Texila International Journal of Academic Research
ISSN: 2520-3088
DOI: 10.21522/TIJAR.2014.12.01.Art003

Analgesic Efficacy of Fentanyl and Dexamethasone with Caudal Ropivacaine in Pediatric Infraumbilical Surgeries

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Abstract

Postoperative pain management in paediatric infra-umbilical surgeries remains a challenge. Caudal epidural anaesthesia with Ropivacaine is widely used, but adjuvants such as Fentanyl and Dexamethasone may enhance its analgesic efficacy. This study aimed to compare the analgesic effects of Fentanyl and Dexamethasone as adjuvants to caudal Ropivacaine in paediatric patients undergoing infra-umbilical surgeries. A prospective, randomized, double-blind study was conducted with 54 paediatric patients aged 1-12 years, classified as ASA I or II, undergoing elective infraumbilical surgeries. Patients were randomly divided into two groups: Group F received Ropivacaine (0.25%, 1 ml/kg) with Fentanyl (1 mcg/kg), and Group D received Ropivacaine (0.25%, 1 ml/kg) with Dexamethasone (0.1 mg/kg). Postoperative pain was assessed using the FLACC scale at regular intervals, and the time to first rescue analgesic was recorded. The mean time to first rescue analgesic was significantly longer in Group D (10 hours) compared to Group F (6 hours, $p < 0.001$). FLACC scores were consistently lower in Group D at all measured time points ($p < 0.001$), indicating superior analgesia. Both groups maintained stable hemodynamic parameters, and adverse effects were minimal. Dexamethasone as an adjuvant to caudal Ropivacaine provides prolonged and superior analgesia compared to Fentanyl, making it a more effective option for postoperative pain management in paediatric infra-umbilical surgeries.

Keywords**:** *Caudal Anaesthesia, Dexamethasone, Fentanyl, Paediatric Surgery, Postoperative Pain, Ropivacaine.*

Introduction

Effective postoperative pain management in paediatric patients undergoing infra-umbilical surgeries is essential for improving recovery outcomes and overall patient experience. These surgeries, which include procedures such as hernia repair, orchidopexy, circumcision, and appendectomy, are common in paediatric practice [1]. Managing pain in children presents a unique set of challenges due to their inability to express pain accurately and heightened sensitivity to stress, discomfort, and the potential psychological effects of pain. Inadequate postoperative pain control can lead to delayed recovery, prolonged hospital stays, and potential long-term psychological effects, including an increased risk of chronic pain and heightened pain sensitivity in future medical encounters [2]. Caudal epidural anaesthesia is a widely used technique for paediatric infra-umbilical surgeries due to its ability to provide effective analgesia while reducing the need for systemic opioids and their associated side effects. The caudal block involves the administration of local anaesthetic agents into the epidural space through the sacral hiatus, thereby blocking the nerve impulses in the lower spinal segments. This technique is particularly favoured in paediatric anaesthesia due to the ease of

Received: 13.11.2024 ***Accepted: 16.12.2024*** ***Published on: 31.01.2025***
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administration and the relative safety of the procedure [3].

Ropivacaine, an amide local anaesthetic, is commonly used in paediatric caudal blocks due to its favourable pharmacological properties. Introduced as a safer alternative to bupivacaine, Ropivacaine has a lower risk of cardiotoxicity and neurotoxicity, making it an attractive choice for paediatric anaesthesia. It is a pure S-enantiomer with vasoconstrictive properties that help prolong its duration of action by reducing systemic absorption. Additionally, Ropivacaine provides effective pain relief with minimal motor blockade, which is particularly important for children, as it allows for quicker mobilization post-surgery [5]. Despite these benefits, the use of Ropivacaine alone may not always provide sufficient analgesia for the entire postoperative period. The need to extend the duration of effective analgesia has led to the exploration of various adjuvants that can be added to local anaesthetics to enhance and prolong their effects. Adjuvants such as opioids, alpha-2 adrenergic agonists, and corticosteroids have been studied in combination with local anaesthetics to improve pain control and reduce the requirement for rescue analgesics. Adjuvants are pharmacological agents that, when combined with local anaesthetics, improve the quality and duration of anaesthesia and analgesia. They work through various mechanisms, including modulating pain pathways, reducing inflammatory responses, and providing synergistic effects that enhance the action of local anaesthetics. The use of adjuvants in paediatric caudal anaesthesia has the potential to offer superior pain management while minimizing the dosage of local anaesthetics, thus reducing the risk of associated side effects [6, 7].

