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Opioid Analgesia Compared with Non-Opioid Analgesia After Operative Treatment for Pediatric Supracondylar Humeral Fractures

Results from a Prospective Multicenter Trial

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Background: Minimal pain and opioid use after operative treatment for pediatric supracondylar humeral fractures have been previously described; however, opioid-prescribing practices in the United States remain variable. We hypothesized that children without an opioid prescription would report similar postoperative pain compared with children prescribed opioids following closed reduction and percutaneous pinning (CRPP) of supracondylar humeral fractures.

Methods: Children who were 3 to 12 years of age and were undergoing CRPP for a closed supracondylar humeral fracture were prospectively enrolled in a multicenter, comparative study. Following a standardized dosing protocol, oxycodone, ibuprofen, and acetaminophen were prescribed at 2 hospitals (opioid cohort), and 2 other hospitals prescribed ibuprofen and acetaminophen alone (non-opioid cohort). The children's medication use and the daily pain that they experienced (scored on the Wong-Baker FACES Scale) were recorded at postoperative days 1 to 7, 10, 14, and 21, using validated text-message protocols. Based on an a priori power analysis, at least 64 evaluable subjects were recruited per cohort.

Results: A total of 157 patients were evaluated (81 [52%] in the opioid cohort and 76 [48%] in the non-opioid cohort). The median age at the time of the surgical procedure was 6.2 years, and 50% of the subjects were male. The mean postoperative pain scores were low overall (<4 of 10), and there were no significant differences in pain ratings between cohorts at any time point. No patient demographic or injury characteristics were correlated with increased pain or medication use. Notably, of the 81 patients in the opioid cohort, 28 (35%) took no oxycodone and 40 (49%) took 1 to 3 total doses across the postoperative period. Patients rarely took opioids after postoperative day 2. A single patient in the non-opioid cohort (1 [1%] of 76) received a rescue prescription of opioids after presenting to the emergency department with postoperative cast discomfort.

Conclusions: Non-opioid analgesia following CRPP for pediatric supracondylar humeral fractures was equally effective as opioid analgesia. When oxycodone was prescribed, 84% of children took 0 to 3 total doses, and opioid use fell precipitously after postoperative day 2. To improve opioid stewardship, providers and institutions can consider discontinuing the routine prescription of opioids following this procedure.

Level of Evidence: Therapeutic Level II. See Instructions for Authors for a complete description of levels of evidence.

Supracondylar humeral fractures are a common pediatric injury with excellent clinical outcomes[1,2]. Postoperative pain and opioid use following closed reduction and percutaneous pinning (CRPP) for pediatric supracondylar humeral fractures have been reported in single-center and retrospective cohorts, with multiple reports questioning the

Disclosure: The **Disclosure of Potential Conflicts of Interest** forms are provided with the online version of the article (http://links.lww.com/JBJS/H740).

need for opioids following this procedure[3-6]. Standardizing postoperative medication orders in this population has been shown to reduce variation in orthopaedic resident prescribing and to decrease the amount of unnecessary opioids[7]. Despite a growing body of retrospective evidence, high-quality prospective studies have been limited, and prescription variation still exists in the United States at the national, institutional, and provider levels.

Promoting opioid stewardship without compromising postoperative analgesia remains a focus for quality, safety, and value initiatives in pediatric orthopaedics. Multiple investigations have shown that children are overprescribed opioids following orthopaedic procedures, increasing the potential for opioid diversion into communities, misuse, and accidental poisonings[8-11]. A 2016 report in *JAMA Pediatrics* found that pediatric hospitalizations due to opioid poisonings rose nearly twofold from 1999 to 2012 and identified young children as an age group at increased risk[12]. Finally, although national opioid-prescribing rates have decreased in recent years, inconsistencies still exist, highlighting the need for additional policy and practice initiatives[13].

The purpose of this investigation was to compare the efficacy of opioid analgesia with that of non-opioid analgesia following CRPP for pediatric supracondylar humeral fractures. The primary aim was to develop evidence-based guidelines for postoperative analgesia in this population. We hypothesized that children taking non-opioid analgesia would report similar postoperative pain control compared with children taking opioid analgesics following this procedure.

Materials and Methods

A prospective, comparative cohort study was conducted at 4 tertiary referral children's hospitals in the United States from 2021 to 2022. Institutional review board approval was obtained at each hospital.

