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Effects of Ultrasound-Guided Thoracic Paravertebral Block on Postoperative Pain in Children Undergoing Percutaneous Nephrolithotomy

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Abstract

Objective: To compare the effects of ultrasound-guided thoracic paravertebral block (PVB) and intravenous paracetamol on postoperative pain control in paediatric patients undergoing percutaneous nephrolithotomy (PNL).

Methods: Forty patients aged 1-5 years, with an American Society of Anesthesiologists physical status I-II, scheduled for PNL were enrolled into this prospective randomised controlled trial. After arrival in the operating room, all patients were administered standardised general anaesthesia. Patients in Group PVB received ultrasound-guided PVB using bupivacaine 0.5% at a total volume of 0.5 mL kg^{-1} at the vertebral levels T11, T12 and L1. Patients in Group P were administered paracetamol intravenously (15 mg kg^{-1}) before the beginning of surgery. Patients in both groups were given tramadol (1 mg kg^{-1}) for supplemental analgesia. Patient demographics, haemodynamic parameters, peripheral oxygen saturation and sevoflurane concentration were recorded. The Face, Legs, Activity, Cry and Consolability pain scores; satisfaction of parents; the number of patients requiring supplemental analgesia; and complications were evaluated during the postoperative period.

Results: Pain scores were significantly lower in Group PVB compared with Group P (p=0.001). There were no analgesic requirements in Group PVB; however, all patients needed a supplemental analgesic in Group P. Parental satisfaction was higher in Group PVB than in Group P.

Conclusion: This study demonstrated that ultrasound-guided PVB provides more effective postoperative analgesia with no side effects compared to intravenous paracetamol in children undergoing PNL.

Keywords: Children, nerve block, paracetamol, postoperative pain, ultrasonography

Introduction

Percutaneous nephrolithotomy (PNL) is widely used in the treatment of renal calculi. However, the dilatation of surrounding tissues due to the nephrostomy tube placement can cause postoperative pain (1). Various analgesic techniques, such as systemic analgesia and central and peripheral nerve blocks (intercostal and paravertebral blocks) are used to provide postoperative analgesia for PNL in adult patients (2-4).

Currently, the use of peripheral nerve blocks applied with landmark-based techniques, nerve stimulators or ultrasound guidance helps to improve postoperative pain management in children (5). In the literature, several studies have indicated that paravertebral block (PVB) provides effective analgesia for various surgical procedures in paediatric populations (6-9). The mechanism of PVB is the penetration of local anaesthetic into the intercostal and sympathetic nerves within the paravertebral space (10).

This study was presented as poster in the meeting of Asian Society of Peadiatric Anaesthesiologists (8-10 May 2014/Istanbul, Turkey).

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Paracetamol is a non-opioid analgesic used widely for postoperative pain in children. It also has an antipyretic effect. Endogenous opioid, serotonergic and nitric oxide pathways are thought to contribute to the mechanism of its analgesic action. It can be administered via the intravenous (IV), rectal or oral route. It has been reported that the maximum plasma concentration is achieved faster with IV paracetamol than with oral and rectal routes. The analgesic effect of paracetamol begins within 15 min following intravenous administration, and it lasts 4-6 hours (11).

For adult patients, ultrasound-guided PVB is widely performed in many surgical procedures, including breast surgery and thoracotomy (12, 13). However, there is a limited number of studies concerning ultrasound-guided thoracic PVB in children (14-16). Thus, the primary aim of our study was to compare the effects of ultrasound-guided thoracic PVB and intravenous (IV) paracetamol on postoperative analgesia based on pain scores in children undergoing PNL surgery. The secondary aim was to evaluate parental satisfaction and requirements for supplemental analgesia in children.

Methods

After obtaining Cukurova University Ethics Committee (Approval no. 20/8-2013) approval and written informed parental consent, 40 children aged 1-5 years, with an American Society of Anesthesiologists (ASA) physical status I-II, who were scheduled for elective PNL, were included in this study. The exclusion criteria were parental refusal, spine deformities, cutaneous infection, bleeding diathesis, allergy to drugs used in the study, or an ASA physical status of III-IV.

