Case Series

Monitored epidural catheter placement-ultrasound-guided neurostimulation-aided thoracic catheter placement via caudal route for perioperative analgesia in neonatal thoracotomies: A technical feasibility study

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ABSTRACT

In this case series, we investigated the feasibility of combining ultrasound and neurostimulation for inserting a stimulating epidural catheter in the thoracic epidural space through the caudal route in neonates. Twelve neonates undergoing tracheo-oesophageal fistula repair under general anaesthesia were studied. The catheter was visible on ultrasound as a hyperechoic dot in the epidural space. Inadvertent high placement was identified in two neonates with neurostimulation, in whom the catheter was withdrawn to the thoracic epidural space, and the position was confirmed on ultrasound. A 0.5 ml/kg bolus dose of 0.125% bupivacaine injected through the epidural catheter was imaged in real-time in the epidural space. Block was effective in 10 neonates; two needed an additional local anaesthetic (LA) bolus. To conclude, ultrasound with neurostimulation facilitates accurate positioning of the caudally placed epidural catheter to the mid-thoracic level in neonates.

Key words: Caudal epidural, neonates, neurostimulation, stimulating catheter, thoracic epidural space, thoracotomy, ultrasound

INTRODUCTION

Traditional landmark-guided placement of thoracic epidural catheters via the caudal route is associated with a relatively high failure rate and catheter-related adverse events.[1,2] Neonatal thoracic epidural catheters are placed with neurostimulation under general anaesthesia.[3] Ultrasound can show the catheter tip in the axial and longitudinal planes, and the local anaesthetic (LA) spread in the epidural space.[4] We report a series of cases where the 'monitored epidural catheter placement (MECP)' technique of real-time ultrasound to place stimulating epidural catheters at the desired thoracic position implanted caudally was used.

CASES' DESCRIPTIONS

After approval from the hospital ethics committee (Paediatric Surgical Centre and Postgraduate Institute, Sangli, vide approval number 165), medical records of neonates who underwent repair of trachea–oesophageal fistula (TOF) through a right thoracotomy from June 2020 to December 2021 were retrieved. The records of 12 neonates were analysed. Consent was obtained for the publication of photographs or videos from the neonates' parents or guardians whenever they were recorded.

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All surgeries were performed within 48 hours post-birth after a brief preoperative evaluation and stabilisation. Neonates were shifted to the operating room with a secure 24G intravenous (IV) cannula. After attaching standard monitors, IV fentanyl 0.5 μg/kg was administered, anaesthesia was induced with sevoflurane and tracheal intubation with an appropriate-size endotracheal tube was performed under spontaneous breathing.

The neonates were positioned in the left lateral decubitus position; the caudal area was prepped and draped. A 19-gauge stimulating needle (PAJUNK, Germany) attached to a nerve stimulator (PAJUNK, Germany) was introduced in the caudal epidural space through the sacral hiatus. The ground electrode was placed on the upper trunk for lower extremity-evoked muscle responses (EMRs) and was shifted to the lower trunk as the catheter travelled cephalad. The current was set at 1.0 mA and raised by 0.1 mA until lower-limb EMR was measured. The current was kept constant while advancing the stimulating catheter (20-gauge catheter; PAJUNK, Germany) until the EMR of bilateral or unilateral thoracic intercostal muscles was obtained. The maximal current necessary to obtain the muscle response was recorded. Any catheter insertion issues, high catheter tip placement in the cervical epidural area or inability to elicit intercostal muscle contractions were retrieved.

Ultrasound was used once the catheter tip was positioned in the thoracic epidural space based on the evoked muscle contractions of the thoracic intercostal muscles. At this point, neurostimulation was stopped, and the position of the catheter tip was evaluated under ultrasound in the axial plane. The epidural catheter was identified on ultrasound imaging as a hyperechoic dot and double barrel in the axial and longitudinal planes. In the axial images, the catheter was visible as a hyperechoic dot in the posterior epidural space from 10 to 3 o'clock [Figure 1]. After confirmation of the catheter position in the mid-thoracic space (T4–T6), neurostimulation was again initiated, and an initial bolus of 0.5 ml/kg of 0.125% bupivacaine was injected. It was observed whether the EMR ceased after the LA injection. The linear ultrasound probe was deployed in a longitudinal plane during LA injection, and the distance the LA travelled was measured in vertebral levels. All the catheters were tunnelled cephalad and fixed. They were flushed with 1 ml (dead space of the catheter) of 0.9% saline and kept in a closed system for further use.

