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Comparison of neuroendocrine responses between caudal block and local infiltration techniques in pediatric inguinal hernia surgery: A prospective comparative clinical study

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MAIN POINTS

- Caudal block and local infiltration produced comparable postoperative cortisol and prolactin responses, as well as similar CHEOPS pain scores.
- Anesthesia and surgical durations were significantly longer in the caudal block group.
- Local wound infiltration may serve as a practical alternative due to its shorter application time and ease of use.
- A significant positive correlation was observed between preoperative and postoperative prolactin levels, independent of the analgesic technique.

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ABSTRACT

Aim: This study aimed to compare the effects of caudal anesthesia and local wound infiltration on postoperative stress hormone responses (cortisol and prolactin) and pain scores in pediatric patients undergoing inguinal hernia repair.

Materials and Methods: A total of 64 children aged 1–4 years, classified as ASA I, scheduled for elective unilateral inguinal hernia surgery were randomized into two groups: caudal anesthesia (Group C) and local infiltration (Group I). All patients received general anesthesia. Group C received 1 mL/kg of 0.25% bupivacaine via the caudal route, while Group I received 0.25 mL/kg of 5 mg/mL bupivacaine via 23-gauge needle infiltration. Postoperative pain was assessed using the CHEOPS scale at 1st, 2nd, 3rd, and 4th hours by a blinded anesthesiologist. Blood samples for cortisol and prolactin levels were collected before induction and 40 minutes after surgery and analyzed by ECLIA.

Results: No significant differences were found between groups in postoperative cortisol and prolactin levels. Pain scores were also similar at all time points ($p>0.05$). A significant positive correlation was observed between preoperative and postoperative prolactin levels ($p<0.05$). Anesthesia and surgical durations were longer in the caudal group ($p<0.05$), while fentanyl requirements were similar.

Conclusion: Both caudal block and wound infiltration provide comparable postoperative analgesia and hormonal stress response control in pediatric inguinal hernia surgeries. Given its shorter application time, local infiltration may offer a practical alternative in suitable clinical settings.

Keywords: Postoperative pain, Inguinal hernia, Wound infiltration, Caudal block, Stress hormone

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INTRODUCTION

Pediatric inguinal hernia is among the common congenital anomalies requiring surgical treatment, particularly during the neonatal and infantile periods. It is observed 4–10 times more frequently in boys compared to girls, with an incidence ranging from 0.8% to 5% in the general pediatric population [1]. In premature infants, this rate may rise to as high as 30% [2]. These cases are typically indirect hernias, developing due to delayed obliteration of the processus vaginalis. Diagnosis is usually established through physical examination, and surgical intervention is necessary to prevent potential complications such as incarcerated hernia, bowel ischemia, or perforation [1]. Early surgical repair is critical in reducing morbidity and preventing such complications.

Due to the physiological and psychological differences in children, postoperative pain management in these surgical inter-

ventions is of great importance. Although pain assessment in pediatric patients is inherently challenging, inadequate analgesia can prolong recovery, extend hospital stay, and has been linked to the development of anxiety, behavioral disorders, and chronic pain in the long term [3]. Currently, multimodal approaches are preferred for postoperative pain management, including opioids, paracetamol, nonsteroidal anti-inflammatory drugs (NSAIDs), regional nerve blocks, and local anesthetic infiltration techniques [3]. However, due to the adverse effects associated with opioids—such as nausea, vomiting, respiratory depression, and sedation—safer and minimally invasive techniques are often favored in children [4].

In this context, caudal anesthesia and local wound infiltration are two commonly used techniques in pediatric surgical procedures. Caudal block is a regional anesthesia technique performed by administering local anesthetic into the epidural space via the sacral hiatus and is widely used in surgeries under the umbilicus [5]. When administered with long-acting local anesthetics such as ropivacaine or levobupivacaine, it provides effective and safe analgesia [5]. Moreover, caudal block has been shown to significantly reduce stress hormone levels such as plasma cortisol and prolactin in the postoperative period [6]. On the other hand, local wound infiltration involves the administration of local anesthetics around the surgical incision and is a non-invasive and easily applicable method. This technique has also been reported to reduce cortisol levels and to be effective in postoperative pain control in several studies [7]. However, it remains unclear which of these two methods is more effective in modulating the stress response, and the literature presents conflicting results on this topic [8].