Fentanyl is a potent synthetic opioid that is frequently used as an adjuvant in regional anaesthesia due to its strong analgesic properties. It binds to mu-opioid receptors in the central nervous system, inhibiting the transmission of pain signals and producing analgesia. Fentanyl's lipophilic nature facilitates rapid onset and prolonged duration of action, making it a valuable addition to local anaesthetics. Previous studies have demonstrated that adding Fentanyl to caudal Ropivacaine can significantly extend the duration of analgesia without causing major adverse effects. However, the use of opioids, including Fentanyl, is not without risks. While caudal administration of Fentanyl is associated with fewer systemic side effects than intravenous administration, it still carries the risk of opioid-related complications such as respiratory depression, pruritus, and nausea. Therefore, the search for alternative adjuvants that can provide prolonged analgesia without the associated opioid risks has gained momentum in recent years [7, 8].

Dexamethasone, a potent corticosteroid, has gained attention as an adjuvant in regional anesthesia due to its anti-inflammatory and immunosuppressive properties. It is hypothesized that Dexamethasone prolongs the duration of analgesia by reducing local inflammation and modulating nociceptive pathways. Its mechanism of action includes inhibiting the release of pro-inflammatory mediators such as prostaglandins and cytokines, thereby reducing pain and inflammation at the site of the nerve block. Studies have shown that adding Dexamethasone to local anaesthetics can significantly extend the duration of analgesia without increasing adverse effects. In paediatric patients, the use of Dexamethasone as an adjuvant to caudal blocks is particularly appealing due to its ability to provide prolonged pain relief without the opioid-related side effects seen with Fentanyl. Dexamethasone has been shown to reduce the need for rescue analgesics, improve patient comfort, and facilitate earlier discharge from the hospital [7, 9].

Given the challenges associated with managing postoperative pain in paediatric

patients and the potential benefits of using adjuvants to enhance caudal anaesthesia, this study aims to compare the analgesic efficacy of Fentanyl and Dexamethasone as adjuvants to caudal Ropivacaine in paediatric infra-umbilical surgeries. Although both Fentanyl and Dexamethasone have been studied individually as adjuvants, there is limited data directly comparing their efficacy in a paediatric population. Understanding which adjuvant provides more effective and longer-lasting analgesia can help optimize pain management protocols in paediatric anaesthesia. The primary objective of this study is to compare the duration of effective analgesia provided by caudal Ropivacaine when combined with either Fentanyl or Dexamethasone in paediatric infra-umbilical surgeries. The study also aims to assess postoperative pain scores using the FLACC (Face, Legs, Activity, Cry, Consolability) scale [10] at regular intervals during the first 12 hours post-surgery. In addition, the time to first rescue analgesic and hemodynamic stability, as well as the incidence of any adverse effects, will be evaluated to determine the safety profiles of the two adjuvants. Effective pain management in paediatric surgery not only improves patient comfort but also plays a crucial role in reducing surgical stress, improving wound healing, and preventing long-term psychological consequences. This study's findings are expected to contribute to the growing body of knowledge on optimizing paediatric postoperative pain management, particularly in the use of adjuvants to caudal Ropivacaine. By comparing Fentanyl and Dexamethasone, this study seeks to identify the more effective adjuvant in terms of prolonging analgesia, minimizing opioid-related side effects, and ensuring hemodynamic stability.

Materials and Methods

Study Design

This was a prospective, randomized, double-blind, parallel-group study designed to compare the analgesic efficacy and safety of Fentanyl and Dexamethasone as adjuvants to caudal Ropivacaine in paediatric patients undergoing infra-umbilical surgeries. The study was conducted at the Department of Anaesthesiology, Sree Balaji Medical College and Hospital, Bharath University, Chennai. Ethical approval was obtained from the institutional review board, and informed consent was obtained from the parents or guardians of all participating patients.

