Psoas Compartment Block for Acute Postoperative Pain Management After Hip Surgery in Pediatrics

A Comparative Study With Caudal Analgesia

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Background: Lower-limb peripheral nerve blocks in pediatrics have gained much more popularity in the last few decades. Our purpose of this study was to compare the postoperative analgesic effects between psoas compartment block (PCB) and caudal block in small children undergoing open hip reduction/osteotomies.

Methods: Forty American Society of Anesthesiologists physical status I–II children aged 1 to 6 years planned to undergo open hip reduction/osteotomies were administered general anesthesia and then randomly assigned to receive 1 of 2 regional anesthetics: caudal block (group C, n = 20) or PCB (group P, n = 20). Ropivacaine 0.25% with epinephrine (5 μg/mL) was used in both blocks. The primary outcome of the study was the total consumption of morphine in the first 24 postoperative hrs. Secondary outcomes included dose of intraoperative fentanyl, occurrence of intraoperative hypotension or bradycardia, postoperative pain scores, time to first morphine analgesia, and occurrence of postoperative vomiting or urine retention.

Results: The cumulative dose of morphine administered in the ward in the first postoperative 24 hrs and the time to first rescue morphine dose were higher in group C than in group P ($P < 0.001$). There were no differences between the 2 groups regarding intraoperative and postoperative complications except for the incidence of urine retention, which was higher in group C than in group P ($P = 0.037$).

Conclusions: Use of single-shot PCB is superior to single-shot caudal block regarding length of postoperative analgesia and cumulative dose of morphine in small children undergoing open hip reduction/osteotomies.

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Lower-limb peripheral nerve blocks in pediatrics have gained much more popularity in the last few decades.[1] However, caudal block is still the most common regional anesthesia technique in pediatrics.[2] Some of advantages of lower-limb peripheral nerve blocks include prolonged analgesia after a single injection, unilateral block, avoidance of hypotension, and decreased incidence of urine retention.

Psoas compartment block (PCB) is used to target the lumbar plexus lying in the substance of the psoas major muscle. This block results in anesthesia of 6 nerves: iliohypogastric, ilioinguinal, genitofemoral, femoral, obturator, and lateral femoral cutaneous nerves. It has been successfully used to provide excellent postoperative analgesia in adults after hip surgeries.[3–8] Some approaches were described to perform PCB in pediatrics.[9,10] However, no comparative studies between PCB and caudal analgesia were published in pediatrics undergoing hip surgeries. Open hip reduction/osteotomy is one of the common operations in pediatric orthopedic practice to treat developmental dysplasia of the hip.

The main objective of our prospective randomized study was to compare the postoperative analgesic effects between PCB and caudal block in young children undergoing open hip reduction/osteotomies.

METHODS

After local institutional review board approval and parental informed written consent were obtained, 40 American Society of Anesthesiologists (ASA) physical status I or II children aged 1 to 6 years scheduled for inpatient open hip reduction/osteotomies for congenital hip dislocation were enrolled. The enrollment period lasted from January 2007 to July 2008 in King Faisal Specialist Hospital and Research Center in Riyadh. Exclusion criteria included severe obesity (body mass index >35 kg/m^2), coagulopathy, spine deformity, infection of the skin over the sacral or lumbar spine, neuromuscular diseases, children with mental changes, and children known to have allergy to amide local anesthetics. All patients were premedicated with oral midazolam 0.5 mg/kg 15 to 20 mins before the procedure. As being inpatients, all children had an intravenous (IV) catheter in place through which general anesthesia was induced. After applying standard monitoring (electrocardiography, pulse oximetry, and noninvasive blood pressure) general anesthesia was induced by IV fentanyl 2 μg/kg and propofol 3 to 4 mg/kg. Hyperventilation with bag and mask was performed using sevoflurane 3% to 4% with 60% nitrous oxide in oxygen to facilitate endotracheal intubation without muscle relaxation. Lungs were then mechanically ventilated to normocarbia as monitored by capnography. Patients were randomly assigned to receive either caudal block or PCB using computerized randomization tables. The randomization was implemented by the central operating theater pharmacist who provided the allocation code in a sealed envelope, which was opened after endotracheal intubation. Ropivacaine 0.75% (Naropin 7.5 mg/mL; AstraZeneca, Wilmington, Del) was diluted to 0.25% using normal saline. Epinephrine 5 μg/mL was freshly added to the local anesthetic solution a few minutes before the block.