This study aims to compare the effects of caudal anesthesia and local wound infiltration on postoperative stress hormone levels in pediatric patients undergoing inguinal hernia surgery. The findings are expected to contribute to the identification of the most appropriate analgesic method in this patient population.

MATERIALS AND METHODS

This study was approved by the Ethics Committee of Şişli Etfal Training and Research Hospital on 23.06.2009, with protocol number 73, and was conducted between July 2009 and July 2010 in the Departments of Pediatric Surgery and Anesthesiology at Şişli Etfal Training and Research Hospital Hospital. All procedures adhered to the ethical standards outlined in the Declaration of Helsinki (2008) and were reported in accordance with the CONSORT (Consolidated Standards of Reporting Trials) guidelines.

Patient selection

Children aged 1–4 years scheduled for elective unilateral inguinal hernia repair and classified as ASA I according to the American Society of Anesthesiologists Physical Status Classification were included. Exclusion criteria were: history of prematurity, neurological disorders, chronic medication use, known allergy to local anesthetics, previous abdominal surgery, bleeding disorders, bilateral hernia, or recurrent hernia.

Sample size

Sample size was calculated based on expected variations in cortisol levels and effect sizes reported in similar studies [9]. Assuming $\alpha = 0.05$, $\beta = 0.20$ (power = 80%), and a between-group difference of 1 standard deviation (effect size $d \approx 1.0$), a minimum of 32 patients per group was required. Accordingly, 64 patients were enrolled (Group C = 32, Group I = 32), achieving the targeted statistical power.

Anesthesia and monitoring

No premedication was administered. Age, sex, and body weight were recorded preoperatively. Standard monitoring included noninvasive arterial blood pressure, ECG, peripheral oxygen saturation (SpO_2), and end-tidal CO_2. Anesthesia was delivered using a Julian® anesthesia machine (Dräger, Lübeck, Germany). Induction was achieved with intravenous propofol (1 mg/kg), followed by insertion of a laryngeal mask airway. Fentanyl (1 mcg/kg IV) was administered, and anesthesia was maintained with 2% sevoflurane in 50% air/oxygen.

Fluid management involved 5% dextrose in 0.2% sodium chloride solution (Isolyte® P). If heart rate or blood pressure increased more than 20% above baseline, an additional dose of fentanyl (0.5 mcg/kg IV) was administered and recorded as part of total fentanyl consumption. All surgical procedures were performed by the same pediatric surgical team, with hemodynamic stability maintained throughout.

Randomization and analgesia protocol

Patients were randomized using a computer-generated block randomization method, ensuring equal allocation between groups. Group C (caudal group) received caudal anesthesia with 0.25% bupivacaine (Chirocaine®, 5 mg/mL; Abbott S.p.A, Latina, Italy) at a dose of 1 mL/kg. The required volume was prepared by diluting the commercially available 0.5% (5 mg/mL) solution 1:1 with sterile 0.9% sodium chloride to achieve a final concentration of 0.25%. This solution was then drawn into a sterile syringe and administered via a 22-gauge short-beveled needle through the sacral hiatus, with the patient placed in the lateral decubitus position, under strict sterile conditions and after confirming negative aspiration.

Group I (infiltration group) received local wound infiltration using the same 0.25% bupivacaine solution. A volume of 0.25 mL/kg was infiltrated into the planned surgical site by the pediatric surgeon prior to skin incision, using a 23-gauge needle. The preparation of the infiltration solution followed the same dilution protocol as in Group C to ensure consistency in drug concentration across groups.

All procedures were performed by the same pediatric surgical team. Analgesia was administered after randomization and

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prior to surgical incision by either an anesthesiologist (Group C) or the surgeon (Group I). No crossover occurred between groups, and the integrity of the intervention allocation was maintained throughout the study.

