Pediatric Anesthesia and Critical Care Journal 2026;14(2):162-167
doi:10.14587/paccj.2026.23

PACCJ

Caudally threaded thoracic epidural analgesia for emergency anaesthetic management of an infant with congenital lobar emphysema in a resource limited setting. Case report

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Keypoints

Regional anaesthetic techniques can facilitate reduced postoperative ventilatory requirements and improved perioperative outcomes in infants undergoing thoracic surgery

Abstract

Congenital lobar emphysema (CLE) is a rare pulmonary malformation that may result in life-threatening respiratory distress during infancy.[1,2] Anaesthetic management is particularly challenging because positive-pressure ventilation can exacerbate lobar hyperinflation and precipitate cardiovascular compromise.[1,3,4]

Case Presentation: We report the case of a two-month-old female infant who presented with severe respiratory distress secondary to right upper lobe congenital lobar emphysema. Owing to progressive respiratory failure and the unavailability of intensive care unit beds and mechanical ventilators, an emergency right upper lobectomy was performed. Anaesthetic management included maintenance of spontaneous ventilation during induction, selective left mainstem bronchial intubation for lung isolation, and caudally threaded thoracic epidural analgesia for perioperative pain control. The patient underwent a successful lobectomy, was extubated immediately following surgery, and recovered without postoperative mechanical ventilation or major complications.

Conclusion: This case demonstrates that careful anaesthetic planning, effective lung isolation, and caudally threaded thoracic epidural analgesia can facilitate safe perioperative management and immediate extubation in infants with CLE.

Keywords

Congenital lobar emphysema, thoracic epidural analgesia, caudal epidural catheter, lung isolation, resource-limited settings.

Introduction

Congenital lobar emphysema (CLE) is a rare developmental pulmonary anomaly that typically presents during infancy, most commonly between four weeks and six months of age.[2,3,5,6] This condition occurs in approximately 1 in 20,000–30,000 live births. It demonstrates a male predominance, with a reported male-to-female ratio of 3:1. [2,5,6] Progressive overinflation of one or more pulmonary lobes, due to a "ball-valve" mechanism that causes air trapping during expiration, characterizes this condition.[1–3,7] This results in hyperinflation of the affected lobe, compression of adjacent lung tissue, mediastinal shift, and varying degrees of respiratory compromise.[6,8]

Infants managed conservatively often have mild forms of CLE, while symptomatic infants require surgical resection of the affected lobe.[4,5,7] Anaesthetic management presents unique challenges because positive-pressure ventilation can worsen lobar hyperinflation, impair venous return to the heart, and precipitate cardiovascular collapse.[2,4,7] Additional complexities include the

presence of associated congenital cardiac anomalies, reported in 12–14% of cases, and the limited availability of perioperative resources in low-resource settings, where postoperative mechanical ventilation may not be readily available.[1,4,7,9]

We present the case of a two-month-old infant with severe respiratory distress due to right upper lobe CLE who underwent emergency lobectomy using selective lung isolation and caudally threaded thoracic epidural analgesia in a resource-limited setting.

Case report

A two-month-old female infant weighing 4 kg was referred from a rural hospital with progressive respiratory distress despite treatment with intravenous ceftriaxone for a presumed pneumonia. Chest imaging demonstrated marked hyperinflation of the right upper lobe with significant leftward tracheal and mediastinal deviation, consistent with congenital lobar emphysema.

Upon admission, the patient exhibited severe respiratory distress characterized by laboured, shallow breathing and the use of accessory respiratory muscles. Their neurological status deteriorated from alert to responding only to painful stimuli on the AVPU scale. Simultaneously, her respiratory rate declined from 77 to 24 breaths per minute, raising concerns of impending respiratory failure and subsequent cardiac arrest.

Given the rapid clinical deterioration and the absence of available intensive care unit beds or mechanical ventilators, both locally or at nearby referral centers, a multidisciplinary decision was made to proceed with emergency right upper lobectomy. The medical team determined that delaying surgery while awaiting ventilatory support would likely result in a poorer outcome.

The team discussed the risks associated with anaesthesia and surgery extensively with the patient's family and obtained informed consent for high-risk procedures. The team liaised with the lab to prepare blood products in anticipation of potential intraoperative blood loss, as the patient was transferred to the operating theatre for emergency intervention (Figure 1).