Patients were given no premedication. All children were monitored with electrocardiogram and pulse oximetry, and their blood pressure was measured non-invasively after arriving to the operating room with their parents. After the induction of anaesthesia with 2%-8% sevoflurane, venous access was established, and all patients received 5-10 mL kg^{-1} h^{-1} Ringer's lactate solution. After muscle relaxation was ensured with rocuronium bromide (0.5 mg kg^{-1}, IV), the patients were intubated. Anaesthesia maintenance was provided with 1%-2% sevoflurane and a mixture of 50% nitrous oxide and oxygen. The sevoflurane concentration was adjusted to maintain haemodynamic parameters within ±25% of preoperative baseline values. If needed, fentanyl (1 μg kg^{-1}) was used for intraoperative analgesia. The intraoperative inspired sevoflurane concentration, systolic and diastolic blood pressures (SBP and DBP), heart rate (HR) and peripheral oxygen saturation (SpO_2) were recorded at 5, 10, 15, 30, 45, 60, 90 and 120th minutes.

Using a computer-generated list, the patients were randomly allocated into two groups to receive either ultrasound-guided PVB (n=20, Group PVB) or IV paracetamol (n=20, Group P). Randomisation was done before the surgery. The patients (or their parents) and the anaesthesiologist who performed the PVB were aware of the allocated arm, but the outcome assessors were kept blinded to the allocation. All PVBs were performed by the same anaesthesiologist experienced in ultrasound-guided nerve blocks in children. After intubation, all patients were placed in the prone position. A 15 MHz linear ultrasound probe (MyLabFive ESAOTE, Maastricht, Netherlands) was placed in the vertical-caudal plane, and the spinous process, transverse process and paravertebral space at each vertebral level from T10 to L1 were identified from midline to lateral. After the skin was cleansed with 10% povidone-iodine solution and draped in a sterile manner, a 5 cm, 22-G insulated needle (Stimuplex; B. Braun Medical Inc, Bethlehem, PA, USA) was inserted. The needle was advanced from the sagittal direction using the in-plane technique. After entering the costotransverse ligament and obtaining a negative aspiration test, a one-third dose of 0.5 mL kg^{-1} of bupivacaine 0.5 % was injected at each dermatome level. Appropriate spread of local anaesthetic (LA) was confirmed with the anterior movement of the pleura in the paravertebral space. The patients in Group P were administered paracetamol (15 mg kg^{-1}, IV) after being placed in the prone position. At the end of PNL, a nephrostomy drainage tube was placed in each patient.

Anaesthesia was discontinued after moving into the supine position at the end of surgery. Neuromuscular blockage was reversed with 15 μg kg^{-1} of IV neostigmine and 50 μg kg^{-1} of IV atropine. All patients were extubated after adequate spontaneous breathing, and then they were transferred to the postoperative recovery room.

Postoperative pain was evaluated with the Face, Legs, Activity, Cry and Consolability (FLACC) scale. The FLACC scale is an observational scoring system used to evaluate postoperative pain of infants and young children aged between 2 months and 7 years. Each parameter is scored between 0 to 2, and the total score ranges from 0 (no pain) to 10 (maximum pain) (17). If the FLACC score was higher than 4, patients in both groups were administered supplemental tramadol (1 mg kg^{-1}, IV). FLACC scores, rescue analgesics, SBP, DBP, HR, SpO_2 and side effects of hypotension, bradycardia, respiratory problems, nausea or vomiting, and local anaesthetic systemic toxicity (LAST) were recorded postoperatively at 5, 10, 15 and 30 minutes and 1, 2, 4, 6 and 12 hours. Additionally, parental satisfaction was evaluated after the surgery, using a 3-point scale (excellent, good or unsatisfied). Postoperative assessments of the patients' pain and parental satisfaction were performed by an anaesthesiologist 12 hours after the surgery.

The pain level was the primary outcome, while the secondary outcome measures were additional analgesic requirements and parental satisfaction in the postoperative period.

Statistical analysis

The sample size was estimated as a minimum of 19 subjects for each study group to find a 30% difference in FLACC scores between the groups based on a previous study (9), at a significance level of 5% and a power of 95%. A statistical analysis was performed using the IBM Statistical Packages for the Social Sciences version 22.0 statistical software package (IBM SPSS Corp.; Armonk, NY, USA). Data were reported as the mean±standard deviation or number (%). The chi-squared test was used to compare categorical measurements between the two groups. The Mann-Whitney U test was used for anaesthesia and surgery time and for the FLACC scores. The statistical significance level was set at 0.05 for all tests.