Postoperative management

After the procedure, anesthesia was discontinued, and patients were extubated once spontaneous breathing resumed, and adequate respiratory parameters were achieved. Patients were then transferred to the Post-Anesthesia Care Unit (PACU) in stable condition. Anesthesia duration was defined as the time from induction to extubation, and surgical duration was defined as the time from induction to final suture placement—both recorded by the attending anesthesiologist.

In the PACU, noninvasive blood pressure, heart rate, respiratory rate, SpO_2, and consciousness were monitored. Postoperative pain was assessed using the Children's Hospital of Eastern Ontario Pain Scale (CHEOPS) by a blinded anesthesiologist at the 1st, 2nd, 3rd, and 4th postoperative hours. Patients were transferred to the ward after stabilization.

Hormone measurement

Blood samples for cortisol and prolactin measurements were obtained twice: immediately before induction and 40 minutes after the end of surgery. Samples were collected in EDTA tubes, centrifuged, and stored at –20°C until analysis. Plasma cortisol (normal ranges: 1–39 µg/dL in the morning, 3–18 µg/dL in the afternoon) and prolactin levels (girls: 3.2–25.3 ng/mL; boys: 2.9–17.1 ng/mL) were measured using electrochemiluminescence immunoassay (ECLIA) on an Elecsys E-170 analyzer (Roche Diagnostics, Basel, Switzerland).

Statistical analysis

Descriptive statistics were presented as mean ± standard deviation (SD) or frequency (%). Categorical variables were compared using the chi-square test. Continuous variables were compared using independent samples t-test under equal variance assumptions. Distribution of the data was assessed with the Shapiro-Wilk test. Postoperative parameters were analyzed with Repeated Measures ANOVA with Bonferroni correction. Repeated measures were analyzed using linear mixed-effects models with random intercepts per patient. Postoperative biomarkers were analyzed using linear regression, with baseline values and group interaction terms as covariates. A two-tailed p-value < 0.05 was considered statistically significant. All analyses were performed using R software version 4.4.1 (R Foundation for Statistical Computing, Vienna, Austria).

RESULTS

A total of 64 pediatric patients were included in the study (Figure 1). There were no statistically significant differences between the two groups in terms of sex distribution, age, or body weight (p>0.05). Baseline demographic characteristics of the participants are summarized in Table 1.

In the caudal block group, both mean anesthesia duration and surgical time were significantly longer compared to the infil-

Table 1. Baseline characteristics by treatment.

Variable	Caudal N = 32[1]	Infiltration N = 32[1]	p-value[2]
Sex			0.4
F	7 (22%)	11 (34%)	
M	25 (78%)	21 (66%)	
Age (months)	30 (19)	33 (26)	0.5
Body Weight (kg)	12.7 (3.4)	13.7 (5.3)	0.4

[1] n (%); Mean (SD), [2] Pearson's Chi-squared test; Two Sample t-test

Table 2. Fentanyl dose, anesthesia and operation durations by group.

Variable	Caudal[1]	Infiltration[1]	p-value[2]
Mean Anesthesia Duration (mins)	71 (36)	50 (23)	0.007
Mean Operation Duration (mins)	60 (33)	46 (18)	0.047
Mean Fentanyl Dose (mcg)	13.2 (4.1)	13.3 (7.7)	>0.9

[1] Mean (SD); [2] Two Sample t-test

Table 3. CHEOPS by hour and groups.

Hours After Operation	Caudal[1]	Infiltration[1]	p-value[2]
1	8.16 (2.50)	7.81 (1.99)	0.5
2	7.66 (2.24)	7.59 (2.00)	>0.9
3	7.78 (2.15)	7.84 (2.32)	>0.9
4	7.66 (2.06)	7.78 (2.04)	0.8

[1] Cheops: Mean (SD); [2] Two-way ANOVA with Bonferroni correction.

Table 4. Results of linear regression analysis of variables affecting postoperative cortisol levels.

Characteristic	Beta	95% CI[1]	p-value
Preoperative Cortisol Level	0.31	-0.23, 0.84	0.3
Group			
Caudal	---	---	
Infiltration	-4.6	-15, 6.0	0.4
Preoperative Cortisol Level * Group			
Preoperative Cortisol Level * Infiltration	0.28	-0.44, 1.0	0.4

[1] CI = Confidence Interval.

