

Beyond the Airway: A Case Report on Caudal Epidural Analgesia to Facilitate Neonatal TEF Repair

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ABSTRACT

Tracheoesophageal fistula (TEF) with esophageal atresia poses significant anesthetic challenges in neonates, especially when compounded by congenital anomalies such as cardiac defects. The anesthetic approach must balance airway management, hemodynamic stability, and postoperative recovery. We describe the perioperative care of a 2-day-old term female infant with type C TEF, imperforate anus, and associated cardiac malformations, including a small-to-moderate post-muscular ventricular septal defect (VSD) and patent foramen ovale (PFO) with left-to-right shunt. In this case, the use of caudal epidural analgesia constituted a key component of management in this case. A caudal epidural catheter was placed at induction, and postoperative ropivacaine infusion provided effective analgesia, eliminating the need for systemic opioids. This minimized the risk of respiratory depression, enabled early extubation, and supported hemodynamic stability. The neonate remained stable intraoperatively on controlled ventilation with low-dose inotropes and experienced an uneventful recovery. This case underscores the utility of regional analgesic techniques in high-risk neonatal TEF repair and 2D echo findings from prior reports that highlight both simple, resource-adapted airway strategies and comprehensive anesthetic planning to optimize outcomes in fragile neonates. Caudal epidural analgesia, when applied judiciously, enhances perioperative stability and reduces respiratory and cardiovascular complications, making it an invaluable component of multimodal neonatal anesthesia.

Introduction

Tracheoesophageal fistula (TEF), with or without esophageal atresia, is a rare congenital anomaly affecting approximately 1 in 2,500–4,500 live births [1-2]. It results from abnormal foregut development during embryogenesis, with both genetic and environmental factors implicated in its etiology. Over recent decades, survival outcomes have improved markedly with advances in neonatal intensive care and surgical techniques, with survival rates now exceeding 85–90% in many centers [1,3]. Nevertheless,

perioperative morbidity remains considerable, particularly in infants with very low birth weight or associated anomalies [4].

TEF often coexists with other congenital malformations, most notably as part of the VACTERL association, which includes vertebral, anorectal, cardiac, tracheoesophageal, renal, and limb anomalies [4-5]. Recognition of these associations is crucial, as they have a significant impact on perioperative management, prognosis, and long-term outcomes. Comprehensive preoperative evaluation of the cardiac, gastrointestinal, renal, and spinal systems is therefore essential in neonates with TEF to ensure safe and successful surgical intervention [5].

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Among the cardiac anomalies seen in TEF, ventricular septal defect (VSD) and patent foramen ovale (PFO) are relatively common and clinically significant [6-7]. A VSD allows abnormal communication between the left and right ventricles, predisposing to left-to-right shunting. In the perioperative setting, this can lead to pulmonary overcirculation, congestive heart failure, and impaired systemic perfusion, especially when pulmonary vascular resistance (PVR) falls [6]. Conversely, if PVR rises (e.g., due to hypoxia, hypercarbia, or acidosis), the shunt may reverse direction, resulting in right-to-left flow and systemic desaturation [6,8].

Similarly, a PFO—a remnant of fetal circulation that persists in many neonates—may remain functionally significant in the presence of elevated right atrial pressures [7]. In this context, it provides a potential pathway for right-to-left shunting and paradoxical embolism, which is particularly concerning during periods of hemodynamic instability or sudden changes in intrathoracic pressure [8].

Neonates undergoing surgical correction of TEF therefore require extremely careful and individualized anesthetic management when such intracardiac lesions are present [1,5-6]. The combined effects of airway compromise, positive-pressure ventilation, and cardiovascular instability create a precarious balance. Even minor disturbances in the ratio of systemic vascular resistance (SVR) to PVR can have profound consequences, precipitating pulmonary overcirculation, systemic hypoperfusion, or hypoxemia [5,9]. Meticulous maintenance of oxygenation, ventilation, acid-base balance, and hemodynamic stability is paramount to reduce the risk of perioperative morbidity in this vulnerable population [6,9].

Case Report

A 2-day-old, 2 kg female neonate, delivered by an elective lower segment caesarean section, posted for surgical repair of TEF. During delivery, difficulty in passing the nasogastric tube was encountered, and the neonate was found to have an imperforate anus.

Radiography revealed a coiled nasogastric tube in the pouch of the upper esophagus.

This raised the suspicion of VACTERL association. Supporting this suspicion, there was trouble in passing a nasogastric tube, and the neonate had an imperforate anus. Radiography showed a curled nasogastric tube in the upper esophageal pouch. The neonate presented with total apnea and required endotracheal intubation on day one. A 3.5 mm uncuffed endotracheal tube (ETT) was placed, and ventilation was initiated with synchronized intermittent mandatory ventilation (SIMV) with 21% FiO₂, 6 cm H₂O PEEP, a respiratory rate of 30 breaths per minute, and pressure control of 10 cm H₂O above PEEP.

