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Journal

Paediatric and Neonatal Pain, 5(1)

ISSN

2379-5824

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Publication Date

2023-03-01

DOI

10.1002/pne2.12091

Peer reviewed

Received: 29 July 2022 | Revised: 14 October 2022 | Accepted: 11 November 2022

DOI: 10.1002/pne2.12091

ORIGINAL ARTICLE

Paediatric & Neonatal Pain WILEY

Does caudal analgesia improve pain control for pediatric burn surgery: A retrospective study

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Abstract

Pediatric burns affect approximately 15–20 patients per 100 000 hospital admissions, but unfortunately there is a lack of evidence to guide optimal strategies for acute pain control. The aim of this study was to evaluate whether caudal analgesia with single injection of local anesthetics reduced pain medication consumption in pediatric patients who required surgical intervention for burn injuries. Retrospective data from patients <7 years old who had burn surgery in the operating rooms at a single regional burn center from 2013 to 2021 was obtained and analyzed. A 1:1 propensity-score matching method using nearest neighbor matching without replacement was utilized to create matched cohorts. Primary outcome was opioid consumption, which is presented as opioid equivalents divided by patient weight in kilograms, at 24 h after surgery. Comparing propensity-score matched groups, there were no statistically significant differences in adjusted morphine equivalents received by the caudal group (0.122 [0.0646;0.186]) and the no caudal group (0.0783 [0.0384;0.153]) at 24 h after surgery ($p = 0.06$). This is the first study to the best of our knowledge of the association of caudal analgesia in pediatric burn patients with postoperative pain control. The data showed an increase in pain medication consumption postoperative at 24 h and intraoperative for patients who received single injection caudal blocks, but when adjusted using propensity-score matching, the difference was no longer statistically significant.

KEYWORDS
burns, caudal, epidural, opioids, pediatric, postoperative

1 | INTRODUCTION

Pediatric burns affect approximately 15–20 patients per 100 000 hospital admissions.[1] Incidence has decreased over time as techniques to manage outpatients have been refined. Still, a proportion of these burns require hospitalization and surgical management. According to the most recent Healthcare Cost and Utilization Project (HCUP) data from 2013, the <1 year old group made up 29.6% of the patients, the highest out of any age group with the most common type of burn in this age group being scald.[2]

Pain management in pediatric patients suffering from burns is complex. The burns themselves and the associated surgeries are profoundly traumatic and painful experiences, but unfortunately there is a lack of evidence to guide optimal strategies for acute pain

control and minimal data on the development of chronic neuropathic pain following burn injury.[3] There is growing interest in using regional anesthesia techniques for management of perioperative pain. In the pediatric burn literature, two studies closest to what is being reported are: a study of 19 patients who underwent donor graft harvest from the thigh and evaluated the effectiveness of local infiltration, lateral femoral cutaneous nerve block, or fascia iliaca and a study evaluating caudal morphine.[4,5]

The caudal epidural block with local anesthetics is one of the most widely administered regional anesthesia techniques in pediatric patients, but little has been reported on its effects in burn patients.[6,7] The procedure is performed by accessing the epidural space through the sacrococcygeal ligament using landmark or ultrasound-guidance. Options for delivery are single injection or continuous infusion. Risks associated with this technique include block failure, systemic toxicity, infection and dural puncture; however, incidence of complications associated with caudal epidurals remain low.[8,9]

The aim of this study was to evaluate whether caudal analgesia with local anesthetics improved pain control in pediatric patients who required surgical intervention for burn injuries. Using retrospective inpatient data collected from a single burn center, the hypothesis that patients who received caudal analgesia would have lower postoperative opioid consumption at 24 h was tested.

2 | METHODS

2.1 | Study population

This study was reviewed by our Institutional Review Board (Human Research Protections Program) and the consent requirement was waived due to the retrospective nature of the study. This retrospective cohort observational study is of patients <7 years old who presented to an American Burn Association verified regional burn center between October 28, 2013, and December 27, 2021, and had burn surgery in the operating room. The electronic medical record was queried for all burn surgeries meeting criteria and resulted in 408 cases.