Study Population

The study enrolled paediatric patients aged between 1 and 12 years who were scheduled to undergo elective infraumbilical surgeries, including procedures such as hernia repair, orchidopexy, circumcision, and hypospadias repair. Patients were classified as American Society of Anaesthesiologists (ASA) physical status I or II. Patients were excluded if they had a known hypersensitivity to local anaesthetics or study drugs, coagulopathy, infection at the site of caudal injection, neurological disorders, psychiatric illness, or if their parents refused consent.

Inclusion Criteria

Paediatric patients aged between 1 and 12 years who were scheduled for elective infraumbilical surgeries, such as hernia repair, orchidopexy, circumcision, or hypospadias repair, were eligible for the study. Patients were required to have an American Society of Anaesthesiologists (ASA) physical status classification of I or II, indicating that they were generally healthy or had only mild systemic disease. Additionally, written informed consent had to be obtained from the patient’s parents or legal guardians before the procedure. All patients were expected to

undergo general anaesthesia with a caudal block for postoperative pain management.

Exclusion Criteria

Patients were excluded from the study if they had an ASA classification of III or IV, indicating severe systemic disease or a life-threatening condition. Other exclusion criteria included patients undergoing emergency surgeries, known allergies to local anaesthetics, Fentanyl, or Dexamethasone, and those with coagulopathy or anticoagulant use. Patients with infections at the site of the caudal block, pre-existing neurological disorders, or psychiatric illness were also excluded. Additionally, any patient whose parents or legal guardians refused to provide informed consent was not enrolled in the study, ensuring ethical compliance.

Sample Size

A sample size of 54 patients was calculated based on a power analysis using data from a similar study by Gandhi et al. (2021), which compared the effects of adjuvants on caudal anaesthesia. The analysis determined that 27 patients per group would provide an 80% power to detect a statistically significant difference in postoperative pain scores (FLACC scores) between the two groups, with a confidence level of 95% and an alpha error of 0.05.

Randomization and Blinding

Patients were randomly assigned into two groups using a computer-generated randomization table. Group F received Ropivacaine (0.25%, 1 ml/kg) with Fentanyl (1 mcg/kg), while Group D received Ropivacaine (0.25%, 1 ml/kg) with Dexamethasone (0.1 mg/kg). Randomization was performed by an independent researcher who was not involved in patient care. The anaesthesiologist performing the caudal block, the patient, and the researcher responsible for postoperative assessments were all blinded to the group allocation. The study drugs were prepared in identical syringes by an independent anaesthesiologist who was not involved in data collection or patient care.

Anaesthesia Protocol

All patients underwent a standard preoperative assessment, including a thorough medical history, physical examination, and routine laboratory investigations. On the day of surgery, patients were kept nil per oral (NPO) for 6 hours for solids, 4 hours for breast milk, and 2 hours for clear liquids. In the operating room, standard monitoring devices were applied, including non-invasive blood pressure (NIBP), pulse oximetry (SpO2), and electrocardiography (ECG). Baseline heart rate, blood pressure, and oxygen saturation were recorded. All patients received premedication with intravenous glycopyrrolate (0.004 mg/kg) and midazolam (0.01 mg/kg) to reduce anxiety and secretions. General anaesthesia was induced with intravenous propofol (2–3 mg/kg) and Fentanyl (2–3 mcg/kg), followed by muscle relaxation with atracurium (0.5 mg/kg). After adequate mask ventilation, either a laryngeal mask airway (LMA) or an endotracheal tube was inserted. Anaesthesia was maintained with oxygen, nitrous oxide, and sevoflurane (1–2%).

Caudal Block Technique

Following induction of general anaesthesia, the patient was placed in the left lateral decubitus position. Under sterile conditions, the caudal epidural space was identified using anatomical landmarks, specifically the sacral hiatus and sacral cornua. A 22-gauge hypodermic needle was advanced through the sacrococcygeal ligament into the caudal epidural space. After negative aspiration for blood or cerebrospinal fluid (CSF), 0.25% Ropivacaine (1 ml/kg) with either Fentanyl (1 mcg/kg) or Dexamethasone (0.1 mg/kg) was administered slowly over 1–2 minutes. The correct placement of the needle was confirmed using the "whoosh" test, in which the injection

of air produced an audible sound as it entered the epidural space. Intraoperatively, heart rate, blood pressure, respiratory rate, end-tidal CO2 (ETCO2), and SpO2 were continuously monitored. At the end of the procedure, neuromuscular blockade was reversed with intravenous neostigmine (0.05 mg/kg) and glycopyrrolate (0.01 mg/kg). Patients were extubated when fully awake and transferred to the post-anaesthesia care unit (PACU) for further monitoring.