Caudal Block (Group C)

The patients were put in the lateral position. Caudal area was then sterilized and draped. A caudal injection of ropivacaine 0.25% with epinephrine 5 μg/mL, 1 mL/kg, was administered using 22-gauge IV cannula. Local anesthetic was administered slowly with frequent intermittent aspirations to exclude intravascular or intrathecal injections.

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Psoas Compartment Block (Group P)

The patients were put in the lateral position with the side of the operation uppermost. Using a skin marker, a line was drawn connecting the 2 iliac crests (intercrestal line). A second line parallel to the spine and passing through the posterior superior iliac spine was drawn. The distance between the intersection of these 2 lines and the midline was divided into 4 equal quadrants. The needle entry site was the connection of the medial ¾ and the lateral ¼ of this horizontal line.[9] After sterilization and draping, an insulated and marked 50-mm, 22-gauge stimulating needle was introduced perpendicularly and connected to a nerve stimulator (Stimuplex; Braun, Melsungen, Germany). Contraction of the quadriceps femoris was sought starting with 1.5-mA output (frequency, 2 Hz; time, 100 msecs). If bone (transverse process of L4) was contacted, the needle was withdrawn and redirected caudally to walk off the bone. If bone was not contacted or quadriceps contraction was not attained at a depth similar to that described by Dalens et al,[10] the needle was withdrawn and redirected upward, downward, or laterally until a response was elicited. The position of the needle was judged to be correct when the quadriceps contractions were still elicited with 0.5-mA output. Ropivacaine 0.25% with epinephrine 5 μg/mL, 1 mL/kg, was then administered slowly with frequent intermittent aspirations. Injection pressure was monitored with an inline pressure monitor (BSmart; Concert Medical LLC, Norwell, Mass). If pressure exceeded 15 psi, the needle was withdrawn a few millimeters to avoid intraneural injection.

After finishing the block (caudal or PCB), patients were then put supine and sevoflurane concentration decreased to 1.5% to 2%. The block was judged to be adequate if the patient did not move in response to the surgical incision (at least 20 mins after placement of the local anesthetic) and his/her heart rate and blood pressure did not increase greater than 10% from their values before the skin incision. Hypotension (>20% from baseline) was treated by incremental doses of IV ephedrine 0.1 mg/kg every 5 mins. Bradycardia was treated by IV atropine 10 μg/kg. Sustained increase of blood pressure and heart rate was considered as inadequate block and treated with IV fentanyl 1 μg/kg as needed. Sevoflurane was discontinued at the end of surgery and tracheal extubation was accomplished while the patient was awake. Patients were then transferred to the postanesthesia care unit (PACU) for a 2-hr observation period. The recovery nurses were blinded to patient allocation.

Pain was assessed in the PACU using modified CHEOPS (Children's Hospital Eastern Ontario Pain Scale) pain score (Table 1).[11] If pain score exceeded 3, patients received IV fentanyl 0.5 μg/kg every 5 mins as needed. Pain score was assessed and recorded 1 and 2 hrs postoperatively in the PACU. Plantar and ankle reflexes in both feet were elicited by recovery nurse. Absence of the reflexes in both feet was considered as evidence of epidural block.

After transferring the patients to the surgical ward, pain scores were assessed at 4, 8, 12, 16, 20, and 24 hrs postoperatively.

TABLE 1. Modified CHEOPS Pain Score (0–10)[11]

Score	0	1	2
Cry	No	Crying, moaning	Scream
Facial	Smiling	Composed	Grimace
Verbal	Positive	None or other complaint	Pain complaint
Torso	Neutral	Shifting, tense, upright	Restrained
Legs	Neutral	Kick, squirm, drawn-up	Restrained

TABLE 2. Patients and Procedure Characteristics

	Group C (n = 20)	Group P (n = 20)
Age, mean (SD), y	3 (1.3)	2.7 (1.4)
Sex, n (male/female)	7/13	8/12
Body mass index, mean (SD), kg/m^2	24.9 (3.2)	24.6 (3)
ASA, n (I/II)	9/11	8/12
Duration of surgery, mean (SD), min	114 (15.4)	112.3 (16.7)
Type of osteotomy, n		
Periacetabular	11	10
Proximal femur	5	4
Combined	4	6
Duration of anesthesia, mean (SD), min	144 (18.1)	139 (17.6)
Duration of block performance, mean (SD), min	6.6 (1.2)	7.4 (1.6)

Nurses of the ward were also blinded to patient group allocation. Morphine IV 0.1 mg/kg was administered by the ward nurses 3- to 4-hourly as needed (if CHEOPS pain score exceeded 3). Time to first morphine dose was recorded, and the total dose administered in the first postoperative 24 hrs was calculated. Vomiting was treated with ondansetron IV 0.1 mg/kg 8-hourly as needed. Urine retention and need for catheterization were recorded. The study period lasted for 24 hrs postoperatively.