2.2 | Data collection

The primary independent variable was the use of intraoperative caudal analgesia (defined as a binary variable indicating whether a caudal was performed or not). The primary outcome of interest was 24-h opioid consumption, which was measured in morphine equivalents (MEQ), and subsequently adjusted by patient weight (kg). Chart review was performed to extract from the health systems electronic record the age at time of surgery, sex, type of surgery (lower extremity burn, lower extremity graft, lower extremity burn and graft, or no lower extremity burn or graft), weight, burn percentage total body surface area (TBSA), burn mechanism (flame, scald, contact), intraoperative medications (acetaminophen, fentanyl, morphine, hydromorphone, ketamine, ketorolac), medications given within 24 h postoperatively (acetaminophen, fentanyl, morphine, hydromorphone, oxycodone, ibuprofen, methadone), Face, Legs, Activity, Cry and Consolability (FLACC) scores in post-anesthesia care unit (PACU) and at post-operative day 1 (POD1).

2.3 | Statistical analysis

R (version 4.2.0) was used to perform statistical analysis. Primary outcome of postoperative analgesia was compared by converting opioid use into morphine equivalents and adjusted based on patient weight. Initially, we performed an unadjusted analysis comparing the patient characteristics and outcomes between both cohorts (caudal vs. no caudal). Shapiro–Wilk tests were performed on each data subset to test for normal distribution. Wilcoxon rank sum tests and 2 proportion *Z*-tests were used for comparison of continuous and categorical variables, respectively. Then, a 1:1 propensity-score matching method using nearest neighbor matching without replacement was utilized to create matched cohorts. The caliper was set at 0.2 SDs of the logit of the estimated propensity score. Thus, the nearest match between subjects from each cohort (based on propensity score) within a subset of potential patients (that are within the selected caliper range) was matched together. The propensity score was based on all of the confounders used in this study. An absolute standardized mean difference of <0.2 between cohorts among each confounder variable was considered adequately matched. Wilcoxon signed-rank and 2 proportion *Z*-tests were used to compare the outcome in the matched cohorts.

A power analysis was performed where 50% reduction in 24-h opioid consumption was assumed to be clinically significant. Sample size of 63 patients in each group for a total of 126 would be able to detect a 50% reduction with 80% power and alpha of 0.05.

3 | RESULTS

3.1 | Patient demographics and caudal analgesia

Out of the 408 identified cases, a total of 164 (40.2%) had surgery for a lower extremity burn, lower extremity graft donor harvest, or both surgery for lower extremity burn and graft donor harvest from a lower extremity. Among these patients, 62 (37.8%), received a caudal block with single injection of 0.5–1 ml/kg of either 0.25% bupivacaine or 0.2% ropivacaine. Documentation of additives was, surprisingly, minimal to absent. There were no statistically significant differences in demographics between both no caudal and caudal cohorts based on age in months (24.0 vs. 20.5, $p = 0.346$), weight in kgs (14.2 vs. 13.2, $p = 0.214$), sex (52/102 vs. 25/62, $p = 0.185$),

TABLE 1 Data from the 164 patients <7 years old who underwent lower extremity surgery for burn and/or graft harvest with data presented as median [lower quartile, upper quartile].

Unmatched	No caudal	Caudal	*p*-Value
Age (months)	24.0 [14.0;59.0]	20.5 [12;51.5]	0.3467
Weight (kg)	14.2 [10.9;20.0]	13.2 [9.82;18.8]	0.2141
Sex	Female 52	Female 25	0.1848
	Male 53	Male 37	
TBSA (%)	4.00 [2.00;8.25]	3.39 [1.50;7.00]	0.7779
Burn mechanism	Chemical 3	Chemical 4	0.2809
	Flame 11	Flame 9	0.4788
	Scald 57	Scald 27	0.1255
	Contact 34	Contact 22	0.7782
INTRAOP			
Adjusted morphine equivalents	0.233 [0.111;0.321]	0.286 [0.191;0.489]	**5.203e-3**
Acetaminophen (%)	60 (57)	26 (42)	**0.03574**
Ketamine (%)	36 (34)	23 (37)	0.8156
NSAID (%)	62 (59)	23 (37)	**0.003242**
POD1			
Morphine equivalents	0.0605 [0.0381;0.140]	0.122 [0.0646;0.186]	**1.803e-3**
Acetaminophen (%)	47 (45)	31 (50)	0.6258
NSAID (%)	17 (16)	14 (23)	0.3483