Postoperative Pain Assessment

Postoperative pain was assessed using the FLACC (Face, Legs, Activity, Cry, Consolability) scale, which is widely used for evaluating pain in children who cannot verbalize their pain levels. The FLACC scale assigns a score of 0 to 2 for each category, with a total score ranging from 0 to 10. A score of 0–3 indicates mild pain, 4–7 indicates moderate pain, and 8–10 indicates severe pain. Pain assessments were conducted at 1-hour intervals for the first 3 hours, followed by assessments every 2 hours for the next 12 hours. The primary outcome measure was the duration of effective analgesia, defined as the time from caudal block administration to the first requirement of rescue analgesia. Rescue analgesia, in the form of intravenous paracetamol (15 mg/kg), was administered if the FLACC score exceeded 4 at any time point.

Secondary Outcome Measures

The secondary outcome measures included evaluating postoperative hemodynamic stability by monitoring heart rate and blood pressure at regular intervals. The study also assessed the incidence of adverse effects such as respiratory depression, nausea, vomiting, pruritus, and urinary retention, which are common complications of opioid and corticosteroid use. The proportion of patients requiring rescue analgesia during the 12-hour postoperative period was recorded, providing insights into the duration and quality of analgesia in both groups. These outcomes helped determine the safety profile and overall effectiveness of Fentanyl and Dexamethasone as adjuvants to caudal Ropivacaine.

Statistical Analysis

Descriptive statistics were used to summarize patient demographics and baseline characteristics. Continuous variables, such as age, weight, and duration of analgesia, were expressed as mean ± standard deviation (SD) and compared between the two groups using an independent t-test. Categorical variables, such as gender distribution and the proportion of patients requiring rescue analgesia, were compared using the chi-square test or Fisher's exact test as appropriate. Pain scores (FLACC scores) were analysed at each time point using repeated measures ANOVA to account for within-subject correlations. Kaplan-Meier survival analysis was performed to compare the time to first rescue analgesic between the two groups, and the log-rank test was used to assess statistical significance. Hemodynamic data, including heart rate and blood pressure, were analysed using repeated measures ANOVA to evaluate changes over time between the two groups. Adverse events were compared using chi-square or Fisher's exact tests. All statistical analyses were conducted using SPSS version 22.0 (IBM Corp., Armonk, NY), and a p-value of < 0.05 was considered statistically significant.

Ethical Considerations

The study was conducted in accordance with the ethical guidelines of the Declaration of Helsinki and Good Clinical Practice (GCP) standards. Ethical approval was obtained from the institutional ethics committee prior to the commencement of the study. Written informed consent was obtained from the parents or legal guardians of all patients before enrolment in the study.

Results

A total of 54 paediatric patients undergoing infra-umbilical surgeries were enrolled in the study and randomly assigned into two groups: Group F (Ropivacaine with Fentanyl, n=27) and Group D (Ropivacaine with Dexamethasone, n=27). The demographic characteristics of the two groups were comparable, with no statistically significant differences. The mean age in Group F was 5.2 ± 1.8 years, while in Group D, it was 5.4 ± 1.9 years ($p = 0.70$) (Figure 1a). The gender distribution was balanced in both groups, with 51.8% males in Group F and 55.5% males in Group D ($p = 0.60$) (Figure 1b). The mean weight was 18.3 ± 3.2 kg in Group F and 18.7 ± 3.1 kg in Group D ($p = 0.65$), showing no significant difference in body weight (Figure 1c). Both groups had a comparable ASA classification, with 74.1% of patients in Group F and 81.5% in Group D classified as ASA I ($p = 0.55$) (Figure 1d).

