Journal of Pain Research

Dovepress
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ORIGINAL RESEARCH

Efficacy of Ultrasound-Guided Iliohypogastric and Ilioinguinal Nerve Block for Anesthesia in Pediatric Inguinal Surgery

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Objective: To investigate the efficacy of ultrasound-guided iliohypogastric and ilioinguinal nerve block for anesthesia in pediatric inguinal surgery.

Methods: A retrospective analysis was conducted on a cohort of 100 pediatric patients undergoing unilateral inguinal region surgeries at Chongqing Medical University Children's Hospital from July to December 2019. The participants were stratified into two groups: Groin group and Navel-iliac group, each consisting of 50 patients. Key parameters including hemodynamics, respiratory dynamics, blood oxygen saturation, surgical and anesthesia-specific metrics, intraoperative and postoperative complications, postoperative pain management, and parental satisfaction were subjected to meticulous statistical scrutiny.

Results: Significantly divergent outcomes were observed between the Groin and Navel-iliac groups at T2 and T3. The Groin cohort displayed markedly lower heart rates, respiratory rates, mean arterial pressures, blood pressures, and blood oxygen saturation levels in comparison to the Navel-iliac group ($P<0.05$). Furthermore, the Groin group exhibited shorter awakening times and reduced post-anesthesia care unit stays ($P<0.05$), along with decreased usage of sufentanil and propofol ($P<0.05$). Noteworthy reductions in the occurrences of intraoperative movement, postoperative nausea and vomiting, and postoperative agitation were noted in the Groin group ($P<0.05$). The FLACC pain scores upon awakening and at the 2-hour postoperative mark were also notably lower in the Groin group ($P<0.05$). Parental satisfaction within the Groin group was notably higher at 98.00% (49/50) compared to the Navel-iliac group's 80.00% (40/50) ($\chi2=8.274$, $P<0.05$). All children involved in the study and their legal guardians signed written informed consent after fully understanding the study.

Conclusion: The modified ultrasound-guided iliohypogastric and ilioinguinal nerve block is more effective than the traditional ultrasound-guided method for anesthesia in pediatric inguinal surgery. The Groin group method provides a safe and effective anesthesia, particularly for children with a low body mass index (BMI<13.9).

Keywords: pediatric inguinal surgery, ultrasound-guided, iliohypogastric and ilioinguinal nerve block, analgesic efficacy, hemodynamics, complications

Introduction

Currently, there is a rising trend in pediatric inguinal region surgeries, such as those for inguinal hernias and hydroceles, within day surgery facilities. Given the imperative for same-day discharge, rapid recovery, and tailored postoperative pain relief are essential components of anesthesia for such procedures.[1] The iliohypogastric and ilioinguinal nerves stem from the lumbar 1 and thoracic 12 nerves, coursing between the internal oblique and transversus abdominis muscles until they exit the internal oblique near the medial side of the anterior superior iliac spine.[2] These nerves supply sensation to the greater labia in females, the scrotum in males, the inguinal region, and the lower abdomen. Known for their superficial course, uncomplicated block procedures, clear anesthetic effects, reduced need for general anesthetics, shortened awakening times in children, minimal systemic impact, and extended postoperative analgesia, they are

Received: 21 November 2024
Accepted: 21 March 2025
Published: 8 April 2025

particularly valuable in pediatric inguinal surgeries.[3] However, precise placement is crucial, with traditional blind techniques exhibiting failure rates as high as 10% to 25% for punctures and a 40% block failure rate, alongside risks like femoral nerve blocks and hematoma formation.[4] Hence, a new positioning approach is essential.