Following the disappearance of EMR after injection of LA in the thoracic epidural space, 0.5 mg/kg atracurium IV was injected, and controlled ventilation of the lungs was achieved with manual ventilation and a respiratory rate of around 25/minute.

Insertion and positioning of the catheter were successful in all 12 neonates. The contractions of mid-intercostal muscles with neurostimulation (mean (standard deviation (SD): 1.5(0.4)) mA [Figure 2] were seen in all the neonates except in two, where the

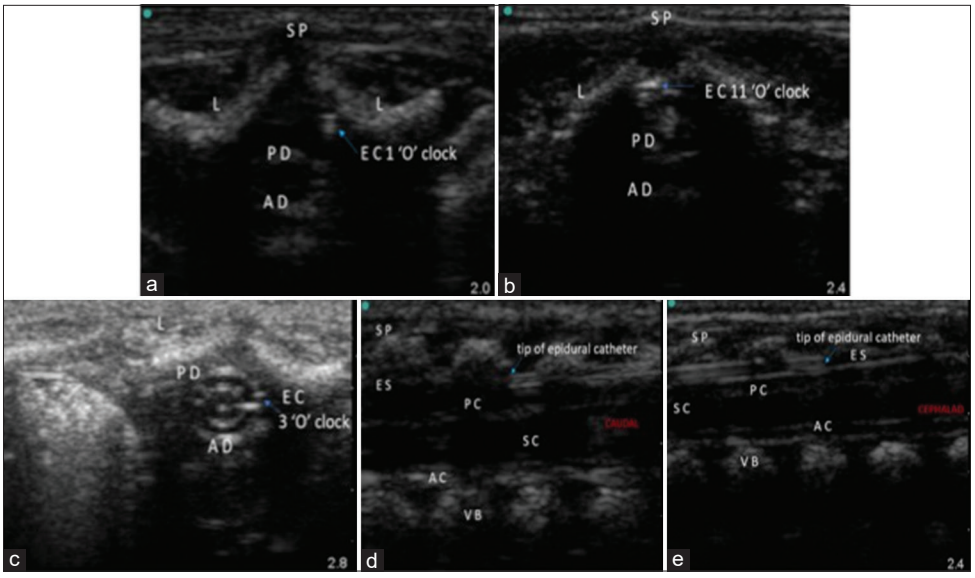

Figure 1: Catheter position in axial and longitudinal views. (a) Tip at 1 o'clock position in axial view. (b) Tip at 11 o'clock position in axial view. (c) Tip at 3 o'clock position in axial view. (d and e) Tip visualised in longitudinal view. SP = spinous process; L = lamina; PC = posterior complex; SC = spinal cord; AC = anterior complex; VB = vertebral body; EC = epidural catheter

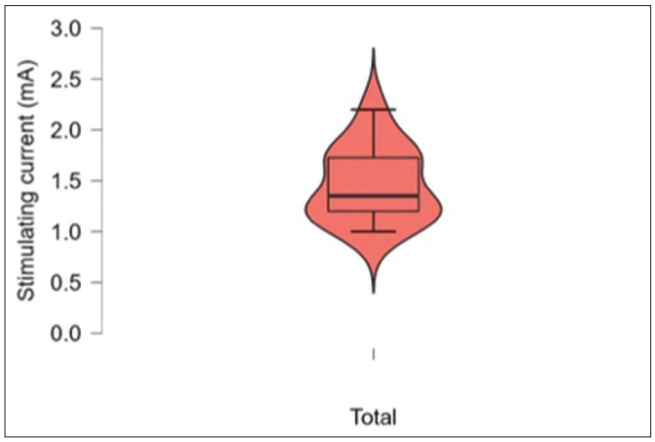

Figure 2: Mean (standard deviation) stimulating current used in the neonates (n = 12) is 1.47(0.36) mA. The horizontal line indicates the median stimulating current; boxes indicate the 25th and 75th percentiles; vertical lines indicate the 5th and 95th percentiles; the violin element of the plot shows the full distribution of the data around the median