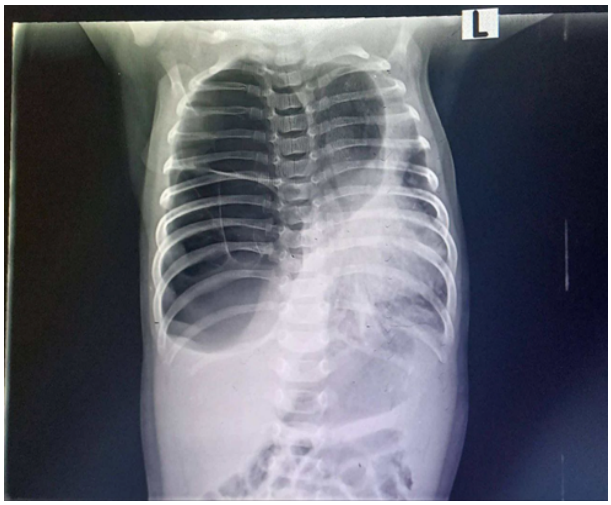

Figure 1. Preoperative chest radiograph demonstrating hyperinflation of the right upper lobe with leftward tracheal and mediastinal shift.

Anaesthetic Management

Upon arrival in the operating room, the patient was receiving 10 L/min of oxygen via a non-rebreather mask and had a 24-gauge intravenous cannula in situ. Standard American Society of Anesthesiologists (ASA) monitoring was applied, including electrocardiography, pulse oximetry, non-invasive blood pressure monitoring, and capnography.

Premedication consisted of atropine 20 µg/kg, followed by ketamine 0.5 mg/kg for light sedation. A 24-gauge arterial cannula was inserted into the right radial artery for continuous invasive blood pressure monitoring.

Anaesthesia was induced using sevoflurane while preserving spontaneous ventilation until successful lung isolation was achieved. This was crucial to ensuring safety by reducing the risk of further lobar hyperinflation and cardiovascular compromise.

Following induction, selective left mainstem bronchial intubation was achieved using a 3.5-mm microcuff endotracheal tube. The tube was advanced into the left main bronchus by rotating it 180 degrees and turning the patient's head to the contralateral side. Correct positioning was confirmed clinically by the absence of breath sounds

over the right hemithorax and adequate ventilation of the left lung.

Due to the unavailability of ultrasound-guided vascular access and central venous catheterisation during overnight hours, two additional 24-gauge peripheral intravenous cannulae were secured in the scalp and left hand. In anticipation of significant blood loss, a unit of cross-matched whole blood was prepared by the lab before surgery.

Fluid management included an initial 10 mL/kg bolus of normal saline followed by maintenance fluids consisting of normal saline supplemented with dextrose to achieve an approximate 2% dextrose concentration. Maintenance fluid administration was calculated according to the standard 4-2-1 rule. An additional 10 mL/kg bolus of Ringer's lactate was administered during the procedure.

Following successful lung isolation, fentanyl 2 µg/kg, paracetamol 10 mg/kg, and vecuronium 0.1 mg/kg were administered intravenously.

Anaesthesia was subsequently maintained with isoflurane at an end-tidal concentration of approximately 1%. Mechanical ventilation was instituted using pressure-controlled ventilation with a respiratory rate of 30 breaths/min, inspiratory pressures between 12 and 15 cmH_2O, an inspiratory-to-expiratory ratio of 1:1.5, and a positive end-expiratory pressure of 5 cmH_2O. Peak airway pressures were maintained below 25 cmH_2O throughout the procedure.

The patient was positioned in the left lateral decubitus position, ensuring that the dependent ventilated lung remained in the lower position to optimise ventilation-perfusion matching during one-lung ventilation.

For perioperative analgesia, a caudally threaded thoracic epidural catheter was inserted. Due to the unavailability of dedicated pediatric epidural sets, the 20-gauge epidural catheter was supplied with an 18-gauge, 80-mm epidural set. After sterile skin preparation with alcohol and povidone-iodine solution, the estimated distance from the sacral hiatus to the T5 vertebral level was measured externally and marked at 16 cm.

An 18-gauge angiocatheter was introduced into the caudal epidural space. Negative aspiration for blood and cerebrospinal fluid was confirmed. An adrenaline-containing test dose (1 µg/kg) was administered without haemodynamic changes suggestive of intravascular placement. Sixteen centimeters of epidural catheter was then advanced cephalad through the caudal route. Ultrasound examination performed on the first postoperative day confirmed catheter placement at approximately the T5–T6 level.

Because syringe infusion pumps were unavailable, intermittent epidural bolus administration was selected. An initial epidural bolus of 0.25% bupivacaine 0.5 mL/kg combined with preservative-free morphine 40 µg/kg was administered. Postoperatively, epidural analgesia was maintained using 0.1% bupivacaine 0.5 mL/kg with fentanyl 1 µg/mL administered at four-hour intervals.

Given the absence of ICU beds and the limited ability to safely administer continuous intravenous opioid infusions postoperatively, epidural analgesia served as the primary analgesic technique. Because epidural morphine carries a risk of delayed respiratory depression, the patient remained under close observation in the post-anaesthesia care unit for approximately 12 hours following surgery.