Preoperative vital signs were heart rate 112/min and blood pressure 60/40 mmHg.

All laboratory investigations were within normal limits. Echocardiography demonstrated small-to-moderate post-muscular VSD and PFO with left-to-right shunting. Both were of major concern intraoperatively due to the risk of pulmonary overcirculation, hypoperfusion systemically, and potential reversal of shunt with hemodynamic instability.

In the operating theatre, standard ASA monitors were attached. After ensuring baseline stability, induction was performed with intravenous glycopyrrolate 0.004 mg/kg, midazolam 0.02 mg/kg, fentanyl 1 mcg/kg, and propofol 2 mg/kg. Neuromuscular relaxation was facilitated by the administration of atracurium 0.5 mg/kg. It was ensured that the neonate was getting ventilated by confirming equal and bilateral breath sounds and capnography.

After induction, a caudal epidural catheter was placed through a 20G Tuohy epidural needle with the patient in the left lateral position. The catheter was placed and fixed at 9 cm at the level of skin. The position of the catheter was confirmed with a test dose of 0.5 ml of 0.2% ropivacaine. Sevoflurane was used to maintain anesthesia in an air-oxygen mixture with intermittent doses of atracurium. 6-7 ml/kg/hr Ringer's lactate along with 2% dextrose was given; blood loss was negligible (~5 ml). Low-dose dobutamine infusion was used to correct intraoperative hypotension.

Hypoxia, hypercarbia, and acidosis were carefully avoided to avoid increases in PVR and exacerbation of left-to-right shunting.

Intraoperatively, upon repair of the tracheoesophageal lesion (TEF), there was an episode of desaturation, which was managed by increasing PEEP and providing 100% oxygenation. This led to adequate ventilation of the neonate.

Postoperatively, the neonate was electively ventilated in the neonatal intensive care unit. The caudal epidural catheter administered 0.1% ropivacaine at 0.2 ml/kg/h for pain control until the second postoperative day and was thereafter discontinued. Postoperative recovery was uneventful without respiratory or hemodynamic difficulties, and the patient was extubated on the first postoperative day. Follow-up with the cardiologist was advised in view of the cardiac condition.

Discussion

VACTERL association describes the constellation of vertebral, anorectal, cardiac, tracheoesophageal, renal, and limb anomalies [5]. In neonates with TEF, evaluation for these anomalies is essential, as they profoundly affect anesthetic planning and outcomes [5]. In our case, imperforate anus and TEF raised suspicion for VACTERL, with additional cardiac anomalies further complicating management.

Cardiac lesions such as VSD and PFO introduce major perioperative challenges. Shunt dynamics are highly sensitive to the balance between PVR and systemic vascular resistance (SVR). Increased left-to-right shunting may cause pulmonary overcirculation and systemic hypoperfusion, while right-to-left shunting can precipitate hypoxemia [6,8]. Controlled ventilation is therefore required to optimize oxygenation without destabilizing shunt flow, and hypoxia, hypercarbia, acidosis, or abrupt vascular shifts must be avoided [6,9]. Careful hemodynamic monitoring is critical in this setting [9].

Regional analgesia plays an important role in facilitating stability. Caudal epidural infusion provides effective pain relief, reduces opioid requirements, and supports early extubation, thereby improving respiratory function and minimizing opioid-induced depression [2,6-7]. These benefits make regional techniques especially valuable in neonates with EA-TEF and cardiac defects, where postoperative respiratory compromise can be life-threatening.

Ultimately, individualized anesthetic strategies remain central to successful outcomes. As Uzumcugil [1] and others highlight, multimodal approaches that integrate regional analgesia align with enhanced recovery after surgery (ERAS) principles now extending into pediatric and neonatal care [2,8]. Such tailored planning optimizes perioperative safety and long-term recovery in this vulnerable population.

Conclusion

In the present case, use of caudal epidural analgesia provided uninterrupted, effective postoperative pain relief that was a key factor in early extubation and uneventful recovery. This was done besides meticulous anesthetic management, including careful control of airway and close hemodynamic and oxygenation monitoring, further highlighting the need for multimodal anesthetic management. EA-TEF and concomitant cardiac anomalies like VSD and PFO require anesthetic

management emphasizing controlled ventilation, hemodynamic stability, and multimodal analgesia. Caudal epidural analgesia can be a key component in perioperative care, with advantages to postoperative respiratory function and general outcome in this high-risk group.

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