Table 5. Results of linear regression analysis of variables affecting postoperative prolactin levels.

Characteristic	Beta	95% CI[1]	p-value
Preoperative Prolactin Level	0.42	0.22, 0.62	<0.001
Group			
Caudal	---	---	
Infiltration	9.6	-4.6, 24	0.2
Preoperative Prolactin Level * Group			
Preoperative Prolactin Level * Infiltration	-0.35	-0.93, 0.24	0.2

[1] CI = Confidence Interval.

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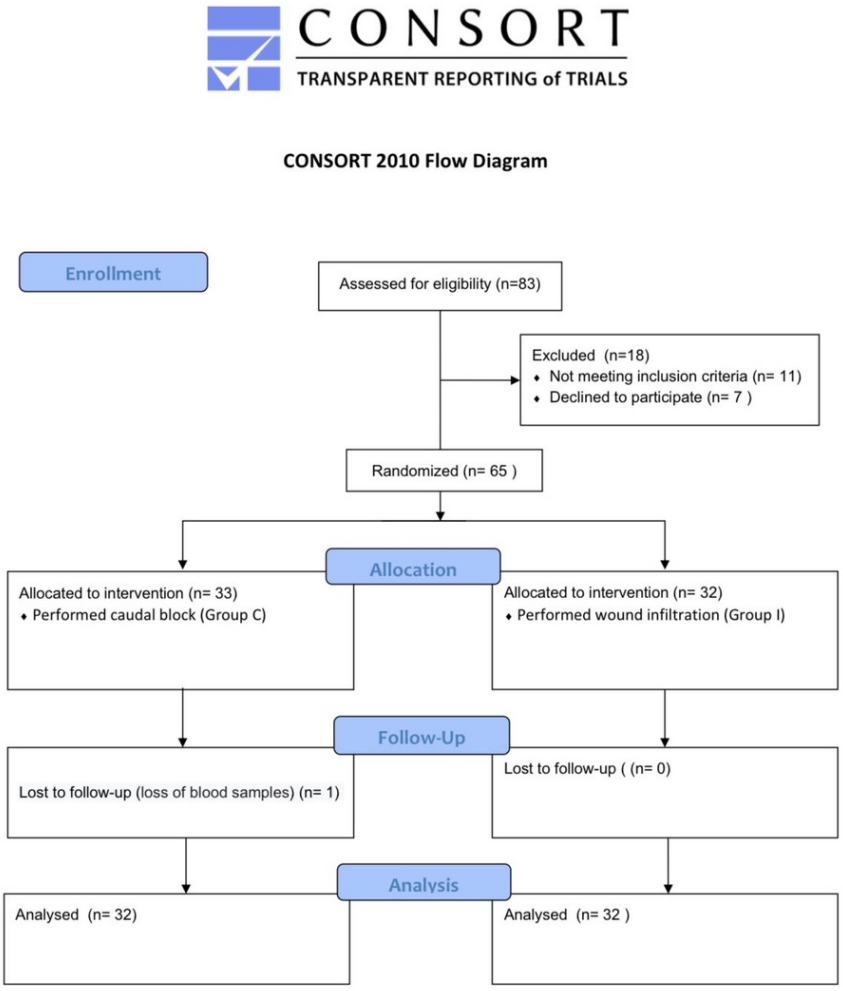

Figure 1. CONSORT flow diagram of the study.

tration group. The difference in anesthesia duration was –21 minutes (95% CI: –36 to –6, p = 0.007), while the difference in surgical duration was –14 minutes (95% CI: –26 to 0, p = 0.047) (Table 2). The mean fentanyl dose was similar between the groups (difference: 0.1 mcg, 95% CI: –3 to +3, p>0.9).

Postoperative CHEOPS pain scores did not differ significantly between the two groups. The mean difference in scores was –0.4, which was not statistically significant (95% CI: –1.7 to 0.8, p = 0.5). Additionally, time had no significant effect on CHEOPS scores (hour effect: –0.14, 95% CI: –0.5 to +0.2, p = 0.4) (Table 3).