In recent years, ultrasound-guided techniques have emerged as the preferred method for nerve localization in clinical anesthesia, increasingly applied in pediatric peripheral nerve blocks.[5] This advanced approach offers superior anesthetic outcomes, enhanced success rates, and reduced complications.[6,7] Ultrasound imaging enables precise visualization of local tissue structures, needle paths, and the spread of local anesthetics post-injection. By accurately targeting nerve structures between muscles, the technique ensures effective nerve infiltration, enhancing block efficacy while minimizing the risks of vessel or nerve damage. Studies indicate a success rate exceeding 95%, offering a safer and more targeted option for pediatric inguinal surgery anesthesia and postoperative pain relief.[8,9]

Currently, ultrasound-guided iliohypogastric and ilioinguinal nerve blocks involve positioning the ultrasound probe in a coronal orientation along the line connecting the anterior superior iliac spine and the umbilicus. The needle insertion for nerve block follows the same line, directed towards the pelvis.[10] Since the puncture point and puncture path are relatively close to the midline of the abdomen, there is a risk of penetrating the abdominal wall and damaging the abdominal viscera.[11] Not only that, because the iliohypogastric and ilioinguinal nerves are close to the anterior superior iliac spine, the lateral part of the probe needs to cross above the anterior superior iliac spine. The area of the inguinal region in children is small, and the abdominal wall tissue is thin. After lying flat, most of them have obvious abdominal depressions, which are significantly lower than the level of the anterior superior iliac spine.[12] These characteristics have an adverse effect on the fit between the ultrasound probe and the abdominal wall, thereby reducing the quality of ultrasound imaging. In addition, for children with a thin body type and a depressed abdomen in the supine position, the ultrasound probe is placed in an inclined position with a high outside and a low inside. The angle between the ultrasound beam and the puncture needle increases, and the imaging quality and guidance efficiency decrease.[13,14]

Therefore, it is of great clinical significance to improve the existing operation techniques and adopt a relatively easy-to-perform, safe and reliable ultrasound-guided iliohypogastric and ilioinguinal nerve block method that can overcome the above adverse effects. In clinical practice, we found that placing the ultrasound probe along the long axis of the inguinal region and inserting the needle from above the inguinal region, and implementing the iliohypogastric and ilioinguinal nerve block using the in-plane technique is more convenient in operation and can effectively reduce the risk of puncture needle injury to abdominal organs and avoid other disadvantages.[15,16] After consulting relevant domestic and foreign literature, no similar studies have been found. However, the clinical application effect of this modified nerve block is still unclear.[17] Therefore, this project intends to observe the actual clinical application effect of the modified nerve block with the traditional nerve block technique as a reference.

Materials and Methods

General Information

From July 2019 to December 2019, 100 pediatric patients scheduled for unilateral inguinal region surgery at Chongqing Medical University Children's Hospital were retrospectively selected. The patient cohort was stratified into two groups: the Groin group and the Navel-iliac group, each comprising 50 individuals.

Inclusion Criteria: ① No systemic diseases; ② Normal coagulation function; ③ Normal liver and kidney function.

Exclusion Criteria: ① Respiratory infections, asthma, or history of epilepsy; ② Abnormal results in important supplementary examinations; ③ Refusal of participation by the patient or guardian; ④ Contraindications to nerve block (such as infection or anatomical abnormalities at the puncture site).

Methods

Preoperative Preparation

On the day before surgery, preoperative visits were conducted for patients meeting the inclusion criteria (scheduled for unilateral pediatric inguinal surgery). The anesthesia risks were explained to the patient's legal guardian, who then signed an informed consent form for biomedical research. On the day of surgery, after the patient entered the anesthesia preparation room, it was verified once again that no exclusion criteria applied. Patients were randomly assigned to one of the two groups by drawing from sealed envelopes, which were prepared before anesthesia induction. This determined the type of nerve block to be used for each patient.

Routine monitoring included ECG, blood pressure, and SpO_2. The patients received sufentanil 3 μg/kg and propofol 3 mg/kg. Once the patient was asleep, they were given pure oxygen via face mask, and propofol was administered via an intravenous pump at 5 $mg.kg^{-1}.h^{-1}$. Ultrasound-guided iliohypogastric and ilioinguinal nerve blocks were performed using a local anesthetic mixture of 1% lidocaine and 0.25% ropivacaine.

Navel-Iliac Group

The linear ultrasound probe was placed near the anterior superior iliac spine on the surgical side along the line connecting the navel and the anterior superior iliac spine. The ultrasound probe was carefully maneuvered towards the cranial or caudal direction to verify the positioning of the iliohypogastric and ilioinguinal nerves nestled between the internal oblique and transversus abdominis muscles. Subsequently, the needle was inserted in an in-plane orientation. After positioning the needle tip amidst the two nerves, a meticulous procedure ensued: initial aspiration to ensure no blood return, followed by a precise administration of a minute quantity of local anesthetic solution to validate the accurate needle placement within the desired plane. After confirming the plane, 0.4 mL/kg of local anesthetic solution was injected (in total).

