workup, the multidisciplinary team of obstetricians, cardiologists, nephrologists, and anesthesiologists concluded the primary diagnoses were: new-onset nephrotic syndrome and decompensated chronic heart failure with preserved ejection fraction (diastolic heart failure). During this evaluation, the fetal cardiotocography became non-reassuring, necessitating an emergency cesarean delivery.

After a thorough multidisciplinary discussion and a detailed risk-benefit analysis with the patient and her family, a decision was made to proceed with a subarachnoid block. The risks of general anesthesia were considered substantial, including potential for

difficult airway management, profound hemodynamic swings during induction and intubation, and the risk of postoperative respiratory depression. Neuraxial anesthesia also carries a significant risk, primarily sympathectomy-induced hypotension in a patient with preload-dependent diastolic dysfunction. It was concluded that a carefully titrated, precisely placed spinal anesthetic, facilitated by ultrasound, offered the most controlled and hemodynamically stable option. The planned dose of bupivacaine was prospectively reduced to 10 mg (from a standard 12-15 mg) to account for the anticipated exaggerated spread secondary to severe hypoalbuminemia (Table 2).

Table 2. Diagnosis, Treatment, and Outcome

A summary of the clinical pathway and results.

DOMAIN	DETAILS
⚠ **Final Diagnosis**	
Primary Conditions	• **New-onset Nephrotic Syndrome** with severe hypoalbuminemia (1.9 g/dL) • **Decompensated Heart Failure** (NYHA Class III) with Grade II Diastolic Dysfunction • Severe Anasarca leading to impalpable spinal landmarks
Indication for Delivery	Emergency Obstetric Condition (Non-reassuring Fetal Status)
⊞ **Anesthetic & Surgical Treatment**	
Anesthetic Technique	• Pre-procedural Lumbar Ultrasound Mapping • Single-attempt Subarachnoid Block at L3-L4 • 27-gauge Whitacre spinal needle
Anesthetic Agent	Reduced Dose: 10 mg of 0.5% Hyperbaric Bupivacaine
Surgical Procedure	Emergency Cesarean Delivery
✓ **Maternal & Neonatal Outcome**	
Maternal Outcome	• Completely Hemodynamically Stable (No vasopressors required) • Adequate surgical anesthesia (T4 sensory block) • Estimated Blood Loss: 500 mL • Discharged on Postoperative Day 7 • No anesthetic-related complications
Neonatal Outcome	• **Viable Female Infant** • Birth Weight: 2150 grams • Apgar Scores: 8 (at 1 minute) and 9 (at 5 minutes)

In the operating theater, standard American Society of Anesthesiologists (ASA) monitors were applied, including non-invasive blood pressure, 5-lead electrocardiogram, and pulse oximetry. Premedication consisted of ranitidine 50 mg and metoclopramide 10 mg administered intravenously. The patient was carefully positioned in the left lateral decubitus position. This position was chosen over the sitting position to optimize hemodynamic stability by maximizing venous return and to enhance patient comfort given her dyspnea.

Due to the complete absence of palpable landmarks, a pre-procedural lumbar ultrasound scan was performed. A low-frequency (2-5 MHz) curvilinear ultrasound transducer (GE Venue Go) was used to ensure adequate penetration through the edematous subcutaneous tissue. A systematic scanning protocol was initiated: (1) Transverse Midline View: The probe was first placed in a transverse orientation at the approximate lumbar level. The spinous process was identified as a superficial, hyperechoic curvilinear structure casting a deep acoustic shadow, confirming the midline; (2) Paramedian Sagittal Oblique View: The probe was then moved approximately 2-3 cm laterally from the midline and rotated into a sagittal orientation. By sliding the probe in a cephalad-caudad direction, the "sawtooth" pattern of the hyperechoic laminae was visualized. The lumbosacral junction was identified by its characteristic continuous hyperechoic line of the sacrum, and the intervertebral levels were confirmed by counting up from this landmark (L5-S1, L4-L5, L3-L4); (3) Final Target View (Transverse Interlaminar View): Having identified the L3-L4 interspace, the probe was returned to the transverse orientation and positioned directly over the interspace. The probe was manipulated using the PART (Pressure, Alignment, Rotation, Tilt) maneuver to optimize the acoustic window. A clear image of the neuraxial structures was obtained. The posterior complex (ligamentum flavum-dura mater) was clearly visualized as a single, bright, hyperechoic line. Deeper to this, the hypoechoic intrathecal space could be seen, followed by the hyperechoic anterior complex (posterior longitudinal ligament) and the posterior aspect of the L4 vertebral body; (4) Depth Measurement: Using the on-screen calipers, the distance from the skin surface to the posterior complex was measured at 4.6 cm. The optimal needle insertion point in the center of the probe was marked on the patient's skin with a sterile surgical marker.