Neither the type of analgesia nor preoperative cortisol levels had a significant effect on postoperative cortisol concentrations (Figure 2, Table 4). Similarly, the type of analgesia did not influence postoperative prolactin levels. However, preoperative prolactin levels showed a positive correlation with postoperative levels (Figure 3, Table 5).

DISCUSSION

This study aimed to compare the effects of caudal block and local wound infiltration on postoperative stress hormone response (cortisol and prolactin) and analgesic efficacy in children aged 1–4 years undergoing inguinal hernia repair. Our findings demonstrate that both techniques provided similar postoperative pain control and did not produce significant differences in cortisol and prolactin levels. Notably, anesthesia and surgical durations were longer in the caudal group.

Caudal anesthesia is a widely used technique in pediatric patients, particularly in subumbilical surgeries, and has been shown in several studies to improve postoperative analgesia and reduce pain scores. For instance, Ingelmo et al. reported that caudal administration of ropivacaine significantly reduced plasma prolactin and cortisol levels [6]. However, that study did not emphasize pain scores and was not conducted under general anesthesia, limiting direct comparison

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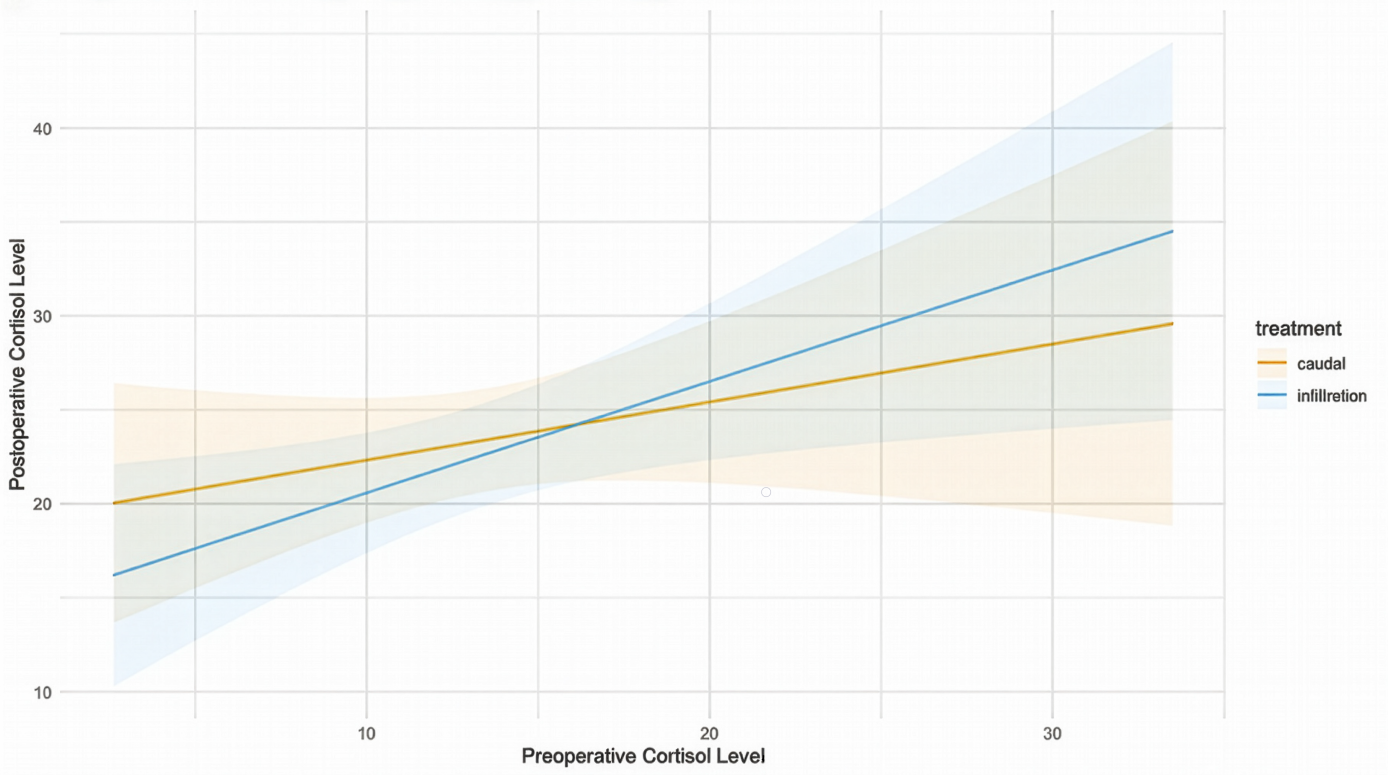