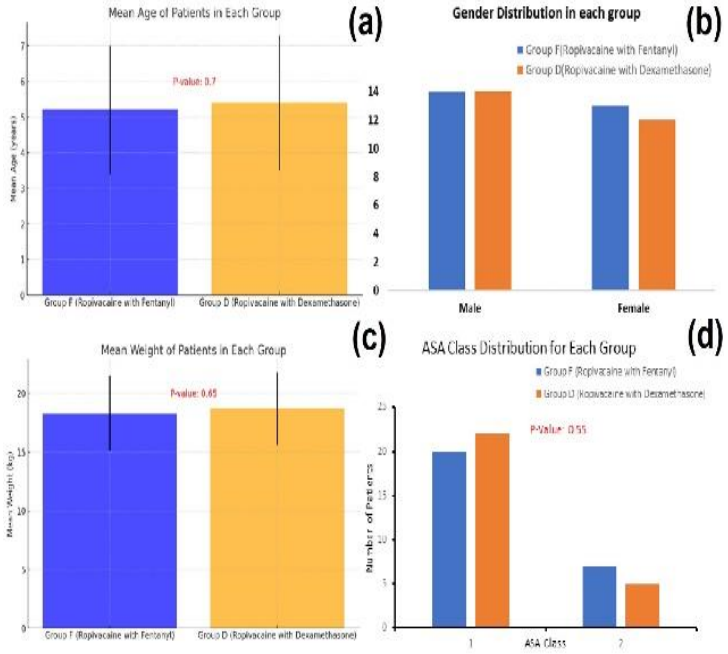

Figure 1. a) Mean Age, b) Gender Distribution, c) Mean weight, d) ASA Class

Postoperative pain was assessed using the FLACC scale at 1-hour intervals for the first 3 hours, and then at 2-hour intervals until 12 hours postoperatively. FLACC scores were significantly lower in Group D (Ropivacaine + Dexamethasone) compared to Group F (Ropivacaine + Fentanyl) at all time points. At 1 hour, Group F had a mean FLACC score of 2.5 ± 1.0, while Group D had a significantly lower score of 1.0 ± 0.5 ($p < 0.001$). At 2 hours, the mean FLACC score in Group F increased to 3.0 ± 1.2, whereas it remained low in Group D at 1.2 ± 0.6 ($p < 0.001$). At 4 hours, Group F's FLACC score rose to 4.0 ± 1.8, compared to 1.8 ± 0.9 in Group D ($p < 0.001$). At 6 hours, Group F's mean FLACC score was 4.5 ± 2.0, while Group D had a significantly lower score of 2.0 ± 1.0 ($p < 0.001$). At 12 hours, the final FLACC scores were 5.0 ± 2.5 in Group F and 3.0 ± 1.2 in Group D ($p < 0.001$) (Figure 2). The results demonstrate consistently lower pain scores in the Dexamethasone group, indicating more effective postoperative pain control compared to the Fentanyl group.

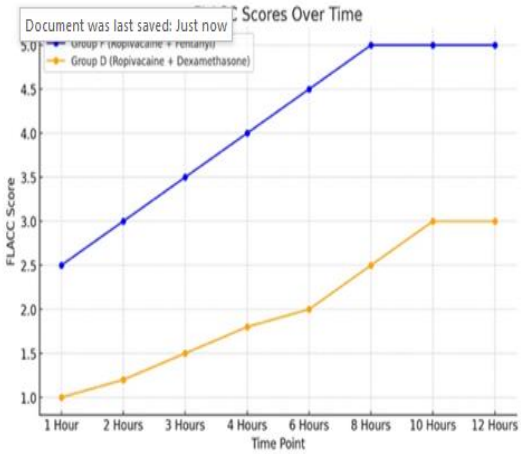

Figure 2. FLACC Scores at Different Time Points

The mean time to first rescue analgesic was significantly longer in Group D (Ropivacaine + Dexamethasone) compared to Group F (Ropivacaine + Fentanyl). In Group F, the mean time to the first administration of rescue analgesia (intravenous paracetamol) was 6 hours (95% CI: 5.5–6.5), whereas in Group D, the mean time was 10 hours (95% CI: 9.5–10.5) ($p < 0.001$) (Figure 3). This indicates that patients in the Dexamethasone group experienced longer-lasting analgesia compared to those in the Fentanyl group. A Kaplan-Meier survival analysis was conducted to compare the time to first rescue analgesic between the two groups, with the log-rank test showing a statistically significant difference favoring Group D ($p < 0.001$). The prolonged duration of analgesia in Group D suggests that Dexamethasone is a more effective adjuvant for extending the analgesic effects of caudal Ropivacaine.