catheter tip had reached the lower cervical epidural space as evident from shoulder abduction. Initial advancement using landmark-based measurements had resulted in higher positioning of the catheter. The catheter was withdrawn in these neonates until the shoulder's abduction ceased, and the thoracic intercostal muscle contraction was obtained. The EMR of the ipsilateral limb was visualised in seven neonates, the contralateral limb in four neonates and bilateral limbs in one neonate.

The catheter tip position was seen at 1 o'clock in four (n = 12), 2 o'clock in one, 3 o'clock in three, 10 o'clock in one (n = 12) and 11 o'clock in 3 neonates. On injecting a bolus of 0.5 ml/kg of 0.125% bupivacaine, the mean (SD) vertebral spread of the anaesthetic measured regarding vertebral levels in the neonates was 2.8 (0.4). There was a 10% rise in heart rate above baseline in two neonates during incision and thoracic manipulation, upon which IV fentanyl 0.5 μg/kg was given, and sevoflurane was increased. In these neonates, the epidural block was considered inadequate, and an additional top-up of 0.25 ml/kg of 0.125% bupivacaine was administered through the epidural catheter. At the end of the surgery, an acetaminophen suppository (25 mg/kg per dose) per rectal was introduced and repeated every 8 hours postoperatively. The trachea was extubated after the reversal of neuromuscular blockade with IV 0.5 mg/kg neostigmine and 0.01 mg/kg glycopyrrolate. Postoperative pain monitoring was performed with the Face, Legs, Activity, Cry, Consolability (FLACC) behavioural pain scale. An epidural injection of 0.25 ml/kg of 0.125% bupivacaine was injected six hours for postoperative analgesia. The epidural catheter was removed under supervision at the end of the 48-hour postoperative period and noted for signs of infection or inflammation.

All catheters were successfully removed at the end of 48 hours with no signs of inflammation at the catheter insertion site. Side effects of the central–neuraxial block, including intraoperative haemodynamic instability or postoperative respiratory insufficiency, were not seen in any patient. No neonate had any residual lower-limb neurological dysfunction at discharge.

DISCUSSION

Stimulating epidural catheters were successfully positioned in all 12 neonates at the desired level in the thoracic epidural space for right thoracotomies. Block efficacy with MECP was 83.33% (10/12); the block failure in two neonates could be due to using a low-volume bolus dose of LA (0.5 ml/kg of 0.125% bupivacaine). The catheters and spread of the bolus dose of LA were visualised in all the neonates on real-time ultrasound imaging.

The 'Tsui test', a technique of using electrical stimulation for accurate epidural catheter placement, ushered in a new era in paediatric epidural anaesthesia.[2] With the use of neurostimulation, the epidural catheters can be accurately positioned to the appropriate dermatomes, allowing for the benefit of lower volumes of LA for analgesia.[5] The neurostimulation success rate was higher than traditional landmark-guided caudal catheter placement (68% vs 84.9%).[6] Accurate single-bolus and catheter placement of the caudal catheter into the lumbar and thoracic epidural spaces is reported with ultrasound guidance without neurostimulation.[3] Tsui *et al.* recommended a 0.5–1.0 ml/kg bolus of 0.125% bupivacaine or 0.3% ropivacaine to establish the epidural block for paediatric patients under general anaesthesia.[7] Based on a previous magnetic resonance imaging (MRI) study, we chose a volume of 0.5 ml/kg spread over 2.6 vertebral levels.[8]

CONCLUSION

MEPC facilitates accurate positioning of the caudally placed epidural catheter to the mid-thoracic level in neonates. Ultrasound imaging in real-time is also helpful in assessing the spread of LA

in the thoracic epidural space. It may assist in decreasing the LA volumes in the neonate during a thoracotomy.

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Conflicts of interest

There are no conflicts of interest.

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