Results

The demographic data, anaesthesia and surgery time were similar in both groups (Table 1). FLACC scores were significantly lower in Group PVB than in Group P (p=0.001) (Table 2). There were no postoperative analgesic requirements in Group PVB. However, 20 patients in Group P required supplemental analgesia in the postoperative period; 19 received tramadol in the first 10 min and 1 received tramadol in the first hour. All patients in Group PVB had FLACC scores <4 during the study period. Patients with FLACC scores of <4 in Group P are shown in Table 3. Parental satisfaction scores were higher in Group PVB than in Group P (Table 4).

No significant difference was found between the two groups in intra- and postoperative haemodynamic parameters. Intraoperative inspired sevoflurane concentrations were significantly lower in Group PVB than in Group P, except at the 5-min measurement (p=0.001).

No side effects, such as hypotension, bradycardia, respiratory problems, nausea or vomiting and LAST were observed in any of the patients.

Table 1. Demographic data of the groups

	Group PVB (n=20)	Group P (n=20)	p
Age (years)	2.77±1.24	3.30±1.40	0.217
Height (cm)	100.15±14.75	106.90±16.45	0.180
Weight (kg)	12.10±2.35	13.37±2.82	0.129
Surgery time (min)	58.65±18.97	61.15±18.99	0.745
Anaesthesia time (min)	66.75±19.28	64.25±19.62	0.501

Data are presented as the mean±standard deviation

Table 2. FLACC scores

Time	Group PVB (n=20)	Group P (n=20)	p
5 min	1.25±1.48*	6.05±1.60	0.001
10 min	0.80±1.32*	5.65±1.72	0.001
15 min	0.35±0.93*	4.25±1.33	0.001
30 min	0.05±0.22*	3.95±1.05	0.001
60 min	0.05±0.22*	2.50±1.90	0.001
2 h	0.05±0.22*	1.80±2.11	0.001
4 h	0.05±0.22*	1.00±1.65	0.034
6 h	0.05±0.22*	0.85±1.38	0.015
12 h	0.05±0.22*	0.60±1.09	0.034

Data are presented as the mean±standard deviation. *p<0.05, compared with Group P. FLACC: face, legs, activity, cry and consolability

Discussion

The results of this study showed that ultrasound-guided PVB is effective against postoperative pain in children undergoing PNL surgery, and it reduced the additional analgesic requirements.

Although tubeless PNL is currently widely performed for renal calculi, a nephrostomy drainage tube was used based on the preference of the surgical team. However, nephrostomy drainage tube has some disadvantages, such as leading to a prolonged hospital stay and increased analgesia requirements (18, 19). We found that ultrasound-guided PVB provided sufficient pain relief for 12 hours after the PNL surgery. Most of the studies in the literature are related to PVB applied using land-

Table 3. The number of patients with FLACC Scores <4

	Group PVB (n=20)	Group P (n=20)
10 min	20 (100%)	1 (5%)
15 min	20 (100%)	6 (30%)
30 min	20 (100%)	8 (40%)
60 min	20 (100%)	13 (65%)
2 h	20 (100%)	15 (75%)
4 h	20 (100%)	19 (95%)
6 h	20 (100%)	19 (95%)
12 h	20 (100%)	20 (100%)

Data are presented as the number and percentage. FLACC: face, legs, activity, cry and consolability

Table 4. Parental satisfaction scores

	Group PVB (n=20)	Group P (n=20)	Total (n=40)	p
Excellent	2 (10%)	0 (0%)	2 (5.0%)	0.001
Good	18 (90.0%)	4 (20.0%)	22 (55.0%)	
Unsatisfied	0 (0%)	16 (80.0%)	16 (40.0%)	

Data are presented as the number and percentage (%) of patients

marks or nerve stimulators, and these studies support our finding that PVB effectively reduces postoperative pain in children (6-8). On the other hand, the number of studies related to ultrasound-guided PVB in children is limited (14, 15, 20). Qi et al. (14) reported that ultrasound-guided bilateral PVB reduces postoperative pain scores in children undergoing the Nuss procedure. In two other studies, a catheter was inserted within the paravertebral space, and then LA infusion with 0.2% ropivacaine was performed (15, 20). These studies demonstrated that ultrasound-guided PVB provided satisfactory pain control in the postoperative period. For clinicians, the use of ultrasound for paravertebral block will be helpful for the real-time visualisation of neurovascular structures, reduced LA dosages and prevention of serious complications (21, 22).

