Clinical Reports

Continuous regional anaesthesia in infants

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Physiological immaturity of the respiratory musculature and central respiratory control centres leads to an increased risk of apnoea and respiratory complications following general anaesthesia in neonates. Regional anaesthetic techniques may obviate the need for general anaesthesia and lessen the risks of perioperative morbidity. Although these techniques have been described in infants, previous reports have dealt with single-shot techniques for brief surgical procedures (<60 min). Experience with prolonged operative cases using regional anaesthesia via indwelling catheters in infants is limited. We present our experience with four infants in whom either caudal epidural or spinal anaesthesia was administered via indwelling catheters for operative procedures that lasted 90 to 180 min. We believe this technique is an alternative to general anaesthesia in these patients.

A cause de l'immaturité physiologique de sa musculature et de son centre respiratoire, le nouveau-né est plus sujet à l'apnée et aux complications après une anesthésie générale. L'anesthésie régionale peut remplacer en partie l'anesthésie générale et diminuer ainsi la morbidité périopératoire. Les techniques régionales sont bien décrites pour l'enfant mais elles sont utilisées en doses uniques pour des interventions brèves (<60 min). L'expérience d'interventions sous régionale avec des cathéters en place est limitée. Nous présentons ici notre expérience avec quatre enfants auxquels on a administré une caudale ou une rachianesthésie continue pour des interventions de 90 à 180 min. Nous croyons que ces techniques sont des alternatives valables à l'anesthésie générale chez ces patients.

Key words

ANAESTHESIA: paediatric;

ANAESTHETIC TECHNIQUES: epidural, caudal, spinal.

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Several studies have suggested that premature infants and neonates have an increased risk of perioperative morbidity following general anaesthesia.^{1,2} Several factors have been proposed which may account for this, including immaturity of respiratory musculature and central respiratory control. Such immaturity leads to an increased incidence of perioperative apnoea and respiratory complications.¹⁻³ In addition, general anaesthesia in this age group requires tracheal intubation and mechanical ventilation and, as a consequence, some neonates may require postoperative mechanical pulmonary ventilation.

Regional anaesthetic techniques have been used in this group of patients as a means of avoiding the risks associated with general anaesthesia and obviating the need for postoperative mechanical ventilation.⁴⁻⁶ Although both caudal epidural and spinal anaesthesia have been utilized, the majority of reports have been with single-shot techniques, with little experience with the use of continuous regional anaesthesia.

The single-shot technique has certain limitations since the duration of surgical anaesthesia is usually only 60 to 90 min. Since some procedures may require more time, alternative regional techniques which provide more prolonged surgical anaesthesia are needed. We present our experience with continuous regional anaesthesia (caudal epidural or spinal anaesthesia) in four former premature infants with chronic lung disease who required intraoperative care during more prolonged surgical procedures.

Case reports

The pertinent past medical history and current medical condition of the four infants are summarized in Table I. The surgical procedure, its duration, the anaesthetic technique and agents are summarized in Table II. All four infants had residual bronchopulmonary dysplasia having required 4 to 14 wk of mechanical pulmonary ventilation for respiratory failure following premature birth. All infants had been weaned from mechanical ventilation and their tracheas extubated at least four weeks before the surgical procedure, but were still in the neonatal intensive care unit.

Catheter placement was accomplished with the infants in the lateral decubitus position after sterile betadine prep-

TABLE I Preoperative history and current medical condition of the four infants

Patient	Age (wks)*	Weight (kg)	Gestational age (wk)	Birth weight	Oxygen requirement	Medications
1	32	2.8	26	780 g	0.5 LPM†	HCTZ‡
2	30	2.6	28	900 g	0.5 LPM	HCTZ
3	20	1.9	30	1100 g	0.2 LPM	HCTZ, furosemide
4	22	2.1	29	1100 g	0.3 LPM	HCTZ, furosemide

*Post-partum age.

†LPM = litres per minute, oxygen.