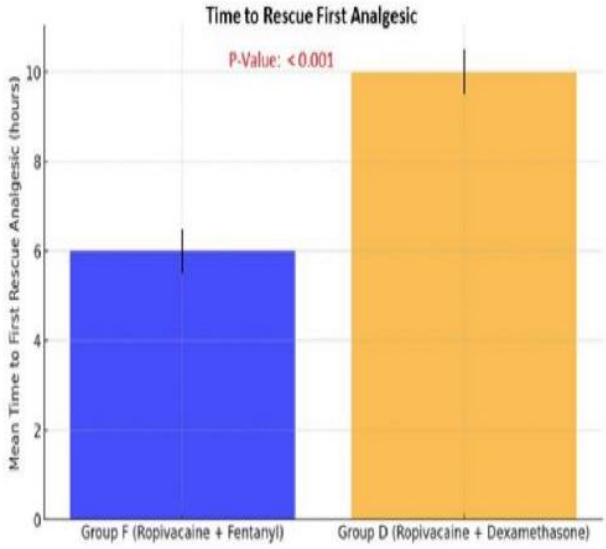

Figure 3. Time to first Rescue Analgesic in both the Groups

Both groups maintained stable hemodynamic parameters throughout the postoperative period. No significant differences were observed in heart rate or blood pressure between Group F and Group D at any time point. At 1 hour postoperatively, the mean heart rate was 105 ± 10 bpm in Group F and 106 ± 9 bpm in Group D ($p = 0.876$). At 4 hours, the heart rates were 102 ± 10 bpm in Group F and 103 ± 9 bpm in Group

D (p = 0.235). At 12 hours, the heart rates remained comparable, with 100 ± 10 bpm in Group F and 101 ± 9 bpm in Group D (p = 0.876) (Figure 4a). Similarly, blood pressure measurements were stable in both groups, with no significant differences. At 1 hour postoperatively, the mean blood pressure was 85/55 mmHg in Group F and 87/57 mmHg in Group D (p = 0.287). At 4 hours, the blood pressure was 82/52 mmHg in Group F and 84/54 mmHg in Group D (p = 0.295). At 12 hours, both groups showed similar readings of 80/50 mmHg in Group F and 82/52 mmHg in Group D (p = 0.806) (Figure 4b and 4c). These findings suggest that both Fentanyl and Dexamethasone maintained stable cardiovascular profiles when used as adjuvants to caudal Ropivacaine.

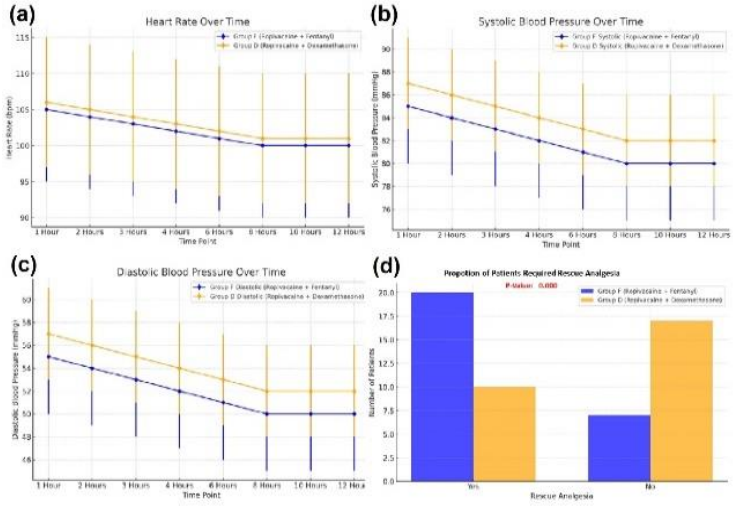

Figure 4. a) Comparison of Heart Rate, b) Comparison of Systolic Blood Pressure, c) Comparison of Diastolic Blood Pressure, d) Proportion of Patients Requiring Rescue Analgesia