The surgical findings confirmed congenital lobar emphysema involving the right upper lobe, and lobectomy proceeded uneventfully. Oxygenation and haemodynamic parameters remained stable throughout the procedure. Total intraoperative fluid administration was 120 mL, estimated blood loss was 150 mL, and 60 mL of whole blood was transfused. At the conclusion of surgery, neuromuscular blockade was reversed using neostigmine and atropine. The patient was extubated awake and transferred to the post-anaesthesia care unit in stable condition.

Postoperative Course:

The thoracic epidural catheter provided effective analgesia for 72 hours, reducing the need for systemic opioids. Hemodynamics remained stable, and our patient was

comfortable throughout the hospital stay. Our patient initially required 1 L of intranasal O_2 support but was quickly weaned off in PACU. They had an uneventful ward stay with adequate pain control, tolerated per oral feeds well, and were discharged home one week postoperatively without complications.

Discussion

Congenital lobar emphysema (CLE) is a rare developmental pulmonary anomaly that can present with progressive respiratory distress during infancy.[1,2,7] The anaesthetic management of these patients is particularly challenging because positive-pressure ventilation may worsen hyperinflation of the affected lobe, resulting in mediastinal shift, impaired venous return, reduced cardiac output, and potentially catastrophic cardiovascular collapse.[4,5,7,9] These challenges are further amplified in resource-limited settings where access to paediatric intensive care, advanced airway devices, and postoperative ventilatory support may be limited.[1,4]

In the present case, the patient demonstrated progressive respiratory deterioration with evidence of impending respiratory failure. Given the lack of available intensive care beds and mechanical ventilators locally and at nearby referral centers, emergency surgical intervention was deemed necessary. This case highlights a common reality in low-resource environments, where clinicians must balance ideal management strategies against the constraints of available resources.[1]

A key principle in the anesthetic management of CLE is to avoid excessive positive-pressure ventilation before isolating the unaffected lung.[2,3,7] Similar approaches have been described by Nandi et al., Gogia et al., and Kotekar et al., who emphasized this approach prior to lung isolation. Maintenance of spontaneous ventilation during induction minimizes further inflation of the emphysematous lobe and reduces the risk of haemodynamic compromise.[3,7,10] In this patient, anaesthesia was induced using sevoflurane while preserving spontaneous respiration until successful left mainstem bronchial intubation was achieved.[4,5] The use of different inhalation and intravenous agents has been well documented, with halothane, sevoflurane, thiopental, and propofol being used to preserve spontaneous respiration.[1,3,5,10] The use of the sevoflurane approach provided effective lung isolation while avoiding the need for specialised paediatric one-lung ventilation devices, which were unavailable at our institution.[5,9,11]

Selective endobronchial intubation remains one of the most practical techniques for lung isolation in infants and neonates.[1,10,11] Double-lumen tubes and bronchial blockers are generally unsuitable or unavailable in this age group, particularly in resource-constrained settings.[2,3,5] In our case, successful left mainstem intubation was achieved using a standard microcuff endotracheal tube, allowing adequate surgical exposure and stable intraoperative oxygenation.

Postoperative respiratory management is another significant challenge in infants undergoing thoracic surgery.[1,10] Although early extubation is generally preferred following lobectomy for CLE, concerns regarding postoperative respiratory insufficiency, inadequate pain control, and limited physiological reserve often result in prolonged mechanical ventilation.[1,5] These concerns may be even more pronounced in resource-limited environments where access to intensive care resources is restricted. [1,12] Effective analgesia was therefore a central component of our perioperative strategy.[7,10] The use of a caudally threaded thoracic epidural catheter provided excellent perioperative and postoperative analgesia while minimizing the need for systemic opioids.[7,10,13] Adequate analgesia likely contributed to successful immediate extubation, improved respiratory mechanics, and avoidance of postoperative ventilatory support.[13,14] Although caudally threaded thoracic epidural catheters are widely described in the pediatric anesthesia literature, their use remains relatively uncommon in many low-resource settings due to limited training opportunities, equipment constraints, and concerns about catheter placement. [7,10]

Several methods were used to improve confidence in epidural catheter positioning. These included negative aspiration for blood and cerebrospinal fluid, administration of an adrenaline-containing test dose without haemodynamic evidence of intravascular placement, and the ease of injection through the catheter. Including subsequent ultrasound examination performed on the first postoperative day, confirming catheter location at approximately the T5–T6 level. [15] While fluoroscopy and ultrasound are the most reliable methods for confirming catheter placement, these modalities may not always be readily available in resource-limited settings. In such circumstances, a combination of established clinical techniques may provide a reasonable alternative when performed by experienced practitioners.