Figure 2. Interaction between preoperative and postoperative cortisol levels according to type of analgesia (caudal vs. infiltration). Shaded areas represent 95% confidence intervals. (No statistically significant interaction was observed between preoperative cortisol levels and type of analgesia (p = 0.4)).

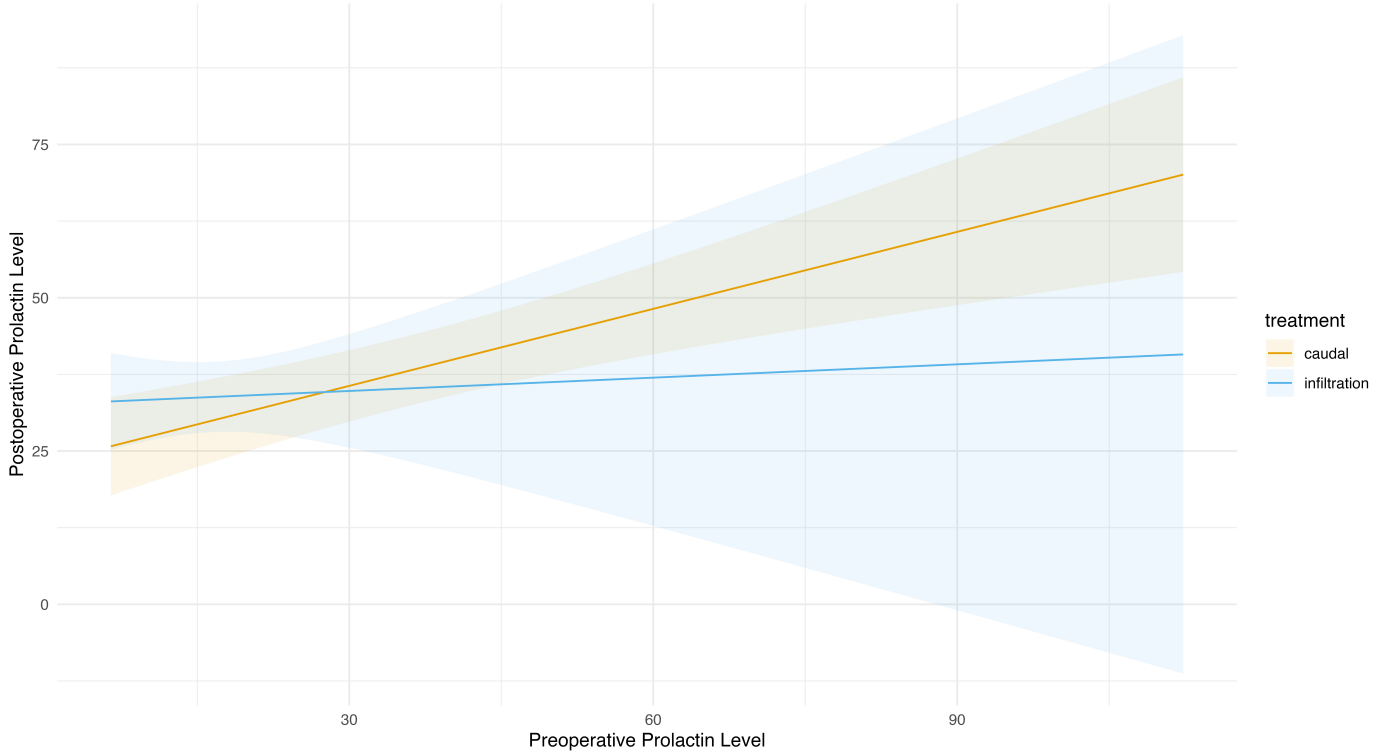

Figure 3. Relationship between preoperative and postoperative prolactin levels by analgesia type (caudal vs. infiltration). Shaded areas represent 95% confidence intervals. (A significant positive association was observed between preoperative and postoperative prolactin levels, regardless of analgesia type (p<0.05)).