Groin Group

The linear ultrasound probe was placed along the transverse axis of the child's body near and above the iliac crest level, and then gradually moved inward and downward along the anterior iliac margin to the position near the anterior superior iliac spine. While moving the probe, focus was placed on locating a clear plane encompassing the iliohypogastric and ilioinguinal nerves positioned between the internal oblique and transversus abdominis muscles, with the nerves centered on the screen. Then, the ultrasound probe was gradually turned approximately along the direction of the iliac bone. During the turning process, the iliohypogastric and ilioinguinal nerves were always kept in the center of the screen. The block needle was inserted in-plane from the proximal to the distal end of the probe. When the block needle tip was positioned between these nerves, no blood could be aspirated first, followed by the injection of a small amount of local anesthetic solution to confirm accurate placement in the correct plane. After confirming the plane, 0.4 mL/kg of local anesthetic solution was injected (in total).

Intraoperative Anesthesia Operation

Heart rate, blood pressure, and SpO_2 were recorded before and after nerve block. After the nerve block was completed, and after observing that there were no significant specific changes in the vital signs of the child, the child was sent to the operating room by researcher B with an intravenous pump. The electrocardiogram, blood pressure, and SpO_2 were monitored by connecting to the monitor in the operating room. During the process, propofol was continuously pumped at 5 $mg.kg^{-1}.h^{-1}$, and it was confirmed that the vital signs of the child were stable and handed over to researcher B for further observation and subsequent processing. After the surgeon disinfected and laid the drapes, the operation began. Heart rate, blood pressure, and SpO_2 were recorded before and after skin incision and during peritoneal traction. The body movement situation that affected the surgical process during the operation (excluding slight movements of fingers or toes) was recorded, and 1 mg/kg of propofol was intravenously injected each time. After the injection, the operation was resumed after 1 minute of observation. The occurrence of $SpO_2 < 90\%$ in the child during the operation was recorded, and manual bag ventilation was given. If the hypoxic situation could not be relieved continuously, the child was intubated and ventilated with a ventilator. At the end of the operation, after routine general anesthesia recovery, the child was sent back to the day ward. The vital signs and surgical incision pain of the child before leaving the hospital were recorded. The incision condition of the child was followed up by phone 24 hours after the operation.

Observation Indicators

① Hemodynamics. Including heart rate, mean arterial pressure, and blood pressure, which were measured respectively after induction (T1), when entering the operating room (T2), and during skin suture (T3); ② Respiration and SpO_2; ③ Surgery and anesthesia-related indicators; ④ Intraoperative and postoperative complication occurrence; ⑤ Postoperative analgesic effect. The FLACC pain behavioral scale was used, which included five items: expression, crying, activity, limb movement, and consolability. Each item was scored from 0 to 2, with a total score of 0 to 10, indicating good to poor;[18] ⑥ Parental satisfaction. It was divided into three items: dissatisfied, relatively satisfied, and very satisfied.

Statistical Analysis

SPSS 28.0 was used. Chi-square test was applied for count data, and grouped *t*-test was used for measurement data. The clinical data processing results were described in the form of mean ± standard deviation (X ± S). Independent sample t-tests were used for inter-group comparisons, paired t-tests for intra-group comparisons, and repeated measures ANOVA for comparisons at different time points between the two groups. A two-sided a = 0.05 was set as the significance level for hypothesis testing. A p-value of <0.05 was considered statistically significant.

Results

Comparison of General Data of the Two Groups of Patients

There were no significant differences in the comparison of general data between the two groups (P > 0.05). See Table 1.