Following sterile preparation of the lumbar region with a 2% chlorhexidine gluconate and 70% isopropyl alcohol solution, the marked point was anesthetized with 2 mL of 2% lidocaine. A 27-gauge Whitacre spinal needle was inserted at the marked point, aiming to replicate the perpendicular trajectory visualized during the ultrasound scan. The needle was advanced slowly and deliberately to the pre-measured depth of 4.6 cm. A distinct tactile "pop" was felt, and upon removal of the stylet, clear, free-flowing cerebrospinal fluid (CSF) was immediately obtained on the very first attempt. The pre-planned reduced dose of 10 mg of 0.5% hyperbaric bupivacaine was injected intrathecally over 20 seconds.

Immediately following the injection, the patient was positioned supine with a 15-degree left lateral tilt using a wedge under her right hip to maintain uterine displacement. The sensory block level was assessed every minute by testing for loss of sensation to cold with an alcohol swab. Within five minutes, a sensory block to the T4 dermatome was achieved, which was adequate for surgery.

The patient's hemodynamic status remained remarkably stable throughout the entire intraoperative period. Hemodynamic parameters were recorded every minute for the initial 15 minutes post-block and every three minutes thereafter. The baseline blood pressure of 133/87 mmHg fluctuated minimally, remaining within a range of 125/75 mmHg to 110/65 mmHg. The heart rate stayed between 80 and 95 beats per minute. At no point did the patient experience hypotension (defined as a decrease in systolic blood pressure >20% from baseline) or bradycardia, and no vasopressor agents, such as phenylephrine or ephedrine, were required. A healthy female infant weighing 2150 g was delivered 8 minutes

after skin incision, with Apgar scores of 8 at 1 minute and 9 at 5 minutes. Following cord clamping, a 3 IU bolus of oxytocin was administered slowly over one minute, followed by a maintenance infusion of 20 IU in 500 mL of normal saline, run at 125 mL/hr, to prevent uterine atony while minimizing hemodynamic side effects. Total intraoperative fluid administration was judiciously limited to 800 mL of crystalloid to avoid volume overload. Given the patient's pre-existing anemia (Hemoglobin 7.7 g/dL), one unit of packed red blood cells was transfused intraoperatively. The estimated blood loss for the procedure was approximately 500 mL. The total duration of the surgery was 45 minutes.