‡HCTZ = hydrochlorothiazide.

TABLE II Surgical procedure, duration, and anaesthetic technique

Patient	Surgical procedure	Duration of surgery*	Anaesthetic technique/agents
1	Bilateral inguinal herniorrhaphy, repair of umbilical hernia, circumcision	2.5 hr	Continuous spinal – bupivacaine
2	Bilateral inguinal herniorrhaphy, circumcision	2 hrs	Continuous spinal – bupivacaine
3	Bilateral inguinal herniorrhaphy	2.5 hrs	Caudal epidural – chloroprocaine
4	Bilateral inguinal herniorrhaphy	1.3 hrs	Caudal epidural – chloroprocaine

*The duration of surgery includes the time involved in the sterile preparation and draping of the patient.

aration and local infiltration with 0.2 to 0.3 ml lidocaine 1% or chloroprocaine 3%. Routine intraoperative monitoring (ECG, pulse oximetry, cutaneous temperature, precordial stethoscope, and non-invasive blood pressure monitoring) was used in all four cases. Supplemental oxygen was delivered at the preoperative flow rate. An intravenous infusion was started before anaesthesia in two infants and after the onset of regional block in the others. Intraoperative fluids consisted of 5% dextrose 1/2 normal saline solution at $4 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{hr}^{-1}$. No intravenous or inhalational medications were administered during catheter placement or during the surgical procedure.

The two continuous spinal anaesthetics utilized a 24 gauge epidural catheter that was placed through a 20 gauge, 2" Crawford needle. The catheter was inserted 2 cm into the intrathecal space and placement was confirmed by aspiration of CSF. This catheter size was chosen due to recent reports concerning the risks of cauda equina syndrome in adults with the use of "microcatheters" (28 or 32 gauge).⁷ The initial dose in both cases consisted of $0.6 \text{ mg} \cdot \text{kg}^{-1}$ bupivacaine administered in 10% dextrose as a 0.5% solution. This resulted in a T_{2-4} sensory level as judged by gentle pinprick. Subsequent doses of $0.3 \text{ mg} \cdot \text{kg}^{-1}$ were administered as needed when the sensory level regressed to T_6 . This required redosing the catheters on an hourly basis.

Caudal epidural anaesthesia was accomplished using a 22 gauge intravenous catheter that was advanced through the sacrococcygeal membrane into the epidural space. Following placement, a T-piece which had been

flushed with chloroprocaine 3% was attached to the catheter and secured in place with a transparent bio-occlusive dressing. The initial dose included $2 \text{ ml} \cdot \text{kg}^{-1}$ chloroprocaine 3% (administered in fractionated doses of $0.5 \text{ ml} \cdot \text{kg}^{-1}$ at three-minute intervals) followed by a continuous infusion of chloroprocaine 3% at $2 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{hr}^{-1}$. The initial bolus doses resulted in a T_{2-4} sensory level in both patients. Subsequent bolus doses of $0.3 \text{ ml} \cdot \text{kg}^{-1}$ were administered if the infants acted as if they were in pain or if the sensory level regressed to T_6 .

Both the caudal epidural and spinal anaesthetic techniques provided adequate intraoperative analgesia. After the surgical procedures, motor and sensory function returned to baseline in 20 min. No complications related to the regional anaesthetic technique were noted in any of the four infants. All four infants were admitted to the neonatal intensive care unit and monitored for at least 48 hr with ECG, pulse oximetry, and an apnoea monitor. No episodes of apnoea, bradycardia or desaturation were noted.

Discussion

Advances in neonatal resuscitation and neonatology have led to a population of so-called "former premature infants" with multiple medical problems who may require anaesthetic care for various surgical procedures. Many of these procedures may be performed using "single-shot" regional blockade, but intraoperative difficulties may require a more prolonged anaesthetic. As such, the pre-

viously described "one shot" techniques may be inadequate. We have found that continuous regional anaesthetic techniques may be used, even in infants, to provide prolonged surgical anaesthesia.