Note: Wilcoxon rank sum tests and 2 proportion *Z*-tests were used for comparison of continuous and categorical variables, respectively. Significant data have been bolded with threshold set at $p < 0.05$.

Abbreviations: INTRAOP, intraoperative; NSAID, non-steroidal anti-inflammatory drug; POD1, post-operative day 1; TBSA, total body surface area.

percent total body surface area of burn (4.00 vs. 3.39, $p = 0.778$), or burn mechanism (chemical, flame, scald, or contact; Table 1).

3.2 | Postoperative pain control at 24 h

When comparing 24-h post-operative opioid consumption, patients who received caudal analgesia received more opioids as demonstrated by higher adjusted morphine equivalents (MEQ/kg): 0.122 [0.0646;0.186] compared with those who did not 0.0605 [0.0381;0.140] ($p < 0.0001$; Figure 1). Statistically significant differences were not detected when comparing whether patients received acetaminophen (47/102 vs. 31/62, $p = 0.625$) or NSAIDs (17/102 vs. 14/62, $p = 0.3483$) postoperative (Table 1).

3.3 | Intraoperative pain control

Analysis of the intraoperative period revealed statistically significant higher adjusted morphine equivalents for patients who had also received caudal analgesia 0.286 [0.191;0.489] compared to those who did not 0.233 [0.111;0.321] ($p < 0.0001$; Figure 2). On the other hand, patients who did not receive caudal analgesia were more likely to have received intraoperative acetaminophen (60/102 vs. 26/62, $p < 0.0001$) or an NSAID (62/102 vs. 23/62, $p < 0.0001$), but not ketamine (36/102 vs. 23/62, $p < 0.0001$; Table 1).

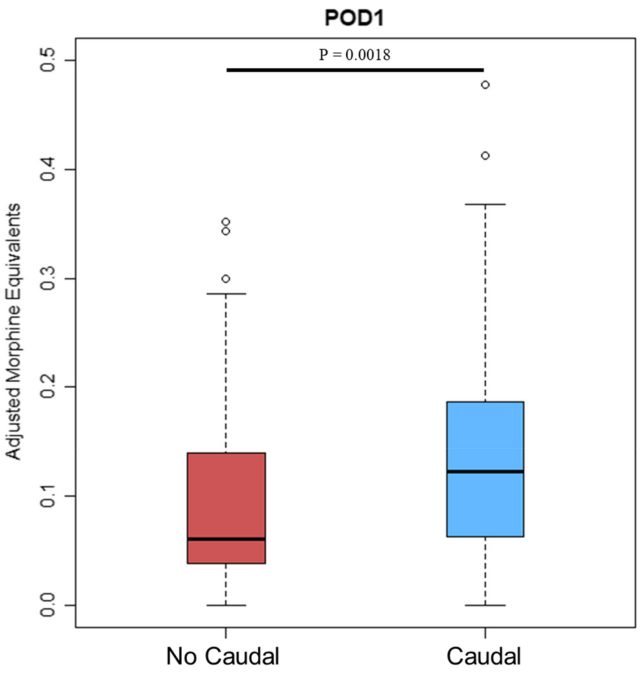

FIGURE 1 Box plot demonstrating postoperative opioid consumption at 24 h presented as adjusted morphine equivalents (MEQ/kg) in patients who did or did not receive caudal analgesia with local anesthetics. Wilcoxon rank sum test was performed, which did demonstrate a statistically significant difference between the two groups.