Subject Recruitment

Children who were 3 to 12 years of age and presented with a closed, modified-Gartland Type-II or III supracondylar humeral fracture were eligible for participation. Only children who actually underwent CRPP were included; those who underwent conversion to open reduction and internal fixation (ORIF) intraoperatively were excluded. Mini-incisions used to guide medial pin placement were not considered ORIF and such cases remained eligible. Children with open fractures, vascular injuries requiring exploration or repair, polytrauma, and refractures were excluded. Only English-speaking families were enrolled, as the questionnaires were only validated in English. Informed consent from parents or legal guardians was obtained.

Medication Dosing Protocol

Following the local standards of care, all children at 2 hospitals were prescribed oxycodone, acetaminophen, and ibuprofen at discharge; these children comprised the opioid cohort. Standard instructions were provided to take oxycodone only as needed for breakthrough pain. It was the local standard of care at the remaining 2 hospitals to prescribe acetaminophen and ibuprofen alone; enrolled children at these institutions comprised the non-opioid cohort. A standardized dosing regimen was developed according to the existing prescription trends at all 4 hospitals (Table I). Children prescribed pain medications other than ibuprofen, acetaminophen, and oxycodone were excluded from the final analysis.

Data Collection

Caregivers received text-message questionnaires on postoperative days 1 to 7, 10, 14, and 21. The distribution of questionnaires was automated through REDCap (Research Electronic Data Capture; Vanderbilt University), using validated text message-based protocols[3,14,15]. At 7:30 A.M. local time, caregivers reported the pain that their child was experiencing (from 0 to 10) on the Wong-Baker FACES Pain Rating Scale. At 6 P.M. local time, caregivers again reported the pain that their child was experiencing as well as the doses of oxycodone (if applicable), ibuprofen, and acetaminophen taken in the previous 24 hours. Children's morning and evening pain scores were averaged to a single daily mean.

Perioperative data were abstracted from the medical record and included age, sex, race, ethnicity, height, weight, body mass index (BMI), nerve injury, fracture type, inpatient pain rating, number of pins, pin configuration, inpatient medications administered, procedure start and end times, postoperative immobilization, length of hospitalization, and complications.

Statistical Analysis

An a priori power analysis was performed. To detect differences in mean pain with a medium effect size, $\alpha = 0.05$, and 80% power, a minimum of 64 evaluable subjects were required per cohort. Pearson chi-square tests and Fisher exact tests were used to compare categorical variables. Spearman rho and point biserial correlations were used to examine relationships between demographic characteristics, pain scores, and medication use. Tests of normality were used to evaluate the distributions of continuous variables. For non-normally distributed variables, the median and interquartile range (IQR) were reported. Nonparametric tests were used to compare pain and medication

TABLE I Outpatient Medication Dosing Protocol

Medication	Dosage	Liquid
Ibuprofen	7.5 to 10 mg per kg every 6 hours as needed	Dispense approximately 237-mL bottle
Acetaminophen	10 to 15 mg per kg every 4 hours as needed	Dispense approximately 237-mL bottle
Oxycodone	0.05 to 0.1 mg per kg every 4 hours as needed for breakthrough pain	7 doses in the initial prescription

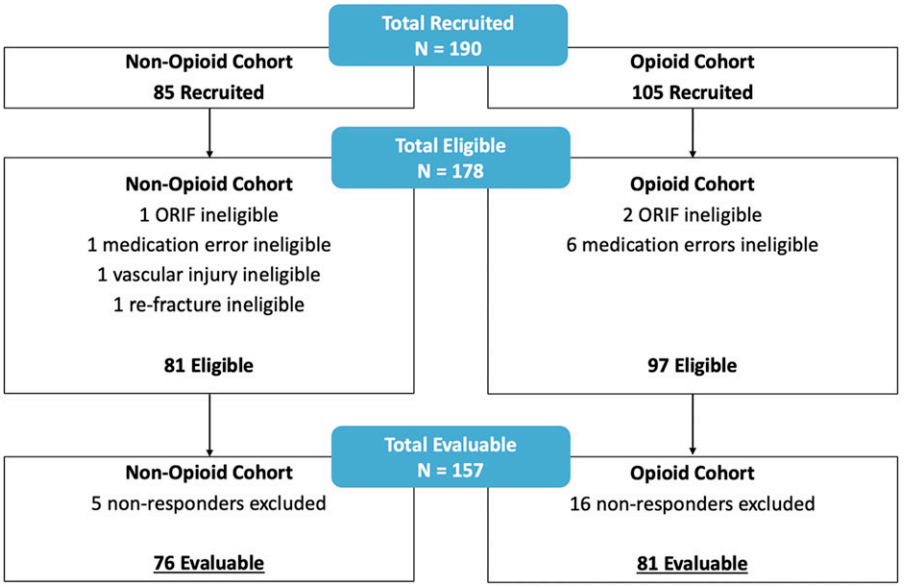

Fig. 1
Study recruitment flowchart.