The options for regional anaesthesia in these patients include either caudal epidural or spinal anaesthesia. The reported advantages of spinal anaesthesia include a lower dose of local anaesthetic (bupivacaine 0.6 to 1 mg · kg⁻¹ for spinal anaesthesia compared with 3 to 4 mg · kg⁻¹ for caudal epidural anaesthesia), a definitive end-point (CSF aspiration) with needle placement, quicker onset of action, more profound motor blockade with more complete muscle relaxation, and improved operating conditions.

The major disadvantage of spinal anaesthesia is an inability to identify the subarachnoid space especially in the preterm neonate. In addition, there are recent reports suggesting that neurotoxicity may follow continuous spinal anaesthesia in adult patients.⁷ These cases followed the use of a microcatheter (28 gauge) to provide continuous spinal anaesthesia. Although the exact mechanisms responsible for the neurotoxicity have not been identified, use of the microcatheter is no longer recommended.

The major disadvantage of caudal epidural anaesthesia is the relatively large doses of local anaesthetic which are required. Until recently, only local anaesthetics with long plasma half-lives such as lidocaine or bupivacaine were used for caudal epidural anaesthesia in infants and children. Most reports have used 3 to 4 mg · kg⁻¹ bupivacaine.^{4,6} Although such doses will not result in toxic serum concentrations following the initial dose,⁸ there is the risk of reaching toxic serum concentrations when repeated doses are needed. To avoid this, we chose to use continuous spinal anaesthesia in our first two patients when it was evident that the duration of anticipated surgical procedure was more than 90 min.

A recent report by Henderson *et al.*⁹ described the use of chloroprocaine for continuous caudal anaesthesia in infants. Due to its short plasma half-life of less than 60 sec, the risks of toxicity are less even after repeated dosing. In the report, chloroprocaine levels were measured in five patients. The levels were 0 in four patients and 0.5 mg · ml⁻¹ in the fifth at the end of the infusion.

Following this report, we decided to use continuous caudal anaesthesia in the last two patients. The reports of cauda equina syndrome in adults following continuous spinal anaesthesia and the success of caudal epidural anaesthesia with chloroprocaine prompted us to switch to caudal epidural anaesthesia as the initial approach. In our patients, we found a relatively rapid onset of total motor and sensory blockade (five to seven minutes) with chloroprocaine 3%. Therefore, the slow onset and incom-

plete motor blockade with previous reports of caudal epidural anaesthesia in infants may be a problem only with dilute concentrations of bupivacaine (0.2 to 0.25%).

As in adults, the use of regional anaesthesia in neonates may be associated with cardiorespiratory compromise. This risk may be greater in infants with residual bronchopulmonary dysplasia as a high thoracic block may lead to loss of chest wall muscle tone and function thereby compromising respiratory reserve and the ability to cough effectively and clear secretions. An extremely high block may, of course, affect central control of respiratory drive. Although we saw no such adverse effects in our patients, the limited number of patients in our series preclude any definite estimation of the risks of these effects. However, to prevent excessively high block, we recommend fractionating the initial bolus dose into increments of 0.5 ml · kg⁻¹.

An additional concern of these techniques is inadequate intraoperative anaesthesia which may occur even in the most experienced hands. Therefore, alternative means of anaesthesia must be available.

Cooperation between the anaesthetic and surgical teams is mandatory, since even with successful blockade, one is still left for two to three hours with an awake neonate. We have found that most infants will either sleep quietly or remain calm with a pacifier wetted with a glucose solution. Agitation unrelated to pain may require treatment with intravenous sedation. In our four patients, intravenous or inhalational agents were not needed. When practical it is best to avoid their administration, since they may lead to intraoperative and postoperative respiratory complications that the regional anaesthetic technique was meant to avoid.¹⁰ As experience with these techniques are still anecdotal, future controlled studies are needed to document their safety and efficacy when compared to general anaesthesia.

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