The primary outcome of the study was the total consumption of morphine in the first 24 postoperative hrs. From our retrospective work on pediatrics undergoing lower-limb and urologic procedures, we found that the required mean morphine dose in the first 24 hrs was 0.41 (SD, 0.15) mg when patients received bupivacaine 0.25% as caudal analgesia (data not published). We assumed that a 40% difference of morphine consumption between the 2 groups would be clinically significant. A sample size was calculated to be 19 at an α error of 0.05 and a β error of 0.1. We enrolled 20 cases per group to accommodate for dropouts. Secondary outcomes included dose of intraoperative fentanyl, occurrence of intraoperative hypotension or bradycardia, postoperative pain scores, time to first morphine analgesia (from placement of the block), and occurrence of postoperative vomiting or urine retention.

Statistical analyses were performed using the SPSS for Windows, version 15 (SPSS Inc, Chicago, Ill). Data were first tested for normality by Kolmogorov-Smirnov test. Normally distributed continuous data were analyzed by using Student *t* test. Non–normally distributed continuous and ordinal data were analyzed using Mann-Whitey *U* test. Categorical data were analyzed by a χ^2 or Fisher exact test as appropriate. The results are presented as mean ± SD, median (range), or number of patients as appropriate. $P < 0.05$ was considered statistically significant.

RESULTS

Sixty-three patients were found eligible for the study. Parents or guardians of 14 patients refused participation, and 9 children met our exclusion criteria. Forty patients were randomized to 2 groups: caudal (C) group (n = 20) and PCB (P) group (n = 20). No patient was excluded from the study.

TABLE 3. Intraoperative and Postoperative Opioid Consumption

	Group C (n = 20)	Group P (n = 20)
Intraoperative fentanyl, median (range), μg/kg	2 (2–3)	2 (2–3)
Patients needed supplemental fentanyl, n (%)	4 (20)	6 (30)
Time to first morphine dose, median (range), hrs	6.7 (4.9–9.3)	14.5 (11.8–19)*
Total morphine dose in first postoperative 24 hrs, mean (SD), mg/kg	0.41 (0.07)	0.19 (0.05)†

*$P < 0.001$.
†$P < 0.001$.

The 2 study groups were found to be similar in terms of age, sex, ASA classification, body mass index, types of osteotomies, and durations of surgical procedures, anesthesia, and block performance (Table 2).

The doses of fentanyl needed intraoperatively were similar in the 2 study groups (Table 3). The cumulative dose of morphine administered in the ward in the first postoperative 24 hrs and the time to first rescue morphine dose were significantly higher in group C than in group P (Table 3).

During injection of the local anesthetic in group P, it was necessary in 5 patients to withdraw the needle a few millimeters to avoid high injection pressures (>15 psi). There were no statistically significant differences in pain scores between groups at any of the determined 8 time points (Table 4).

Table 5 shows the incidence of intraoperative and postoperative complications in the 2 study groups. All the patients in group C showed loss of plantar and ankle reflexes in both lower limbs. Only 1 patient in PCB showed loss of the reflexes in both lower limbs and evidenced as having had an epidural spread.

DISCUSSION

Our study shows that the use of PCB with general anesthesia in children undergoing open hip reduction/osteotomies is superior to caudal block in terms of decreased postoperative morphine consumption and increased duration of analgesia.

Psoas compartment block is considered a relatively safe block in experienced hands. Only a small number of pediatric anesthesiologists perform this block, whereas caudal epidural block is performed by almost all pediatric anesthesiologists. Reluctance of many anesthesiologists to perform PCB especially in pediatrics stems from the bad reputation of this block in some case reports.[12–15] Major complications of PCB reported in literature include retroperitoneal hemorrhage, renal hematoma, and total spinal. However, in all prospective studies investigating PCB, none of these complications have been reported.[4,6–10] This can be presumably explained by lack of experience in performing PCB in those who reported major complications, using too high or too medial approaches or by publication bias by only reporting the major mishaps. However, good experience is needed to perform this block, and its use may not be rationalized in surgeries that do not cause severe postoperative pain, for example, inguinal hernia repair. We have been performing this block for years (>5 years) in our institute without major complications. Average number of cases exceeds 50 cases per year.