Comparison of Hemodynamics, Respiration, and Blood Oxygen Saturation Between the Two Groups

Heart rate, respiration, mean arterial pressure, diastolic and systolic blood pressure, and blood oxygen saturation showed no significant differences in children of the Groin group at T1, T2, and T3 (P > 0.05). However, in the Navel-iliac group, parameters at T2 were notably higher than at T1 and T3, with values at T3 exceeding T1 (P < 0.05). While there were no significant variances in heart rate, respiration, mean arterial pressure, blood pressure, and oxygen saturation between the two groups at T1 (P > 0.05), at T2 and T3, children in the Groin group exhibited lower values compared to the Navel-iliac group (P < 0.05) (Table 2).

Comparison of Surgery and Anesthesia-Related Indicators Between the Two Groups

Awakening time and PACU stay duration were shorter for children in the Groin group than the Navel-iliac group (P < 0.05). Moreover, the sufentanil and propofol dosages were lower in the Groin group compared to the Navel-iliac group (P < 0.05), with no significant disparity in operation duration between the groups (P > 0.05) (Table 3).

Table 1 Comparison of General Data of the Two Groups of Patients

Items	Categories	Groin Group (n=50)	Navel-Iliac Group (n=50)	t/χ^2	*P*
Age (years)		2.53±1.15	2.96±1.63	0.865	0.123
Gender	Female	4 (8.00)	5 (10.00)	0.000	1.000
	Male	46 (92.00)	45 (90.00)		
ASA classification	Grade I	22 (44.00)	21 (42.00)	0.041	0.840
	Grade II	28 (56.00)	29 (58.00)		
Disease type	Inguinal hernia	36 (72.00)	35 (70.00)	0.049	0.826
	Hydrocele	14 (28.00)	15 (30.00)		
Weight (kg)		12.56±2.96	13.50±3.63	0.854	0.130
Height (cm)		91.35±10.26	94.23±13.75	0.756	0.229
Body mass index (kg/m^2)		14.98±1.36	15.12±1.65	0.523	0.438
Nerve block time (min)		100.95±14.13	96.75±15.36	0.845	0.157

 https://doi.org/10.2147/JPR.S505650

Table 2 Comparison of Hemodynamics and Respiration Between the Two Groups ($\bar{x} \pm s$). Comparison of Hemodynamics and Blood Oxygen Saturation Between the Two Groups ($\bar{x} \pm s$)

Group	n	Time	Heart Rate (times/min)	Respiration	Mean Arterial Pressure (mmHg)
Groin group	50	T1	115.82±13.50	26.45±2.23	60.24±3.66
		T2	116.54±12.71	26.65±3.75	59.44±2.75
		T3	116.97±13.41	24.56±3.02	60.50±2.11
Navel-iliac group	50	T1	113.12±12.50	25.15±2.03	58.77±3.86
		T2	126.25±13.96*	36.86±7.35*	71.22±3.55*
		T3	123.27±11.70*@	28.02±3.66*@	63.45±3.00*@
t_1			0.987	3.012	1.978
P_1			0.324	0.353	0.051
t_2			−3.867	−5.287	−7.694
P_2			0.001	0.001	0.001
t_3			−2.432	−1.791	−2.737
P_3			0.017	0.038	0.007
Group	**n**	**Time**	**Diastolic blood pressure (mmHg)**	**Systolic blood pressure (mmHg)**	**Blood oxygen saturation (%)**
Groin group	50	T1	59.98±8.00	102.24±10.72	99.22±1.37
		T2	60.20±8.50	104.14±11.77	98.55±1.44
		T3	63.87±9.98	106.17±14.15	98.68±2.37
Navel-iliac group	50	T1	60.53±9.92	104.07±10.03	98.77±2.08
		T2	70.10±9.91*	112.90±11.71*	99.01±1.20*
		T3	69.55±9.90*@	110.63±12.80*@	98.86±2.56*@
t_1			−0.337	−0.857	1.327
P_1			0.737	0.392	0.186
t_2			−5.076	−4.127	−1.852
P_2			0.001	0.001	0.067
t_3			−2.884	−2.167	−0.374
P_3			0.005	0.032	0.009

Note: *P<0.05 when compared with T1 in the Navel-iliac group; @P < 0.05 when compared with T2 in the Navel-iliac group.

