Application of Ultrasound-guided Caudal Block: Anesthesia in Pediatric Percutaneous Nephrolithotomy

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Abstract: Objective: Evaluation of ultrasound-guided caudal block anesthesia in pediatric percutaneous nephrolithotomy. Methods: Fifty children undergoing percutaneous nephrolithotomy were equally and randomly divided into general anesthesia group (Group G) and ultrasound-guided caudal block combined with general anesthesia group (Group C). The recovery time, emergence agitation and postoperative complications of the two groups were observed. The children in Group G received general anesthesia with tracheal intubation, and the children in Group C received tracheal intubation general anesthesia after caudal block. The consumption of intraoperative opioids was compared, the postoperative recovery time, emergence agitation and early postoperative pain score were observed, and the postoperative complications were recorded. Results: The number of opioid analgesics in Group C was less than that in Group G (P <0.05). Recovery time in Group C was shorter than that in Group G, and CHIPPS score in Group C was less than Group G in PACU (P <0.05). The incidence of emergence agitation in Group C was significantly less than that in Group G (P <0.05). The incidence of nausea and vomiting in Group C was significantly less than those in Group G (P <0.05). Conclusions: Ultrasound-guided caudal block can be safely used in pediatric percutaneous nephrolithotomy. Caudal block can reduce the dosage of opioid analgesics, improves the quality of recovery and the effect of postoperative analgesia. It is easy to operate and has fewer complications.

1 INTRODUCTION

Urinary calculus is a common and frequently-occurring disease in urology, while urinary calculus in children accounts for 2 ~ 3% of total urolithiasis (Castagnetti 2010). Studies have pointed out that kidney stones disease has been increasing at all ages in recent years, which leads to an increasing number of patients needing corresponding surgical treatment (Zeng 2018). With the development of urology endoscopy, most children's upper urinary tract stones are treated by endoscopy, with the characteristics of less injury, high success rate and fewer complications (Hong 2018). Children need general anesthesia because it is hard for them to cooperate during operation, and combined caudal block anesthesia is gradually paid attention to because of the advantages of a small amount of general anesthetic, quick recovery after an operation and so on. Ultrasound-guided caudal block is simple and safe, giving attention to both surgical anesthesia and postoperative analgesia, and has been gradually used in pediatric surgery (Ecoffey 2010). In this study, ultrasound-guided caudal block combined with general anesthesia was used in pediatric percutaneous nephrolithotomy and compared with general anesthesia with tracheal intubation alone, and the recovery time, restlessness during recovery and early postoperative pain were observed, which remained a reference for clinical practice.

2 MATERIALS AND METHODS

2.1 General Information

This study was approved by the Medical Ethics Committee of our hospital, and informed consent was signed with the parents or legal guardians of the children. From December 2019 to March 2021, 50 children undergoing elective percutaneous nephrolithotomy in our hospital were selected, all of whom were with unilateral kidney calculi, 32 males and 18 females, aged 3-6 years, with ASA I or II. The

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blood routine and coagulation function were normal before an operation, and there was no obvious abnormality in liver and kidney function, no obvious oropharynx, head and neck deformity or activity disorder, and no diseases of the central nervous system and blood system. There was no skin infection or sacrum deformity in the sacrococcygeal region. Children were randomly divided into general anesthesia group (Group G) and ultrasound-guided caudal block combined general anesthesia group (Group C), with 25 cases in each group.

2.2 Methods

Children were routinely fasted and forbidden to drink before surgery, and dexmedetomidine was dripped intranasally at 1 ug/kg, alternately dripped into bilateral nostrils, and gently rubbed the nasal wings on both sides for 2 ~ 3 times. After entering the operating room, the peripheral venous access was opened, oxygen was inhaled with a conventional mask, HR, BP, ECG and SpO2 were monitored, and the corresponding type of endotracheal tube was selected according to the age. In Group C, the children were given ultrasound-guided caudal block anesthesia, and the children were in the left lateral position. After routine disinfection and towel laying, the local anatomical structure of sacral hiatus was observed with a 10 ~ 15 MHz linear array probe using a color Doppler ultrasound instrument (GE Venue 50). The probe was placed in a sterile plastic sleeve, perpendicular to the long axis of the body (cross-section), and gradually moved upward from the tailbone until a typical sacral hiatus image appeared (Fig. 1). The puncture needle was inserted at the midpoint of the probe using the out-of-plane technique. After a sense of breakthrough appeared or when the cross-section of the needle shaft in the sacral hiatus was seen under ultrasound, the bloodless or cerebrospinal fluid was pumped back, and then 0.2% ropivacaine was injected 1ml/kg (Wang 2015). During caudal solution injection, ultrasound showed that the sacral hiatus was dilated (the sacrococcygeal ligament was lifted), which indicated that the caudal solution was injected into the sacral hiatus. Anesthesia intubation was performed after nerve block took effect and no adverse reactions such as local anesthetic poisoning or total spinal anesthesia were confirmed.

