

RESEARCH ARTICLE

Preoperative caudal blocks associated with decreased cumulative opioid requirements compared to postoperative caudal blocks in pediatric urologic surgery

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Abstract

Background: Caudal blocks (CB) are a cornerstone of pediatric urologic surgery, providing effective analgesia while mitigating potential neurotoxicity associated with general anesthesia and opioids. However, the optimal timing of CB—preoperative versus postoperative—remains controversial. This study compares total opioid requirements in pediatric patients receiving preoperative versus postoperative CB to determine the timing that best minimizes opioid use.

Methods: All male patients aged 6–36 months who underwent urologic surgery from January 2019 to January 2023 at a single institution and had anesthesia care delivered by one of two attending pediatric anesthesiologists were retrospectively reviewed. One routinely administers preoperative CB following induction while the other performs postoperative CB immediately prior to emergence. Data collected included patient demographics, CB timing and dosage, opioid dosages, total anesthesia time, and postanesthesia care unit (PACU) time. Statistical analysis used Mann–Whitney *U*-test and chi-square test, with results considered statistically significant at $p < 0.05$.

Results: 41 patients met inclusion criteria; 24 received preoperative CB, 17 received postoperative CB. There were no significant differences in age, weight, CB dose, total anesthesia time, or PACU time between the groups. Compared to the postoperative CB group, the preoperative CB group had significantly lower mean total opioid dose (3.875 vs. 26.470 mcg, $p < 0.001$), lower mean weight-based dose (0.360 vs. 2.620 mcg/kg, $p < 0.001$), and fewer patients requiring opioids at all (37.5% vs. 94.1%, $p < 0.001$).

Conclusion: In this study, preoperative CB administration was associated with a significantly reduced cumulative opioid requirement in pediatric urologic surgery compared to postoperative administration.

KEYWORDS

caudal block, narcotics, opioids, pediatric urology, regional block

Jordan L. Mendelson and William Brenseke are co-first authors of this manuscript.

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1 | INTRODUCTION

Regional anesthetic blocks have become increasingly popular in pediatric surgery over the course of the last few decades. A large variety of peripheral and central nerve blocks have been studied and validated as analgesic adjuncts in an effort to decrease the neurotoxicity associated with general anesthesia in children and reduce the amount of both general anesthesia and opioids required. Recent studies have shown that nearly one-quarter of anesthetic procedures performed on children worldwide now involve regional anesthesia^[1]. Caudal blocks (CB) are one of the most commonly administered regional blocks in pediatric patients undergoing infraumbilical surgery, accounting for 34%–40% of regional anesthetic blocks in children^[1,2]. During a CB, a needle is passed through the sacrococcygeal ligament into the caudal space and local anesthetic, most often either bupivacaine or ropivacaine, is then delivered, sometimes in conjunction with other adjuvant medications^[3,4]. Meredith Campbell, a urologist, first described CB in 1933 in relation to pediatric urologic surgery^[5]. Veyckemans et al. later described a single institution's experience performing 1100 CB between 1986 and 1989 and found that CB is a reliable, effective method of administering regional anesthesia with an analgesic success rate greater than 99% and a relatively short learning curve^[6]. Schuepfer et al. evaluated the learning curve for CB and found that seven anesthesiology residents required an average of just 32 CB each to achieve a success rate of 80%, comparable to their attending pediatric anesthesiologists, reinforcing the relative ease with which the procedure can be learned by beginners^[7]. Some of the most common indications for CB today include inguinal surgery and penile surgery, such as hypospadias repair^[4].

Within the last 35 years since Veyckemans and colleagues published their institution's experience, a host of articles have been published demonstrating the efficacy of CB in pediatric surgery, most often in the context of pediatric urologic surgery. A randomized controlled trial of 60 pediatric patients undergoing inguinal hernia repair showed that, when compared to general anesthesia alone, general anesthesia combined with CB led to decreased pain, greater intraoperative hemodynamic stability, and a significantly repressed neuroendocrine stress response to surgery, with lower serum glucose and cortisol concentrations^[8]. Aside from its obvious analgesic properties, CB in the pediatric population has been shown to be associated with both decreased postoperative agitation and decreased time spent in the postanesthesia care unit (PACU)^[9,10]. Several studies have shown that complication rates directly related to CB administration are exceedingly low, often ranging from 0% to 3%, and very rarely serious^[1–3]. CB has similarly been shown to not be

associated with any increased incidence of postoperative complications as well^[11–14].