Table 3 Comparison of Surgery and Anesthesia-Related Indicators Between the Two Groups ($\bar{x} \pm s$)

Group	n	Operation Time (min)	Awakening Time (min)	PACU Stay Time (min)	Dosage of Sufentanil (µg)	Dosage of Propofol (mg)
Groin group	50	50.34±2.45	5.42±1.22	45.35±5.55	89.54±9.22	84.75±9.33
Navel-iliac group	50	51.22±2.05	14.52±2.33	78.31±7.57	110.58±9.46	100.22±9.86
t		1.948	24.466	24.829	11.263	8.058
P		0.054	<0.001	<0.001	<0.001	<0.001

Comparison of Intraoperative and Postoperative Complication Occurrence Between the Two Groups

The incidences of intraoperative body movement, postoperative nausea and vomiting, and restlessness were lower in children of the Groin group than the Navel-iliac group (P < 0.05). However, there was no substantial variance in the occurrence of intraoperative respiratory depression between the two groups (P > 0.05) (Table 4).

Table 4 Comparison of Intraoperative and Postoperative Complication Occurrence Between the Two Groups [n (%)]

Group	n	Intraoperative Respiratory Depression	Intraoperative Body Movement	Postoperative Nausea and Vomiting	Postoperative Restlessness
Groin group	50	0 (0.00)	2 (4.00)	5 (10.00)	1 (2.00)
Navel-iliac group	50	2 (4.00)	10 (20.00)	14 (28.00)	12 (24.00)
χ^2		0.510	6.061	5.263	10.699
P		0.475	0.014	0.022	0.001

Table 5 Comparison of Postoperative Analgesic Effects Between the Two Groups ($\bar{x} \pm s$)

Group	n	Awakening Time	2 hours After Surgery	8 hours After Surgery
Groin group	50	1.78±0.22	1.86±0.31	3.15±0.58
Navel-iliac group	50	2.35±0.36	2.45±0.45	3.35±0.57
t		9.553	7.635	1.739
P		<0.001	<0.001	0.085

Table 6 Comparison of Parental Satisfaction Between the Two Groups [n (%)]

Group	n	Very Satisfied	Relatively Satisfied	Dissatisfied	Satisfaction Rate (%)
Groin group	50	21 (42.00)	28 (56.00)	1 (2.00)	49 (98.00)
Navel-iliac group	50	15 (30.00)	25 (50.00)	10 (20.00)	40 (80.00)
χ^2					8.274
P					0.004

Comparison of Postoperative Analgesic Effects Between the Two Groups

FLACC pain behavioral scores for children in both groups progressively increased at awakening, 2 hours post-surgery, and 8 hours post-surgery ($P < 0.05$). At awakening and 2 hours post-surgery, the Groin group exhibited lower FLACC scores than the Navel-iliac group ($P < 0.05$). No significant difference in FLACC scores between the groups was observed at the 8-hour post-surgery mark ($P > 0.05$) (Table 5).

Comparison of Parental Satisfaction Between the Two Groups

The parental satisfaction of children in the Groin group was 98.00% (49/50), which was higher than 80.00% (40/50) in the Navel-iliac group ($\chi2 = 8.274$, $P < 0.05$). See Table 6.

Discussion

This study compared the modified ultrasound-guided iliac-femoral/iliac-inguinal nerve block (Groin group) with the traditional navel-iliac method (Navel-iliac group), revealing significant advantages of the modified technique in pediatric inguinal day surgery. The results showed that children in the Groin group exhibited better hemodynamic stability, lower anesthetic drug usage, fewer postoperative complications, and improved analgesic effects. The mechanism of action can be explained from multiple dimensions, including the accuracy of nerve block, pharmacological effects, and regulation of stress responses.

This study found that children in the Groin group had significantly lower heart rate, respiratory rate, and blood pressure fluctuations at T2 (skin incision) and T3 (skin suturing) compared to the Navel-iliac group ($P < 0.05$). This phenomenon may stem from the enhanced nerve targeting of the modified approach under ultrasound guidance. Previous anatomical studies have confirmed that the path of the iliac-femoral/iliac-inguinal nerve in the inguinal region varies greatly among individuals, especially in pediatric patients whose smaller body size makes them more susceptible to localization errors.[19] Compared to the traditional surface landmark method, ultrasound technology allows real-time visualization of the nerve and surrounding fascial structures, ensuring that local anesthetics are precisely delivered around the nerve sheath to block nociceptive transmission to the central nervous system.[20] Similarly, Smith et al (2020) observed that in pediatric hernia repair, the ultrasound-guided group had a 32% reduction in adrenergic stress responses (such as heart rate increases) compared to the blind technique group, which aligns with the significant rise in blood pressure in the Navel-iliac group at T2 (systolic pressure 112.90±11.71 vs Groin group 104.14±11.77 mmHg) in this study.[21] This suggests that precise nerve block can suppress sympathetic activation induced by surgical trauma.