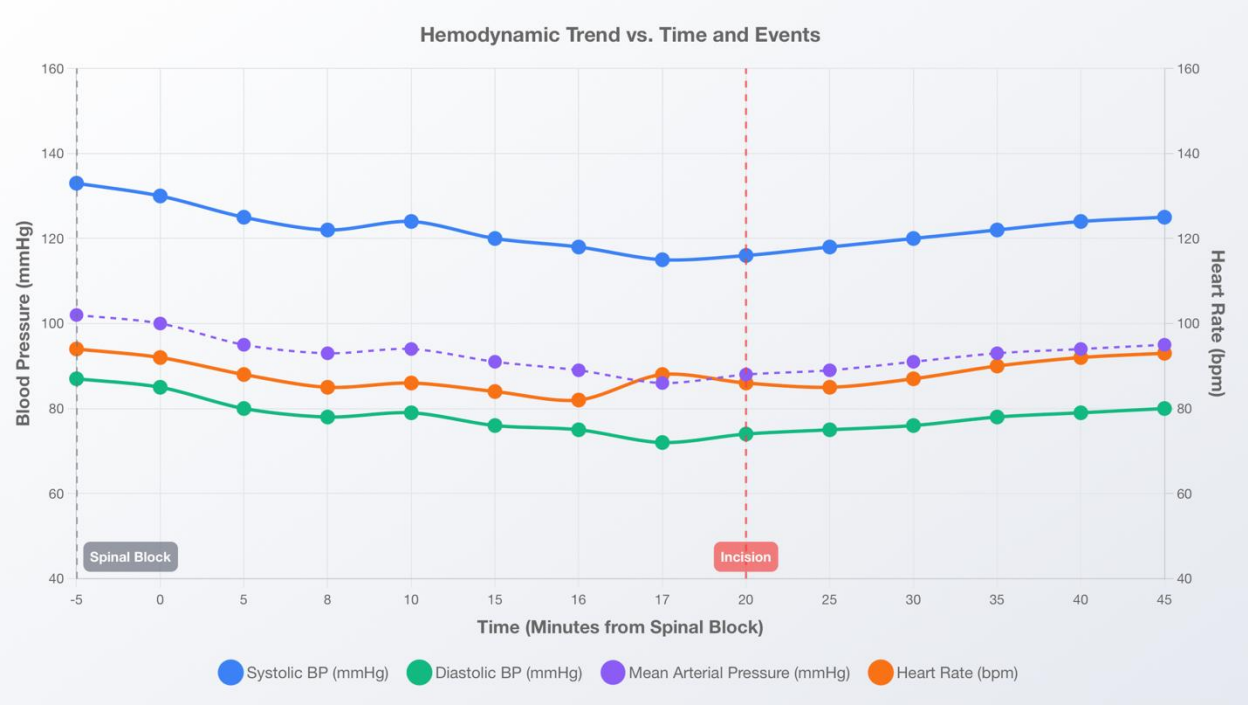

Figure 1. Intraoperative hemodynamic trend.

Post-procedure, the patient was transferred to the medical intensive care unit (MICU) for continuous cardiorespiratory monitoring and specialized care. Postoperative analgesia was effectively managed with intravenous paracetamol 1 gram every 6 hours and a patient-controlled analgesia (PCA) pump with morphine. She remained hemodynamically stable without any signs of respiratory compromise. Her respiratory status and dyspnea improved significantly within the first 24 hours post-delivery as the physiological load of pregnancy was removed. She was successfully mobilized on the third postoperative day and was discharged from the hospital on the seventh postoperative day. A comprehensive follow-up plan was arranged with both nephrology and cardiology services for the ongoing management of her chronic conditions. No anesthetic-related complications were observed during her hospital stay or at her one-month follow-up visit.

3. Discussion

This case report of a critically ill adolescent parturient presents a "perfect storm" of anesthetic challenges, converging at the levels of anatomy, pharmacology, and cardiovascular physiology. The successful outcome was not a matter of fortune but a

direct result of a methodological approach that leveraged modern imaging technology to deconstruct and solve each component of this complex clinical puzzle.[11] The discussion will focus on the pathophysiological underpinnings of these challenges and how ultrasound-guided neuraxial precision provided a definitive, integrated solution.

Figure 2. Timeline of clinical events.