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with our results.

In our study, both groups received general anesthesia, allowing for a more isolated assessment of the analgesic technique's effect. This likely explains the similar pain scores between groups. Çınar et al. reported a significant decrease in cortisol levels in children receiving levobupivacaine via wound infiltration [7]. While a similar hormonal suppression was observed in our study, no statistically significant difference was found between the two techniques.

Another study by Sakellaris et al. reported a significant reduction in postoperative prolactin levels in children who received ropivacaine wound infiltration [8]. Our findings align with this in the infiltration group; however, we also observed a positive correlation between preoperative and postoperative prolactin levels, suggesting that individual hormonal responses may be partially predictable.

In a randomized controlled trial by Gavrilovska-Brzanov et al. caudal block and local infiltration were compared, revealing that although caudal block provided longer analgesia, both techniques similarly reduced cortisol levels [9]. These findings support our results, indicating that both methods, when appropriately applied, can effectively modulate postoperative stress responses.

Park and Lee also found that wound infiltration shortened overall procedure time and was easier to administer [10]. In our study, the longer time required for positioning and performing the caudal block led to prolonged anesthesia and surgical durations, highlighting an important practical consideration.

There are several limitations to our study. It was not blinded, and the sample size was relatively small. However, the use of a consistent surgical team and blinded pain assessment by an independent anesthesiologist mitigate some of these limitations. Additionally, hormonal levels were measured only at two time points (preoperative and 40 minutes postoperative); longer-term follow-up could provide further insight into hormonal adaptation dynamics.

In conclusion, our findings show that both caudal block and local wound infiltration are similarly effective in managing postoperative pain and stress hormone responses in pediatric patients undergoing inguinal hernia repair. In clinical practice, the choice of analgesic technique should be guided by patient characteristics, ease of application, and procedural duration. Although caudal block may offer longer-lasting analgesia, wound infiltration remains a technically simpler and time-efficient alternative. Both techniques can be safely utilized in appropriate clinical settings.

CONCLUSION

This study demonstrated that caudal anesthesia and local wound infiltration provide comparable efficacy in postoperative pain control and hormonal stress response in pediatric inguinal hernia surgeries. While no significant differences were observed in cortisol or prolactin levels, or in pain scores and fentanyl consumption, our findings offer several clinically relevant insights.

Notably, caudal anesthesia required significantly longer anesthesia and surgical time, likely due to positioning and procedural complexity, which may affect workflow and resource allocation in busy clinical settings. In contrast, local wound infiltration is technically simpler, more time-efficient, and can be performed directly by the surgeon—factors that may contribute to lower costs and increased procedural autonomy.

Moreover, caudal block necessitates lateral positioning of the child, potentially introducing a confounding variable in hormonal stress response due to physical manipulation or procedural anxiety. Additionally, the circadian rhythm of stress hormones—particularly cortisol—raises the possibility that timing of sample collection may influence results. Future studies should account for these factors, including economic analysis, timing-related hormonal fluctuations, and role differentiation between anesthesia and surgical teams, to optimize analgesic strategies in pediatric practice.

Ethics Committee Approval: This study was approved by the Ethics Committee of Şişli Etfal Training and Research Hospital (Protocol No: 73, Date: 23.06.2009).

Informed Consent: Written and verbal consent was obtained from the parents of the children.

Peer-review: Externally peer-reviewed.

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

Author Contributions: Concept: O.D, A.S.Ç.; Design: M.A., S.S.IS.Ç., A.S.Ç.; Supervision: O.D., M.A., B.B., F.O.D., B.D., S.S.I.Ç., M.İ., A.S.Ç.; Materials: B.D., M.İ.; Data Collection and/or Processing: M.A., F.O.D., M.İ.; Analysis and/or Interpretation: O.D., B.B., F.O.D., B.D.; Literature Review: S.S.I.Ç.; Writing: O.D., B.B., F.O.D., S.S.I.Ç., M.İ.; Critical Review: M.A., B.B., B.D., A.S.Ç.

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