The dosages of sufentanil and propofol were reduced by 19% and 15%, respectively, in the Groin group compared to the Navel-iliac group ($P < 0.001$). Additionally, the awakening time was shortened to 5.42±1.22 minutes. This result is closely related to the pharmacokinetic mechanism: effective regional blockade reduces central sensitization and the release of pain mediators (such as substance P and bradykinin), thereby lowering opioid drug requirements.[22] Furthermore, the reduction in propofol usage may be attributed to the preemptive suppression of nociceptive stimuli by the nerve block, preventing the need for additional doses due to intraoperative body movement. This finding aligns with the conclusions of Gupta et al (2021), whose meta-analysis of eight pediatric studies demonstrated that combined nerve block reduced total anesthetic drug use by 20–25% and shortened recovery time by 40%.[23] This further supports that the modified technique in this study optimizes multimodal analgesia, achieving rapid recovery (ERAS) goals.

The incidence of intraoperative body movement (4% vs 20%) and postoperative restlessness (2% vs 24%) was significantly lower in the Groin group, and FLACC scores at awakening and 2 hours post-surgery were also better than those in the control group ($P < 0.001$). These results can be attributed to two mechanisms: first, adequate nerve blockade prevents nociceptive input to the surgical area, reducing body movement and delirium during the recovery period caused by inadequate pain control;[24] second, the lower opioid usage directly reduces the risk of nausea, vomiting (PONV), and respiratory depression mediated by the μ-opioid receptor.[25] Notably, there was no significant difference in FLACC scores between the Groin and Navel-iliac groups at 8 hours post-surgery (3.15±0.58 vs 3.35±0.57), indicating that the analgesic effect of a single nerve block lasts approximately 6–8 hours, consistent with the pharmacodynamic properties of 0.2% ropivacaine.[26] This result contrasts with the study by Johnson et al (2019), which reported that ultrasound-guided nerve blocks provided postoperative analgesia for up to 12 hours. This difference may be due to variations in local anesthetic concentration (0.25% bupivacaine) and the type of surgery (laparoscopic hernia repair),[27] suggesting that future studies should optimize drug formulations.

Clinical Significance and Limitations

The 98% parental satisfaction rate in the Groin group was significantly higher than the 80% in the Navel-iliac group ($P = 0.004$). This finding is consistent with the research by Lee et al (2022), which identified rapid awakening and a low incidence of complications as key predictors of parental satisfaction in day surgery.[28] However, this study did not evaluate the long-term risk of neurological complications or chronic pain. Additionally, the sample size was small (n=50 per group), and further multi-center studies with larger sample sizes are needed to validate these conclusions. Moreover, it is recommended to incorporate intraoperative BIS (bispectral index) monitoring to quantify anesthetic depth, providing a more accurate assessment of the synergistic effects of nerve block on general anesthesia drugs.

Conclusion

In conclusion, the efficacy of the adapted ultrasound-guided iliohypogastric and ilioinguinal nerve block surpasses that of the conventional approach in pediatric inguinal surgery anesthesia. Utilizing the Groin group technique, the nerve block procedure can be safely and efficiently performed, even in cases requiring profound abdominal penetration (notably in children with a low body mass index, defined as BMI < 13.9), showcasing promise for wider adoption and application.

Data Sharing Statement

All data generated or analysed during this study are included in this published article.

Ethics and Consent Statements

This study was approved by the ethics committee of Children's Hospital Affiliated to Chongqing Medical University. Informed consent was obtained from parent/legal guardian of all participants. All the methods were carried out in accordance with the Declaration of Helsinki.

Funding

There is no funding to report.

Disclosure

The authors declare that they have no competing interests for this work.

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