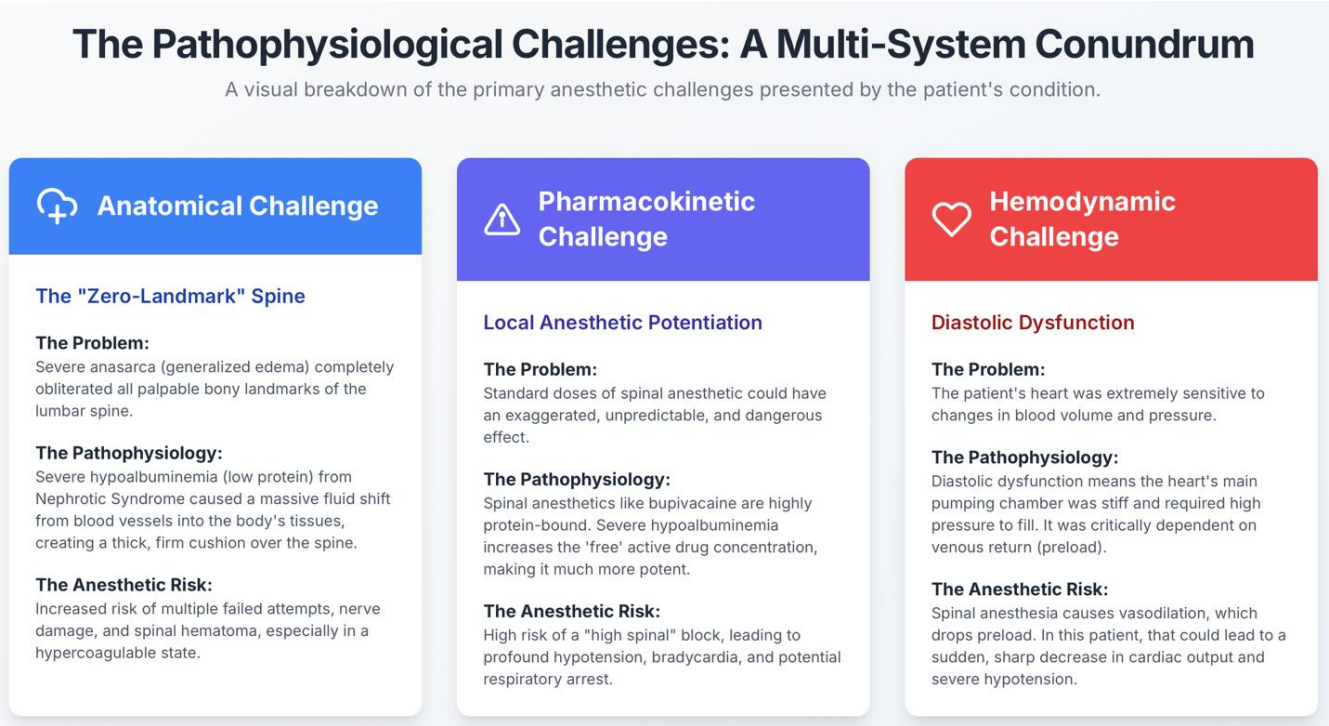

Figure 3. The pathophysiological challenges: a multi-system conundrum.

The most immediate obstacle in this case was the complete obliteration of palpable spinal landmarks (Figure 3). This was a direct physical manifestation of the severe hypoalbuminemia (1.9 g/dL) secondary to nephrotic-range proteinuria. According to the Starling principle, fluid distribution between the intravascular and interstitial compartments is governed by the balance between hydrostatic and oncotic pressures.[12] Albumin is the principal determinant of plasma oncotic pressure. Its severe depletion in this patient drastically reduced the intravascular oncotic pull, leading to a massive fluid shift into the interstitial space.[13] This process was exacerbated by the normal physiological changes of pregnancy, which include sodium and water retention and increased capillary hydrostatic pressure. The resulting anasarca created a thick, firm, edematous cushion over the lumbar spine, rendering the spinous processes and iliac crests—the foundational landmarks of neuraxial anesthesia—completely impalpable.

Attempting a landmark-based technique in such a "zero-landmark" scenario transforms a precision procedure into an exercise in dangerous guesswork.[14] Each failed needle pass through the edematous tissue increases patient discomfort, procedural time, and the risk of dural puncture, nerve root irritation, and intrathecal catheter shearing. More ominously, repeated needle trauma increases the risk of bleeding. In a patient with nephrotic syndrome-induced hypercoagulability (evidenced by a fibrinogen of 650 mg/dL), the potential for a clinically significant epidural hematoma—a rare but catastrophic complication that can lead to permanent paralysis—is significantly magnified.

The patient's severe hypoalbuminemia also posed a profound pharmacological challenge. Bupivacaine, the local anesthetic used, is highly protein-bound in the plasma (approximately 95%), primarily to albumin and alpha-1-acid glycoprotein. It is the small, unbound (free) fraction of the drug that is pharmacologically active and able to diffuse across

neuronal membranes to block sodium channels. In a state of severe hypoalbuminemia, the number of available binding sites for the drug is drastically reduced. This leads to a significant increase in the unbound, active fraction of bupivacaine for any given total dose administered.[15]

The clinical consequence of this altered pharmacokinetic profile is a potentiation of the drug's effect. A standard dose of spinal bupivacaine could lead to an exaggerated and unpredictable clinical response, including a higher-than-expected sensory block level (a "high spinal") and an increased risk of systemic toxicity. A high spinal block can ascend to the upper thoracic and cervical levels, causing profound bradycardia via blockade of the cardiac accelerator fibers (T1-T4), severe hypotension from extensive sympathectomy, and even respiratory arrest from phrenic nerve paralysis. In a patient with already compromised cardiac function, such an event would be poorly tolerated and potentially fatal. Therefore, the ability to confidently administer a prospectively reduced dose of bupivacaine directly into the target space was a critical component of the anesthetic plan.

The most subtle yet most dangerous challenge was the patient's cardiac physiology, defined by Grade II diastolic dysfunction. Diastolic dysfunction represents an impairment of ventricular relaxation (lusitropy), leading to a stiff, non-compliant left ventricle. This ventricle requires higher filling pressures (higher preload) to achieve an adequate end-diastolic volume according to the Frank-Starling mechanism. Consequently, the patient was critically dependent on her venous return to maintain stroke volume and cardiac output.[16]