Another important physiological consideration in infant thoracic surgery is the risk of ventilation-perfusion mismatch with lung isolation.[1,3,4] Compared with older children and adults, infants have reduced functional residual capacity, increased chest wall compliance, and less efficient hypoxic pulmonary vasoconstriction, making them more susceptible to hypoxaemia during one-lung ventilation.[3,7] Lateral positioning further alters the distribution of pulmonary blood flow.[1,3,7] To minimise these effects, the patient was positioned with the dependent ventilated lung in the lower position, and lung-protective ventilation strategies were maintained throughout the procedure.[3,5,7] These measures likely contributed to the absence of significant intraoperative oxygenation difficulties.[2,7,16]

This case demonstrates that successful management of severe CLE is achievable even in resource-constrained settings.[1] Careful preservation of spontaneous ventilation during induction, selective lung isolation using readily available equipment, and the use of caudally threaded thoracic epidural analgesia facilitated emergency lobectomy, immediate postoperative extubation, and an uncomplicated recovery despite the absence of intensive care resources.[4,5,10] The case further highlights the potential role of regional anaesthetic techniques in reducing postoperative ventilatory requirements and improving perioperative outcomes in infants undergoing thoracic surgery (Figure 2,3).[10,13,17]

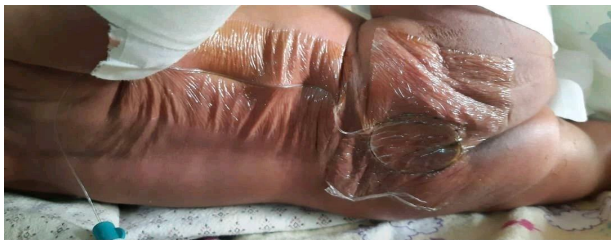

Figure 2. Caudally threaded Thoracic epidural catheter in situ on 1st post op day

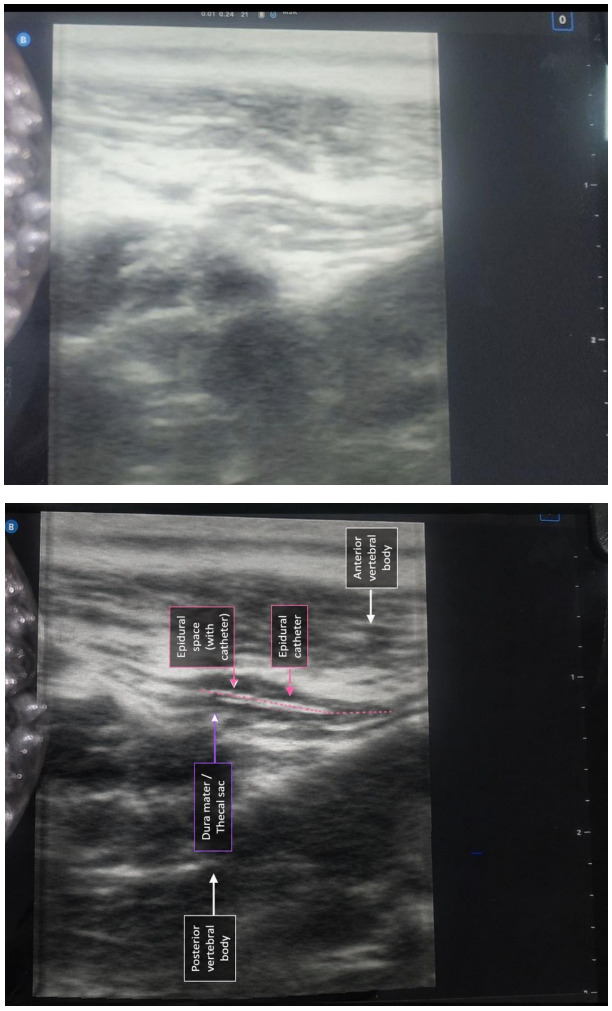

Figure 3. Ultrasound image of epidural catheter in situ.

Conclusion

CLE can present with life-threatening respiratory compromise in infants. In resource-limited settings, proper and meticulous anesthetic management planning, including lung isolation, maintenance of spontaneous

ventilation during induction, and effective use of regional analgesia, demonstrates the feasibility of immediate extubation and favorable outcomes without postoperative mechanical ventilation.

Limitations: Several limitations must be acknowledged, including the unavailability of dedicated pediatric epidural equipment, catheter placement performed with the available epidural set, the lack of fluoroscopic confirmation of epidural catheter placement, and postoperative verification of position using ultrasound. Additionally, resource constraints limited access to postoperative intensive care and advanced airway equipment.

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