Despite the abundance of data to support the widespread use of CB in pediatric surgery, there still exists some debate about when to administer the block in relation to the surgical procedure. Two studies in the 1990s examined postoperative pain outcomes in pediatric patients based on whether they received a CB prior to the surgery or immediately postoperatively. Rice et al. conducted a randomized, double-blinded study of 40 children. Patients were randomized to receive a CB either immediately after induction of anesthesia or immediately after the surgery was completed, prior to emergence. Postoperative pain scores were assessed with an objective pain scale. The study found no significant difference between the two group in regards to postoperative pain scores, the need for postoperative analgesics, or time spent in PACU^[15]. Holthusen et al. conducted a similarly designed randomized, double-blinded study of 25 children undergoing circumcision, with the children randomized to similar groups. He found no significant difference between the two groups in cumulative postoperative analgesic requirement within the first 48 h postoperatively or in time to initial analgesic administration. However, the postoperative CB group was shown to have decreased cumulative pain scores for the first 8 h postoperatively^[16].

Unlike this study, these prior studies did not also examine the intraoperative analgesic or opioid requirements of these patients. Provided that the timing of a CB does not appear to significantly affect the degree of postoperative pain, we set out in this study to determine if the timing of a CB instead affects the cumulative dose of opioids a pediatric patient receives, both intraoperatively and postoperatively. We hypothesized that preoperative CB would lead to decreased cumulative administration of intraoperative and postoperative opioids.

2 | METHODS

We conducted a retrospective review of all male pediatric patients, aged 6 months to 36 months, undergoing one of a selection of various pediatric urologic procedures under the care of one of two attending pediatric anesthesiologists at a single institution between January 2019 and January 2023. Female patients were not intentionally excluded from this study; the observed lack of representation was simply due to the penoscrotal nature of most of these cases. Surgical procedures included hypospadias repair, chordee repair, inguinal hernia repair, circumcision, and orchiopexy, as shown in Table 1. One of the pediatric anesthesiologists routinely performs CB preoperatively following induction while the other routinely performs CB postoperatively just prior to emergence. CB were administered with

either bupivacaine or ropivacaine. In PACU following conclusion of the case, patients routinely receive acetaminophen and/or ibuprofen if they are experiencing some degree of obvious pain and/or agitation. In a stepwise fashion, patients then sometimes receive opioids for additional analgesia if the initial medications are not helpful in relieving the pain/agitation. Selection of specific opioid was similar between the two groups. Extensive patient and procedure data were collected on demographic information, CB agent and dosage, intravenous (IV) and non-IV non-steroidal anti-inflammatory drugs (NSAIDs) administration and dosage, opioid administration, agent and dosage, total surgical time (i.e., time from induction to emergence as documented in the electronic medical record), and total time in PACU. Patients were categorized based on whether they received a preoperative CB or postoperative CB. Potential confounders include the use of adjunct

analgesics. Statistical analyses were conducted using the Mann-Whitney *U*-test or the chi-square test, as deemed appropriate. Analyses were performed in Python using the Pandas and NumPy libraries. A result was considered statistically significant at $p < 0.05$. The owner of the dataset referenced herein is the authors' own institution.

3 | RESULTS

41 patients met inclusion criteria. Of these 41 patients, 24 received preoperative CB and 17 received postoperative CB. There was no significant difference between the two groups in regards to mean age ($p = 0.481$), weight ($p = 0.842$), CB dose ($p = 0.750$), total anesthesia time ($p = 0.131$), procedure duration ($p = 0.057$), or time spent in PACU ($p = 0.701$). Table 2 summarizes these results. Additionally, there was no significant difference between the two groups in regard to CB dose ($p = 0.782$) or CB weight-based dose ($p = 0.425$). However, all patients (17/17) in the postoperative (post-op) CB group received bupivacaine 0.25% while most (22/24) patients in the preoperative (pre-op) CB group received ropivacaine 0.25%, as demonstrated in Table 3. No patients experienced any complications related to the delivery of the CB.

3/24 patients in the preoperative CB group received an acetaminophen suppository in comparison to 15/17 patients in the postoperative group. Despite both groups receiving adjunct IV analgesics (pre-op CB 15/17 and post-op CB 22/24), the analgesic of choice routinely differed: the preoperative CB group was more likely to receive IV acetaminophen (21/24), while the postoperative CB group was more likely to receive IV ketorolac (15/17) ($p < 0.001$). As a result, there was a statistically significant difference in the mean dose and

TABLE 1 Procedural data for pre-op CB and post-op CB groups.