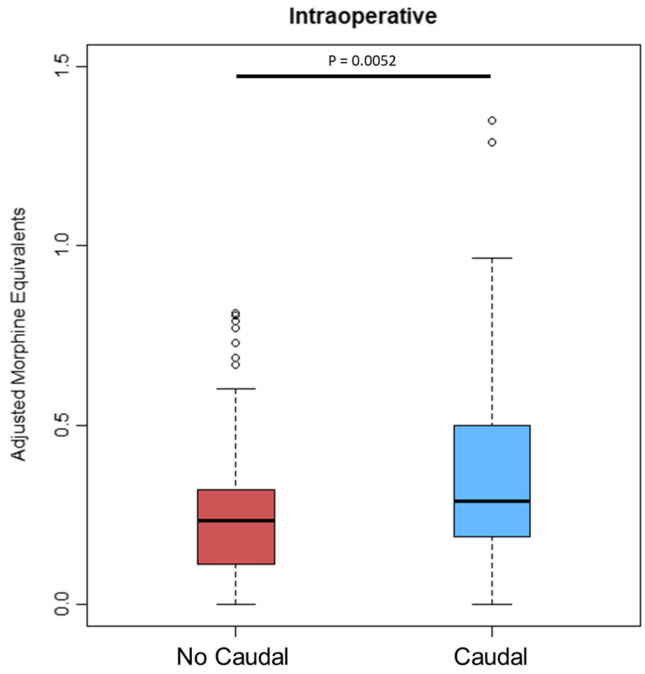

FIGURE 2 Box plot demonstrating intraoperative opioid consumption presented as adjusted morphine equivalents (MEQ/kg) in patients who did or did not receive caudal analgesia with local anesthetics. Wilcoxon rank sum test was performed, which did demonstrate a statistically significant difference between the two groups.

3.4 | Comparison of propensity-score matched cohorts

Propensity score-matching was performed with 62 patients in each matched cohort using TBSA, sex, burn mechanism, age, and weight as covariates to generate matched cohorts (Table 2). In the matched cohorts, there were no statistically significant differences in adjusted morphine equivalents (Figure 3) received within 24 h after surgery between the caudal group 0.122 [0.0646;0.186] and no caudal group 0.0783 [0.0384;0.153] ($p = 0.06$). The proportion that received either acetaminophen 28/62 vs. 31/62 ($p = 0.59$) or NSAIDs 11/62 vs. 14/62 ($p = 0.50$) were also not different. Analysis of intraoperative adjusted morphine equivalents (Figure 4) and whether patients received acetaminophen, ketamine, or NSAIDs did not find any statistically significant differences between the patients who received caudal analgesia and those who did not.

4 | DISCUSSION

The results of the study demonstrated that when comparing propensity-score matched groups, caudal analgesia was not associated with a decrease in postoperative opioid consumption at 24 h.

Caudal analgesia is a proven technique to provide pain relief in the post-operative period in the pediatric population for infraumbilical

TABLE 2 The 1:1 propensity-score matching method was utilized to create matched cohorts.

Matched	No caudal	Caudal	*p*-Value
Age (months)	19.5 [13.3;41.5]	20.5 [12.0;51.5]	0.999
Weight (kg)	12.5 [10.5;18.4]	13.2 [9.82;18.8]	0.871
Sex	Female 24	Female 25	0.8543
	Male 38	Male 37	
TBSA (%)	3.00 [1.00;9.00]	3.39 [1.50;7.00]	0.8334
Mechanism	Chemical 3	Chemical 4	
	Flame 10	Flame 9	
	Scald 28	Scald 27	
	Contact 21	Contact 22	
INTRAOP			
Adjusted morphine equivalents	0.274 [0.155;0.334]	0.286 [0.191;0.489]	0.2703
Acetaminophen (%)	35 (56)	26 (42)	0.106
Ketamine (%)	19 (31)	23 (37)	0.4479
NSAID (%)	30 (48)	23 (37)	0.2038
POD1			
Morphine equivalents	0.0783 [0.0384;0.153]	0.122 [0.0646;0.186]	0.06182
Acetaminophen (%)	28 (45)	31 (50)	0.5896
NSAID (%)	11 (18)	14 (23)	0.5019

Note: Wilcoxon signed-rank and 2 proportion *Z*-tests were used to compare the outcome in the matched cohorts.
Abbreviations: INTRAOP, intraoperative; POD1, post-operative day 1; TBSA, total body surface area.