TABLE 4. Postoperative Pain Scores

Time	Group C (n = 20)	Group P (n = 20)
Postoperative 1 hrs	1 (0–1)	0 (0–1)
Postoperative 2 hrs	0.5 (0–1)	0 (0–1)
Postoperative 4 hrs	1 (0–1)	1 (0–1)
Postoperative 8 hrs	2 (1–3)	0 (1–2)
Postoperative 12 hrs	1 (1–2)	1 (0–2)
Postoperative 16 hrs	1.5 (1–2.5)	1 (1–2)
Postoperative 20 hrs	1 (1–2)	1 (0.5–2)
Postoperative 24 hrs	1 (1–2)	1 (1–1.5)
Patients experiencing pain scores ≥3	8 (40)	5 (25)

Data are presented as median (interquartile range) or n (%).

TABLE 5. Intraoperative and Postoperative Complications

Variable	Group C (n = 20)	Group P (n = 20)
Intraoperative hypotension	2 (10)	1 (5)
Intraoperative bradycardia	0 (0)	0 (0)
Postoperative emesis	8 (40)	4 (20)
Postoperative urinary retention*	6 (30)	1 (5)†

Data are presented as n (%).
*Needs intermittent catheterization to empty the bladder.
†$P = 0.037$.

In PCB, we used the landmarks prescribed by Dadure et al.[9] These computed tomography–based landmarks showed successful block in 15 consecutive children with no major complications. Again, our blocks seemed to be successful in all our patients with minimal manipulations of the needle to attain quadriceps femoris contraction in response to peripheral nerve stimulation.

Epidural spread of local anesthetic is a relatively common adverse effect of PCB especially with Chayen approach, which allowed medial direction of the needle.[16] This may even result in dangerous intrathecal injection of the local anesthetic. To decrease the incidence of this adverse effect, we avoided medial direction of the local anesthesia needle. We also avoided injecting the local anesthetic at pressures higher than 15 psi. This pressure limit is the routine in our local practice, and we actually use it based on anecdotal data. Interestingly, and after finishing our cases, Gadsden and colleagues[17] found that limiting injection pressure to less than 15 psi in PCB is a safeguard against neuraxial spread of the local anesthetic when compared with injecting at pressures more than 20 psi. They had to terminate the study early because of the high incidence (50%) of neuraxial block reported in the high-pressure (>20 psi) group. With these precautions, only 1 patient of PCB group (5%) had an evidence of epidural spread. So the morphine-sparing effect noted in the PCB group was most probably due to the effect of lumbar plexus block, not the epidural block.

The duration of PCB in previous studies ranged from 4 to 15 hrs, depending on the type and volume of the local anesthetic.[3,18] It is very difficult to compare between these studies because of the diversity of used local anesthetics, their concentrations, and the role of additives. The median duration of block in our PCB group as evidenced by first rescue morphine dose was 14.5 hrs, which is considered long. This may be due to

the long-acting effect of ropivacaine, the high volume used, and the addition of epinephrine to the injectate. We used the maximum safe dose allowed for ropivacaine to increase the volume of injectate. This resulted in a prolonged block in most patients and attained a duration that is almost double that attained by caudal block. It is important to emphasize that adding morphine to caudal block would prolong postoperative analgesia, which was not the case in our study.

Postoperative vomiting in the first 24 hrs tended to be higher in group C, but it did not reach a statistical significance. This tendency was most probably due to the higher morphine consumption in group C and not due to the type of block. Increased incidence of urine retention in group C might also be related to increased morphine consumption or to the caudal block itself. Data are conflicting regarding the effect of caudal analgesia on voiding,[19,20] while morphine is well known to cause urinary retention and urodynamic problems.[21] However, our study was not designed or powered enough to detect the effect of the block on voiding.

Use of continuous PCB using a catheter in postoperative period allowed extending analgesia for 24 to 48 hrs.[3] Unfortunately, we could not use this technique in our patients because most of hip osteotomies were followed by hip cast (spica) application, which encroached the site of catheter exit from the skin.

In conclusion, use of single-shot PCB is superior to single-shot caudal block for postoperative analgesia in small children undergoing hip osteotomies in terms of more prolonged duration of analgesia and less cumulative dose of morphine in the first 24 postoperative hrs. However, use of this block in children needs good knowledge and experience to avoid major complications.

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