Procedure	Pre-op CB ($n = 24$)	Post-op CB ($n = 17$)
Orchiopexy	13	5
Circumcisions	9	9
Inguinal hernia repair	5	3
Penoplasty	6	3
Hypospadias repair	3	4
Chordee repair	5	2
Penile torsion repair	2	0
Penile cyst excision	0	2

Note: Most of the surgeries consisted of multiple procedures, which is why the total number of procedures is greater than the total number of patients.

Abbreviations: CB, caudal block; post-op, postoperative; pre-op, preoperative.

TABLE 2 Demographic, procedural data, opioid use for pre-op CB and post-op CB groups.

Demographic, procedural data and opioid use	Pre-op CB ($n = 24$)	Post-op CB ($n = 17$)	<i>p</i> -value
Mean age (months)	15.83	14.00	0.481
Mean weight (kg)	10.77	10.60	0.842
Mean CB dose (mL)	10.68	9.99	0.750
Mean total general anesthesia time (min)	95.00	115.71	0.131
Mean procedure duration (min)	56.38	74.41	0.057
Mean total PACU time (min)	69.83	77.47	0.701
Mean opioid total dose (mcg) ^a	3.875	26.470	< 0.001
Mean opioid weight-based dose (mcg/kg) ^a	0.360	2.620	< 0.001
Percent patients receiving opioid ^a	37.5% (9/24)	94.1% (17/17)	< 0.001

Note: No post-op pain medication was administered to any patients in either group during their PACU stay prior to discharge.

Abbreviations: CB, caudal block; post-op, postoperative; pre-op, preoperative; PACU, postanesthesia care unit.

^aOpioid use consisted of intraoperative fentanyl administration.

weight-based dose for IV acetaminophen and ketorolac across both groups, as shown in Table 4.

The groups differed in the cumulative amount of opioids received for analgesia. The preoperative CB group received a significantly smaller mean total opioid dose (i.e., cumulative intraoperative and postoperative opioid dose; 3.875 vs. 26.470 mcg, $p < 0.001$) and mean weight-based opioid dose (0.360 vs. 2.620 mcg/kg, $p < 0.001$). The percentage of patients who received any opioids either intraoperatively or postoperatively was also significantly lower in the preoperative CB group (37.5% vs. 94.1%, $p < 0.001$), as seen in Table 2. Pain scores were determined subjectively by PACU nursing.

4 | DISCUSSION

In this study, the group of pediatric male patients undergoing pediatric urologic procedures that received preoperative CB received less opioids for sufficient analgesia both intraoperatively and postoperatively when compared to the group that received postoperative CB. While the ideal timing of CB is still somewhat open for debate, it is abundantly clear within the current available literature that CB decreases the

need for additional adjunct analgesic medications within pediatric surgery. In 2018, Alizadeh et al. demonstrated that CB was associated with decreased intraoperative fentanyl requirement during hypospadias repair^[17]. A similarly designed, earlier randomized study by Tobias et al. found that, when compared to postoperative infiltration of local anesthetic into the incisional site, CB was associated with both decreased isoflurane requirements intraoperatively and decreased opioid requirements postoperatively for analgesia^[18]. Additional randomized studies have only served to validate these findings; CB has been shown in other pediatric patient populations to lead to decreased propofol use, decreased opioid use, and decreased sevoflurane use^[19–21]. And, though two prior studies compared the efficacy of preoperative CB and postoperative CB in pediatric patients in relation to postoperative pain scores and postoperative analgesic use, they did not account for potential differences in intraoperative analgesic use^[15,16]. Thus, we believe this is the first study to look at the comparative efficacy of preoperative CB and postoperative CB in pediatric patients in regards to cumulative opioid dose received both intraoperatively and postoperatively.

This has potentially huge ramifications in pediatric surgery, as opioids in general are known to have the potential to produce long-lasting neuropsychological effects in the pediatric population, such as decreased visuo-constructional ability as a measure of higher-order executive function, though this is often an effect of prolonged, repeat exposure to opioids^[22]. Still, based on the data within this study, the potential long-term risks posed by opioid use in the pediatric population, and the overall efficacy and safety profile of CB in general, our findings suggest that preoperative CB should be administered in most cases—barring any contraindications—prior to infra-umbilical surgery in the pediatric population in an

TABLE 3 Caudal block data for pre-op CB and post-op CB groups.

CB type	Pre-op CB (n = 24)	Post-op CB (n = 17)
Bupivacaine 0.25%	1	13
Bupivacaine 0.25% + epinephrine	1	4
Ropivacaine 0.25%	22	0

Abbreviations: CB, caudal block; post-op, postoperative; pre-op, preoperative.