Two groups of children were given an intravenous injection of propofol medium/long-chain fat emulsion injection 3 ~ 3.5 mg/kg, fentanyl citrate injection 2 ug/kg and rocuronium bromide injection 1 mg/kg for anesthesia induction. After mechanical ventilation with the Omeda anesthesia machine, the operation was started, continuous monitoring of end tidal carbon dioxide Pressure ($P_{ET}CO_2$) was maintained at 35 ~ 45 mmHg. During the operation, remifentanil hydrochloride was injected intravenously for 5 ~ 10 ug kg^{-1} h^{-1}, and sevoflurane was inhaled for 2% ~ 3% to maintain anesthesia, with an end-tidal concentration of 0.8 ~ 1.0 MAC. After the operation, remifentanil hydrochloride and sevoflurane were stopped, and the children were sent to PACU after spontaneous breathing returned to normal, swallowing and cough reflex became active, and the endotracheal tube was pulled out, oxygen was inhaled through the mask, and vital signs were stable.

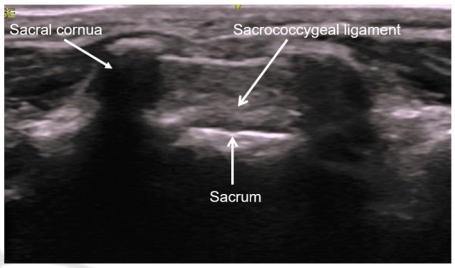

Figure 1: Ultrasound image of sacral hiatus.

2.3 Observation Indicators

The dosage of opioid analgesics during the operation was recorded in the two groups, and the recovery time and the occurrence of restlessness during the recovery period were observed. The recovery time was from the end of operation to the time of pulling out the endotracheal tube. After entering PACU, the agitation was evaluated by five-point scale: 0: drowsiness, wakefulness; 1: Quiet, sober and cooperative; 2: Crying, need appeasement; 3: Crying and fidgeting are serious, unable to comfort, but do not need braking; 4: dysphoria, disorientation, need to press and brake, 3 points or 4 points mean restlessness. 15 minutes after being sent to PACU, the postoperative pain of children was evaluated by the CHIPPS scoring method, and the behaviors such as crying, facial expression, trunk posture, leg posture and restlessness were scored. Each item was subdivided into three levels, and the scores were recorded as 0, 1 and 2 points step by step, with a total score of 10 points. The higher the total score, the higher the degree of pain. The CHIPPS score ≥ 4 points suggested the need for joint analgesic drugs. The postoperative complications such as nausea, vomiting, hypoxemia, laryngeal spasm and reflux aspiration were recorded. All operations were performed in the same operating room, and all children were graded by anesthesiologists in PACU.

2.4 Statistical Analysis

Data were analyzed using the SPSS19.0 software (SPSS Inc., Chicago, IL, USA). Data were presented as mean ± standard deviation (SD). Comparisons among multiple groups were performed using a one-way analysis of variance. Data within groups were analyzed using analysis of variance with repeated measurements. $P < 0.05$ was considered statistically significant.

3 RESULTS

3.1 Comparison of General Data of Children between the Two Groups

There is no significant difference in sex composition, age, body weight and operation time between the two groups ($P > 0.05$), as shown in Table 1.

Table 1: Comparison of general information between two groups.

	Group C (n=25)	Group G (n=25)
Gender (Male/Female)	15/10	17/8
Age (years)	4.2±2.5	4.5±2.7
Body mass (kg)	15.8±3.6	16.3±4.2
Operation time (min)	82.5±30.1	96.3±37.4

3.2 Comparison of the Number of Opioid Analgesics Used in the Operation between the Two Groups

The amount of opioid analgesics used in the operation of Group C is less than that in Group G, and the difference is statistically significant ($P < 0.05$), as shown in table 2.

Table 2. Comparison of consumption of intraoperative opioids between two groups

	Group C (n=25)	Group G (n=25)
Remifentanil (ug)	126.5±31.8*	224.6±47.2
Fentanyl (ug/kg)	2.5±0.3*	3.4±0.7

Compared with Group G: *$P < 0.05$.

3.3 Comparison of Recovery Time and Postoperative CHIPPS Score between the Two Groups

The recovery time in Group C is shorter than that in Group G, and the CHIPPS score in Group C is smaller than that in Group G, the difference is statistically significant ($P < 0.05$), as shown in table 3.

Table 3. Comparison of recovery time and CHIPPS scores between two groups.

	Group C (n=25)	Group G (n=25)
Awaking time (min)	10.3±4.5*	16.7±5.2
CHIPPS score (points)	2.5±0.7*	4.3±1.1

Compared with Group G: *$P < 0.05$.