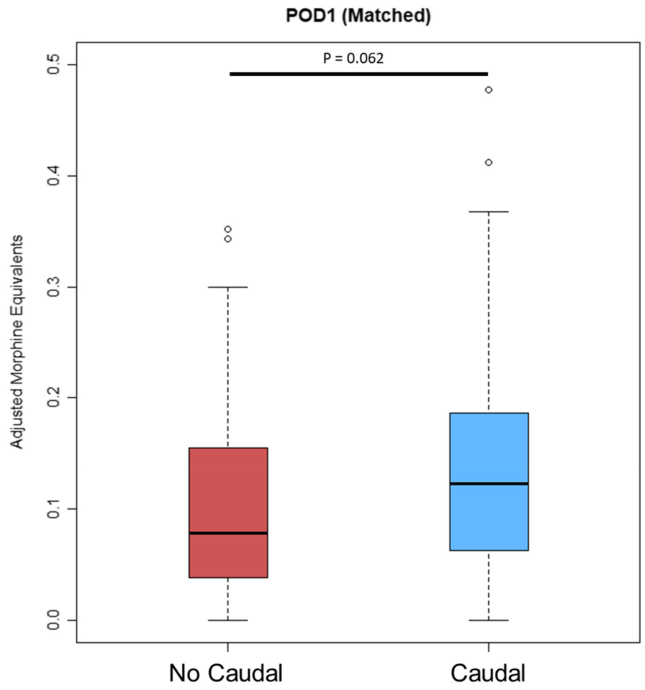

FIGURE 3 Box plot demonstrating postoperative opioid consumption at 24 h presented as adjusted morphine equivalents (MEQ/kg) in cohorts, created with 1:1 propensity-score matching method using nearest neighbor matching without replacement, that did or did not receive caudal analgesia with local anesthetics. Wilcoxon rank sum test was performed, which did not show a statistically significant difference between the two groups.

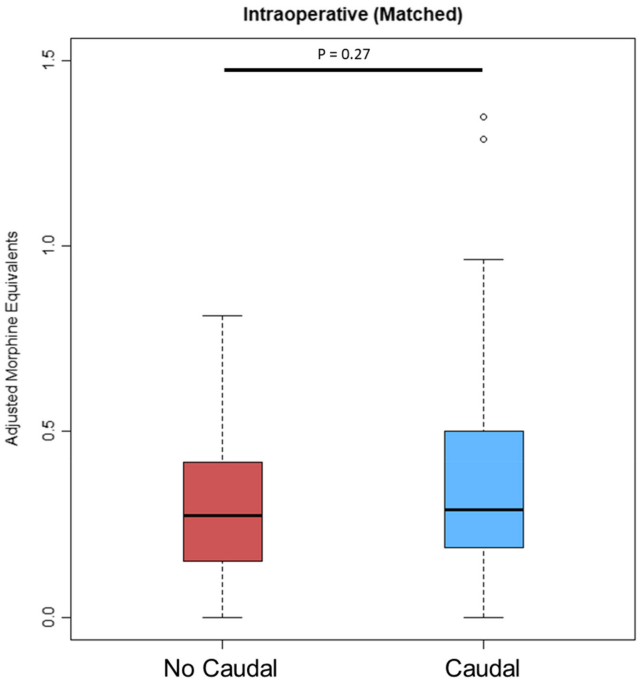

FIGURE 4 Box plot demonstrating intraoperative opioid consumption presented as adjusted morphine equivalents (MEQ/kg) in cohorts, created with 1:1 propensity-score matching method using nearest neighbor matching without replacement, that did or did not receive caudal analgesia with local anesthetics. Wilcoxon rank sum test was performed, which did not show a statistically significant difference between the two groups.

surgeries. However, not much is known about the effect of caudal analgesia in burn surgery. The goal of this retrospective observational study was to determine whether patients who received single shot caudal blocks had better pain control in the post-operative phase as reflected by lower opioid requirements.