In our study, none of the children who underwent ultrasound-guided PVB needed any additional analgesia during the postoperative 12-hour period. In a series of 4 cases related to the inguinal region surgery reported by Eck et al. (23), patients with PVB did not need additional opioids during the first 24 hours postoperatively. Similar studies have shown that PVB, which can be applied via landmarks or nerve stimulators, decreases the use of supplemental analgesia when compared to other methods, such as ilio-inguinal, epidural, or caudal blocks (6-8, 24, 25). Although IV paracetamol is used for postoperative pain control in children, the present study indicated that ultrasound-guided PVB is superior for postoperative analgesia compared to IV paracetamol (11). Furthermore, in the present study, the children in Group P had the FLACC scores <4 in the postoperative period. This can be explained by the analgesic efficiency of tramadol used for supplemental analgesia (26). Additionally, our study showed that ultrasound-guided PVB provided satisfactory analgesic management according to the parents.

PVB can be performed using single- or multiple-injection techniques. The radiographic and sensorial distributions of multiple injections are more comprehensive and secure than single injections, which may indicate greater efficacy in neural tissues (27). However, previous studies have claimed that the multiple-injection technique in PVB may increase the risk of possible complications, including vascular injury, pneumothorax, pleural puncture haematoma, pain at the injection site and epidural/intrathecal spread (8, 9, 24). The single-injection technique has a lower incidence of complications due to less exposure to needle punctures (28). Nevertheless, Berta et al. (6) stated that the vascular puncture rate was 8.3% with the single-injection technique. On the other hand, a study on the multiple-injection technique reported that local tenderness at the injection points was experienced in only 3 patients, with no other complications (24). We did not observe any complications with the multiple-injection technique. In accordance with our study, Qi et al. (14) showed that despite the use of bilateral PVBs, there were no complications. These results support the use of ultrasound in PVB to allow visualisation of adjacent structures, thus reducing complications (21). Additionally, PVB leads to less postoperative nausea, vomiting and hypotension compared to other regional techniques (29). None of these complications occurred in any of our patients.

Although ultrasound-guided peripheral nerve block in children reduces the dosage of LA agents, there is a limited number of studies related to optimal dosage regimens (30, 31). In the literature, it is recommended not to exceed the maximum dose of bupivacaine (2.5 mg kg^{-1}) due to possible LAST (32). Ponde et al. (33) stated that bupivacaine 0.5 % at dose of 0.5 mL kg^{-1} was successfully applied in ultrasound-guided infraclavicular brachial nerve block in children. Similarly, bupivacaine 0.25% (1 mL kg^{-1}) was used in caudal block (34-36). A study on caudal block in children undergoing surgery for congenital pyloric stenosis was reported by Moyao-García et al. (37), who reported that the frequency of major complications was low for caudal block with bupivacaine 0.25% (1.6 mL kg^{-1}). Similarly, we achieved effective postoperative analgesia with 0.5 mL kg^{-1} of bupivacaine 0.5%, and no complications occurred based on the LA dose.

A limitation of this study was that there was only a 12-hour follow-up period after the surgery due to a lack of staff for observation. Another limitation of the study was the absence of a sham block technique, so the study did not include a control group. In addition, although our study demonstrated that ultrasound-guided PVB reduced the inspired sevoflurane concentration, we did not measure the amount of sevoflurane consumption. Nevertheless, our findings may provide a positive contribution for children, as exposure to anaesthesia in early childhood is associated with adverse neurodevelopmental outcomes (38).

Conclusion

Ultrasound-guided thoracic PVB provides more effective postoperative analgesia compared to IV paracetamol, without any side effects, in children undergoing PNL surgery.

Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of Çukurova University School of Medicine (Approval no. 20/8-2013).

Informed Consent: Verbal and written informed consent was obtained from all parents.

Peer-review: Externally peer-reviewed.

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– E.G.; Literature Review – G.A., E.G.; Writer – G.A., Z.H.; Critical Review – D.O.; Other – G.A.

Conflict of Interest: The authors have no conflicts of interest to declare.

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