Spinal anesthesia induces a potent sympatholysis below the level of the block, causing profound dilation of both venous capacitance vessels and arterial resistance vessels. The venodilation leads to pooling of blood in the periphery and a significant reduction in venous return to the heart—a sharp drop in preload. In a healthy heart, this is often compensated for by a baroreceptor-mediated increase in heart rate and contractility. However, in a heart with diastolic dysfunction, this sudden loss of preload can cause a precipitous fall in ventricular filling, leading to a dramatic decrease in stroke volume, cardiac output, and profound hypotension. The moderate mitral regurgitation further complicated the hemodynamic goals; while the afterload reduction from sympathectomy could potentially decrease the regurgitant fraction, this benefit would be negated by a critical drop in preload. This placed the patient in a very narrow physiological window, where both hypotension from inadequate preload and pulmonary edema from excessive fluid administration were imminent risks. The anesthetic technique therefore, had to produce the most controlled, predictable, and least disruptive sympathectomy possible.[17] Pre-procedural lumbar ultrasonography provided a direct, elegant, and integrated solution to these intertwined pathophysiological challenges. By utilizing sound waves to visualize the underlying anatomy, the technique rendered the unreliable tactile information from the edematous surface obsolete.

The systematic "pre-scan" protocol allowed for the unequivocal identification of the underlying bony structures, transforming the procedure from a blind probe into a targeted, image-guided intervention. The hyperechoic spinous processes and laminae were easily visualized despite the overlying edema, and the hypoechoic interspinous spaces were clearly delineated.[18] The crucial structure—the hyperechoic posterior complex representing the ligamentum flavum and dura mater—was identified with high resolution, providing an unambiguous target for the needle tip. This "sono-cartography" was pivotal.

Critically, the ultrasound provided an accurate, objective measurement of the skin-to-dura depth (4.6 cm). This single piece of data is invaluable in a patient with distorted anatomy. It informed the anesthesiologist precisely how far to advance the needle, mitigating the dual risks of under-insertion (leading to multiple, frustrating re-directions) and overshooting the target (risking anterior dural puncture, neural injury, or venous plexus trauma).[19] The direct result in this case was a clean, single-pass

needle insertion. This first-pass success is not merely a measure of efficiency; it is a critical safety outcome. It minimizes tissue trauma, thereby reducing the inflammatory response and the risk of hematoma formation in a hypercoagulable patient, and it significantly shortens the time to anesthetic delivery in an urgent clinical setting.

By guaranteeing first-pass success and ensuring precise delivery of the anesthetic into the intrathecal space, ultrasonography provided the procedural confidence necessary to employ the planned dose-reduction strategy. The ability to deposit a small, 10 mg dose of bupivacaine directly into the target compartment was a critical tactic to mitigate the risk of a high spinal in the context of hypoalbuminemia. This prevented an uncontrolled spread of anesthetic and a subsequent overwhelming sympathectomy.

The controlled, segmental block that resulted was sufficient for surgery (T4 level) without causing the abrupt and profound hemodynamic collapse often feared in patients with diastolic dysfunction undergoing spinal anesthesia. The controlled onset allowed the patient's compromised cardiovascular system to adapt to the gradual changes in preload and afterload. The remarkable hemodynamic stability observed in our patient—with no vasopressors required—was not a chance occurrence. It was a direct physiological consequence of the procedural and pharmacological precision afforded by the pre-procedural ultrasound examination. It allowed the anesthetic to be perfectly tailored to the patient's unique and challenging physiology.[20]

We acknowledge the inherent limitations of a single case report. The observed hemodynamic stability, while temporally and mechanistically associated with our precise anesthetic technique, cannot be definitively attributed to it alone, and other patient-specific compensatory factors may have played a role. The findings and the success of this specific approach, while compelling, are derived from an N=1 study and may not be immediately generalizable to all patients with similar comorbidities. However, the report serves as a robust proof-of-concept and a detailed methodological guide for a challenging clinical scenario.

4. Conclusion

This case of a critically ill adolescent parturient with nephrotic syndrome, decompensated diastolic heart failure, and severe anasarca highlights the profound limitations of traditional anesthetic techniques when faced with complex pathophysiology and distorted anatomy. Pre-procedural lumbar ultrasonography was not merely an adjunct but an essential, non-invasive enabling technology that was central to the safe and effective anesthetic management. By providing a clear roadmap of the underlying neuraxial structures, it facilitated a single-attempt subarachnoid block, which in turn enabled precise, pharmacologically informed dose administration. This cascade of precision contributed directly to maternal hemodynamic stability and a successful outcome for both mother and infant. In the modern era of high-risk obstetrics, these findings support the growing consensus that ultrasound guidance should be strongly considered as a primary technique, rather than a rescue tool, for any parturient in whom anatomical challenges are anticipated or hemodynamic fragility is a primary concern.

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