The incidence of adverse effects was minimal in both groups, with no major complications reported. However, Group F (Ropivacaine + Fentanyl) had a higher occurrence of minor side effects compared to Group D (Ropivacaine + Dexamethasone). In Group F, 3 patients (11.1%) experienced pruritus, 2 patients (7.4%) had nausea, and 1 patient (3.7%) reported vomiting. In Group D, no cases of pruritus, nausea, or vomiting were reported. Respiratory depression was not observed in either group, or there were no cases of urinary retention. The difference in the incidence of adverse effects between the two groups was not statistically significant, but the absence of side effects in the Dexamethasone group further supports its favourable safety profile. The proportion of patients requiring rescue analgesia during the 12-hour postoperative period was significantly higher in Group F (Ropivacaine + Fentanyl) compared to Group D (Ropivacaine + Dexamethasone). In Group F, 20 out of 27 patients (74.1%) required rescue analgesia, while only 10 out of 27 patients (37.0%) in Group D needed additional analgesia (p < 0.001) (Figure 4d). This further emphasizes the superior analgesic efficacy of Dexamethasone when used as an adjuvant to Ropivacaine in caudal blocks.

Discussion

Postoperative pain management in paediatric patients undergoing infra-umbilical surgeries presents a significant challenge due to the patients' limited ability to express pain and the potential for both short- and long-term physiological and psychological consequences if pain is inadequately treated. Caudal epidural anaesthesia, particularly with Ropivacaine, is a well-established technique for providing effective intraoperative and postoperative analgesia in paediatric patients. However, the

duration of analgesia provided by Ropivacaine alone is often insufficient to cover the entire postoperative period, necessitating the use of adjuvants to prolong its effects [11, 12, 13]. This study compared the analgesic efficacy and safety of two adjuvants, Fentanyl and Dexamethasone, when added to caudal Ropivacaine in paediatric infra-umbilical surgeries. The results demonstrate a clear advantage of Dexamethasone over Fentanyl in terms of prolonged analgesia, lower postoperative pain scores, and fewer rescue analgesia requirements.

The primary outcome of this study was the duration of effective analgesia, measured as the time to first rescue analgesic. The findings clearly showed that Dexamethasone provided a significantly longer duration of analgesia compared to Fentanyl. In Group D (Ropivacaine + Dexamethasone), the mean time to first rescue analgesic was 10 hours, compared to 6 hours in Group F (Ropivacaine + Fentanyl) ($p < 0.001$). This difference is clinically significant, as it indicates that patients in the Dexamethasone group experienced prolonged pain relief, reducing the need for additional analgesics during the immediate postoperative period. The mechanism by which Dexamethasone prolongs analgesia is likely multifactorial. As a potent anti-inflammatory corticosteroid, Dexamethasone reduces local inflammation at the site of nerve blockade, which can enhance the effect of local anaesthetics. It also modulates nociceptive pathways, potentially stabilizing nerve membranes and reducing pain transmission. These actions contribute to the sustained analgesic effects observed in the Dexamethasone group. The findings align with previous studies that have demonstrated the analgesic benefits of Dexamethasone when used as an adjuvant in various regional anaesthesia techniques, including caudal blocks [14, 15, 16, 17].

In contrast, while Fentanyl also enhanced the duration of analgesia compared to Ropivacaine alone, its effects were notably shorter than those of Dexamethasone. Fentanyl, as a synthetic opioid, works by binding to mu-opioid receptors, providing potent analgesia. However, the relatively short half-life of Fentanyl may account for the earlier requirement of rescue analgesics in Group F. The opioid effects of Fentanyl also raise concerns about potential side effects, although the incidence of such effects was low in this study [18, 19, 20, 21].

The FLACC pain score, used to assess postoperative pain in non-verbal pediatric patients, revealed significantly lower scores in the Dexamethasone group at all postoperative time points. The FLACC scores in Group D remained below 2 for the first 6 hours postoperatively, compared to significantly higher scores in Group F during the same period. At 12 hours postoperatively, Group F had a mean FLACC score of 5.0 ± 2.5, while Group D maintained a lower score of 3.0 ± 1.2 ($p < 0.001$). These lower pain scores in Group D reflect the superior analgesic efficacy of Dexamethasone, which likely stems from its anti-inflammatory properties and its ability to reduce local tissue irritation. By preventing the release of pro-inflammatory cytokines and reducing peripheral sensitization, Dexamethasone minimizes the perception of pain. The sustained low pain scores in the Dexamethasone group support its use as a highly effective adjuvant in paediatric caudal blocks [22, 23, 24].