3.4 Comparison of Restlessness and Postoperative Complications between the Two Groups

The children in Group C were mostly quiet after tracheal extubation, and the incidence of restlessness in Group C was significantly less than that in Group G ($P < 0.05$), and the incidence of nausea and vomiting in Group C was less than that in Group G ($P < 0.05$). There was no hypoxemia, laryngospasm and reflux aspiration in both groups, as shown in table 4.

Table 4: Comparison of emergence agitation and complication between two groups.

	Group C (n=25)	Group G (n=25)
Nausea and Vomiting	2 (8.0)*	5 (20.0)
emergence agitation	3 (12.0)*	12 (48.0)

Compared with Group G: *$P < 0.05$.

4 DISCUSSION

Caudal block is commonly used in children's inguinal region surgery, urinary system surgery and lower limb surgery, and it is combined with general anesthesia in clinical practice. The anesthesia effect is exact, which can reduce the number of general anesthetics during operation, exert ideal muscle relaxation and analgesic effect, effectively block the stress response induced by surgical stimulation, reduce the use of opioid analgesics after the operation, prolong the postoperative analgesia time, promote postoperative recovery and further reduce the average hospitalization days (Schloss 2015). Conventional caudal block is a safe method, complications may be observed especially in children. Complications such as subcutaneous and intraosseous injection, local anesthetic toxicity or spinal anesthesia are related to inaccurate placement of the puncture needle (Afshan 1996). With the improvement of high-resolution portable ultrasound equipment and probe technology, ultrasound technology has been more and more used in nerve block anesthesia, which broadens the role of ultrasound in clinical anesthesia. Ultrasound-guided caudal insert can see the sacral hiatus, sacrococcygeal ligament and sacral lumen, and can observe the liquid flow produced by the injected local anesthetic drug in the sacral lumen in real-time. The sensitivity and specificity of ultrasonic monitoring of the correct position of puncture needle during ultrasound-guided caudal block are 96% and 100%, which is feasible and practical for clinical application (Schwartz 2008). Because the structure of sacral hiatus and local anesthetic injection can be observed in real-time under ultrasound, the drug injection position can be accurately judged, the puncture difficulty can be reduced, and the success rate of blocking can be improved.

In this study, 0.2% ropivacaine was used for sacral canal block, which had little toxicity, no local anesthetic poisoning reaction or total spinal anesthesia, and produced a good anesthetic effect. The recovery time of Group C was shorter than that of Group G and the CHIPPS score after PACU was lower than that of Group G which indicated that the sacral canal block under ultrasound guidance was effective and the circulation was stable, which reduced the dosage of opioid analgesics during operation, effectively shortened the recovery time of children, and provided perfect postoperative analgesia, which was beneficial to rapid recovery and early postoperative pain relief.

Emergence agitation refers to a mental state in which children's consciousness and behavior are separated during the awakening period after general anesthesia, which is characterized by stubbornness, irritability and inability to comfort, even crying, hands and feet moving and disorientation, etc., and it is impossible to identify familiar people or things in the past (Mihara 2015, Hijikate 2016). The incidence of restlessness during the awakening period is mainly related to factors such as operation type, unfamiliar environment, urinary catheter, quick awakening after anesthesia and postoperative pain degree (Kim 2013). In this study, the incidence of emergence agitation in Group C was significantly lower than that in Group G. It is considered that caudal block can reduce the stimulation of urinary catheter, improve the analgesia and prolong the postoperative analgesia time, thus reducing the circulation fluctuation caused by general anesthesia drugs and pain induced emergence agitation and reducing the incidence of nausea and vomiting. Postoperative canal block has a good long-term analgesic effect, which also has a good effect on the operation and psychological recovery of children, and improves the satisfaction of their families to the operation, thus increasing the safety factor of anesthesia (Wang 2015).

Our study has several obvious limitations. It may be difficult to display the needle using the out-of-plane technique in some children. We did not have a comparative group with conventional caudal block, so we cannot comment on the efficiency and success rate of placement using ultrasound-guidance. In addition, the incidence of complications may not be correctly determined in groups with small sample size. Therefore, studies should be conducted on groups with larger sample sizes. Finally, this study did not compare the analgesic effect and duration of local anesthetics with different concentrations.

5 CONCLUSIONS

Ultrasound-guided caudal insert can see the sacral hiatus, sacrococcygeal ligament and sacral lumen, and can observe the liquid flow produced by the injected local anesthetic drug in the sacral lumen in real-time. Ultrasound-guided caudal block can produce a good anesthetic effect. Compared with general anesthesia alone, it reduces the dosage of opioid analgesics, improves the quality of anesthesia recovery and provides perfect postoperative analgesia. Ultrasound-guided canal block in children can achieve accurate positioning, reduce puncture difficulty and the complications, improve the success rate of a block. It is convenient to operate, has few complications, is safe and effective, is satisfactory to parents and children, and is worthy of clinical application.

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Availability of Data and Materials

The datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Consent for Publication

Not applicable.

Competing Interests

All authors declare no conflicts of interest

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