TABLE 4 Nonsteroidal anti-inflammatory drug (NSAID) use for pre-op CB and post-op CB groups.

NSAID use	Pre-op CB (n = 24)	Post-op CB (n = 17)	p-value
Number of patients receiving suppository acetaminophen	3	15	N/A
Mean suppository acetaminophen dose (mg)	28.54	165	< 0.001
IV NSAID administration			
Number of patients receiving IV ketorolac	1	15	N/A
Mean ketorolac dose (mg)	1.625	8.72	< 0.001
Mean ketorolac weight-based dose (mg/kg)	0.021	0.840	< 0.001
Number of patients receiving IV acetaminophen	21	0	N/A
Mean acetaminophen dose (mg)	144.167	0	< 0.001
Mean acetaminophen weight-based dose (mg/kg)	13.150	0	< 0.001

Note: All suppositories were administered preoperatively and all IV NSAIDs were administered intraoperatively.

Abbreviations: CB, caudal block; IV, intravenous; N/A, not applicable; NSAID, nonsteroidal anti-inflammatory drug; post-op, postoperative; pre-op, preoperative.

effort to further decrease the utilization of intraoperative and postoperative opioids.

There are several limitations of this study. Perhaps most notably, a small patient population was evaluated. Despite the small patient population, though, a statistically significant difference was observed between the two groups in opioid use. The inclusion of only two pediatric anesthesiologists—each with a fixed routine of either preoperative or postoperative administration—represents a potential confounding variable, as differences in opioid use may reflect individual preferences in practice rather than timing of the CB alone. Future studies should include multiple practitioners performing both types of blocks to better isolate the timing effect. Furthermore, one might argue that the difference in opioid requirements may be because the postoperatively administered CBs may not have had sufficient time to exert their effects before patients began experiencing pain in the PACU, which could have prompted early opioid administration. However, since all opioids and IV NSAIDs were administered intraoperatively, this possible explanation has a very low probability. Furthermore, this was a single-center, nonrandomized, retrospective analysis and is therefore subject to the potential biases that may introduce and the inherent limitations associated with such a study, including its potentially limited external validity.

5 | CONCLUSIONS

In this study, preoperative CB was associated with a significantly decreased opioid requirement compared to postoperative CB in pediatric male patients undergoing urologic surgery. Our findings suggest that preoperative CB should be routinely favored over postoperative CB in an effort to minimize opioid use in male patients undergoing pediatric urologic surgery. Additional, randomized studies with strict parameters regarding the indications for opioid/analgesic administration are warranted to best evaluate the optimal timing of CB administration in this setting.

AUTHOR CONTRIBUTIONS

Jordan L. Mendelson and William Brenseke contributed equally to this work. They were responsible for conceptualization, data curation, formal analysis, investigation, methodology, writing of the original draft, and review and editing of the manuscript; they led the retrospective chart review, performed data collection, analyzed the statistical results, and drafted the primary manuscript. Diego Alvarez Vega contributed to data curation, formal analysis, visualization, and writing (review and editing), including management of the dataset, assistance with statistical analysis, refinement of the manuscript for

submission, and formatting of the data for presentation. William Nguyen, Mohammed Shium, and Saige Gitlin contributed to data curation, validation, and writing (review and editing), including data extraction during the chart review process and editing of the final draft. Ronnie G. Fine and Steven C. Friedman contributed resources, investigation, and writing (review and editing), including providing patients to the study cohort and offering clinical insight into the urologic surgical procedures involved. Mark Horowitz contributed resources, investigation, and writing (review and editing), including providing clinical insight into the urologic surgical procedures involved. Walter I. Weiss and Raghu Idupuganti contributed to conceptualization, methodology, investigation, resources, and writing (review and editing); Walter I. Weiss served as a primary attending anesthesiologist, performed anesthesia interventions, and established the postoperative caudal block protocols analyzed in this study, while Raghu Idupuganti served as a primary attending anesthesiologist, performed anesthesia interventions, and established the preoperative caudal block protocols analyzed in this study. Jordan S. Gitlin contributed to conceptualization, formal analysis, methodology, project administration, supervision, and writing (review and editing); he conceived the study, supervised the entire project, provided oversight of the statistical analysis, facilitated access to patient records, and critically revised the manuscript.

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The authors have nothing to report.

CONFLICT OF INTEREST STATEMENT

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors. The authors do not have any competing financial interests or personal relationships that could have influenced this article.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

ETHICS STATEMENT

Institutional Review Board (IRB) exemption was awarded for this retrospective study. All data have been de-identified to protect patient privacy and no identifiable patient information was used.

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