The data of the unmatched cohorts interestingly showed that patients who received a caudal block required more pain medication both intraoperatively and postoperatively. Those differences disappeared when performing propensity-score analysis to create matched cohorts. This suggests that the difference observed was likely due to an imbalance of confounders and covariates among the two cohorts.

The chart review and data analysis also revealed opportunities for systemic improvement. The Face, Legs, Activity, Cry and Consolability (FLACC) score has been used for assessment of pain in pediatric patients aged 2 months to 7 years who may not be able to verbalize their pain.[10] Unfortunately, validity of the score and its application in burn patients is questionable and has not been established.[11] One issue that came up during chart review was the incongruency between the recorded FLACC score and the pain intervention. For example, a patient with FLACC score of 8 might not necessarily be given any pain medicine whereas one with a score of 3 would. Ultimately, after much discussion it was decided to omit the FLACC score from analysis given the subjective nature of the score and the inconsistencies between the score and pain intervention.

Additionally, it was noted that very few pain interventions occurred in the post-anesthesia care unit (PACU), leading to several patients returning to the burn unit with significantly elevated pain scores. More investigation is required but one hypothesis is a gap in knowledge and familiarity with pediatric patients. Our institution is one of 73 American Burn Association verified burn centers in the United States. This certification process is standardized and is a true mark of distinction indicating that a burn center provides high quality patient care from the time of injury through rehabilitation. These burn centers are the best place to treat burn patients because of their super specialized nature. However, most of these centers are not children's hospitals and often the ancillary staff do not have specific pediatric training. While burn treatment and care of the pediatric patient are exemplary, training and experience with pediatric pain assessment may be lacking. The review of the data suggests that pain medication administration was often not based on the appropriate pediatric pain indicators. This study, although it shows no change in pain medication administration in patients with or without caudal, does reveal a possible opportunity to improve and enhance staff's ability to recognize and appropriately treat pain in the pediatric patient. A quality improvement project has been initiated to help address this gap and improve pain management of pediatric burn patients in the PACU.

There are many limitations to this study. The major limitation was the variability in part because this was a retrospective observational study with nonrandomized patient cohorts. The decision to perform a caudal was therefore dependent on the attending pediatric anesthesiologist. Since there are no guidelines on candidacy for caudal block at our institution, there may have been bias towards performing caudal blocks in patients that were deemed to have more painful burns and/or surgeries. There appears to have been significant variability in dosing of local anesthetics and inclusion of adjuvants for caudal blocks among pediatric anesthesiologists as well as from patient-to- patient with the same anesthesiologist. It is predicted that attempts to standardize caudal dosing will be met with significant resistance. Still, the data does highlight an unexpected observation and next step will be to conduct a prospective trial with a consensus protocol for single injection caudal epidural dosing. It will be interesting to see if this phenomenon is reproducible in randomized cohorts.

5 | CONCLUSION

This is the first study to our knowledge looking at the association of caudal analgesia in pediatric burn patients on postoperative pain control. The data showed an increase in pain medication given to patients who received caudal blocks, but when adjusted using propensity-score matching, the difference was no longer statistically significant. This was a surprising finding that rejected the initial hypothesis that patients with caudal analgesia would require less postoperative pain medication. A possible explanation for this observation would be that the pediatric anesthesiologist was more likely to perform caudal analgesia on patients who were presumed to have more pain. In addition, propensity-score matching is a surrogate for the gold standard, randomized patient cohorts, which would help control for confounders. Lastly, the process of reviewing pain control of pediatric burn patients has revealed other opportunities to improve quality of care and postoperative pain management for our pediatric burn patients.

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How to cite this article: Yao PY, Shaw SJ, Gabriel RA, Soria CS. Does caudal analgesia improve pain control for pediatric burn surgery: A retrospective study. *Paediatr Neonatal Pain*. 2023;5:10-15. doi:10.1002/pne2.12091