Both Fentanyl and Dexamethasone maintained stable hemodynamic parameters in the postoperative period. There were no significant differences in heart rate or blood pressure between the two groups at any time point, and all patients remained hemodynamically stable throughout the study. These findings are important, as they demonstrate that both adjuvants can be used safely in paediatric patients without causing significant cardiovascular fluctuations. While Fentanyl is known to cause bradycardia and

hypotension in some cases, the low doses used in this study were well-tolerated by the patients. Similarly, Dexamethasone has a favourable safety profile and did not induce any significant hemodynamic changes. The incidence of adverse effects was minimal in both groups, though Fentanyl was associated with a slightly higher occurrence of side effects. In Group F, 11.1% of patients experienced pruritus, and 7.4% reported nausea. These are common side effects of opioids and can be distressing for pediatric patients. In contrast, no patients in Group D reported pruritus, nausea, or vomiting, further emphasizing the safety of Dexamethasone as an adjuvant. Respiratory depression, a major concern with opioid use, was not observed in any patients, likely due to the low dose of Fentanyl administered. However, the potential for respiratory complications remains a significant consideration when using opioids in paediatric patients. Dexamethasone, on the other hand, did not cause any opioid-related side effects, and its anti-inflammatory properties may have contributed to a smoother postoperative recovery with fewer complications. These findings suggest that Dexamethasone may be the preferable adjuvant in paediatric caudal blocks, offering both superior analgesia and a lower incidence of side effects.

The findings of this study are consistent with previous research comparing the analgesic effects of Fentanyl and Dexamethasone as adjuvants to local anaesthetics. Studies have shown that Dexamethasone, when used in caudal blocks, significantly prolongs the duration of analgesia without major side effects. For example, a study by Kim et al. (2014) [9] demonstrated that Dexamethasone provided prolonged postoperative pain relief in paediatric patients undergoing orchidopexy, with a duration of analgesia similar to that observed in the present study. Similarly, other studies have reported that Fentanyl enhances the duration of analgesia when used with caudal Ropivacaine but is associated with a higher incidence of opioid-related side effects. This study's findings align with those results, further supporting the use of Dexamethasone as the superior adjuvant for prolonging analgesia and minimizing side effects.

The results of this study have important clinical implications for paediatric anaesthesiologists. Effective postoperative pain management in paediatric patients is critical for improving recovery outcomes, reducing stress responses, and preventing long-term psychological consequences. The findings suggest that Dexamethasone should be considered the preferred adjuvant to caudal Ropivacaine in paediatric infra-umbilical surgeries, as it provides longer-lasting analgesia with fewer side effects than Fentanyl. The use of Dexamethasone could lead to improved patient comfort, reduced need for rescue analgesics, and shorter hospital stays, all of which contribute to better overall recovery. Furthermore, the lower incidence of side effects associated with Dexamethasone makes it a safer option, particularly in paediatric patients, who are more vulnerable to opioid-related complications. These benefits highlight the value of incorporating Dexamethasone into standard pain management protocols for paediatric infra-umbilical surgeries.

While this study provides valuable insights into the analgesic efficacy of Fentanyl and Dexamethasone, there are some limitations to consider. The relatively small sample size may limit the generalizability of the findings, and the study was conducted at a single center, which could introduce bias related to local practices. Additionally, the study focused on short-term outcomes, with follow-up limited to the first 12 hours postoperatively. Future research should include larger, multicenter trials with longer follow-up periods to assess the long-term safety and efficacy of these adjuvants.

Conclusion

This study demonstrates that Dexamethasone is a more effective and safer adjuvant than Fentanyl when used with caudal Ropivacaine in paediatric infra-umbilical surgeries. Dexamethasone provided significantly longer analgesia, lower postoperative pain scores, and fewer rescue analgesia requirements than Fentanyl. It also had a more favourable safety profile, with fewer opioid-related side effects. These findings support the use of Dexamethasone as an ideal adjuvant in paediatric caudal anaesthesia for infra-umbilical surgeries.

Conflict of Interest

The authors declare that there is no conflict of interest.

Acknowledgements

We would like to thank all those who have helped us in carrying out the research.

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