data across the cohorts; however, for ease of visualization and clinical application for the reader, the figures were created with mean values. To account for repeated measures, a mixed-effects model was performed. Analyses were performed using SPSS Statistics (version 28; IBM) and STATA version 16 (StataCorp), with the significance threshold set at $p < 0.05$.

Source of Funding
This investigation was funded by the Pediatric Orthopaedic Society of North America (POSNA) 2020 Angela S.M. Kuo Memorial Award.

Results

Patient and Injury Characteristics

From May 2021 to August 2022, 190 children were recruited (44.7% in the non-opioid cohort and 55.3% in the opioid cohort). Twelve children were later excluded because of intraoperative or postoperative factors that violated eligibility criteria. An additional 21 families were nonresponsive to questionnaires and were excluded. Ultimately, 157 children were evaluated (48.4% in the non-opioid cohort and 51.6% in the opioid cohort) (Fig. 1).

The median age at the time of the surgical procedure was 6.2 years (IQR, 5.1 to 7.7 years), and 50.3% of the children were male. There were no significant differences in age, sex, race, or BMI between the cohorts (Table II). The non-opioid cohort included more Hispanic and Latino patients (33%) than the opioid cohort (11%) ($p < 0.001$); however, across the study population, ethnicity was not correlated with children's mean postoperative pain scores or total medication use. Four children (2.5%) had a nerve injury at the initial presentation, and 1 child (0.6%) had postoperative median nerve neurapraxia (Table II); all recovered uneventfully. No patient demographic variables (age, sex, race, ethnicity, BMI) or injury characteristics (modified-Gartland classification, presence of nerve injury) had significant correlations with postoperative pain or medication use.

Operative Characteristics

Pain scores documented at the initial hospital presentation were not significantly different between cohorts (median, 4.0 [IQR, 1.5 to 6.5] in both; $p = 0.903$). The opioid cohort had longer documented median procedure times (34 minutes) than the non-opioid cohort (27 minutes) ($p = 0.006$) (Table II). Nearly all fractures required 2 or 3 pins, and the non-opioid cohort had a higher rate of cross-pinning (Table II). Most children (87.3%) had cast immobilization, and there were no differences in the rate of casting compared with that of splinting between the cohorts. The rate of prophylactic cast bivalving in the operating room was higher in the non-opioid cohort (80.0%) compared with the opioid cohort (27.8%) ($p < 0.001$) (Table II). Most children (86.6%) received ketorolac for perioperative analgesia; however, multimodal analgesia strategies did vary between cohorts (Table III).

There were no significant correlations between postoperative pain and operative time, number of pins, pin configuration, or immobilization type. There were similarly no correlations between these variables and medication use. Similarly, prophylactic cast bivalving had no significant correlation with early (postoperative days 1 to 3) postoperative pain or medication use.

Postoperative Pain and Analgesia

There were no significant differences in pain ratings between the non-opioid cohort and the opioid cohort from postoperative days 1 to 21 (Fig. 2, Table IV). A repeated-measures mixed-model multivariable analysis was performed to compare the effect of access to opioids on the mean postoperative pain

TABLE II Patient Demographic and Operative Characteristics

	All Patients (N = 157)	Non-Opioid Cohort (N = 76)	Opioid Cohort (N = 81)
Demographic characteristics			
Age at time of surgery* *(yr)*	6.2 (5.1 to 7.7)	6.0 (5.0 to 7.6)	6.5 (5.4 to 7.8)
Sex†			
Male	79 (50.3%)	39 (51.3%)	40 (49.4%)
Female	78 (49.7%)	37 (48.7%)	41 (50.6%)
Race†‡			
White	107 (77.0%)	48 (78.7%)	59 (75.6%)
Black	5 (3.6%)	0 (0%)	5 (6.4%)
Asian	14 (10.1%)	9 (14.8%)	5 (6.4%)
Multiracial	4 (2.9%)	2 (3.3%)	2 (2.6%)
Other	9 (6.5%)	2 (3.3%)	7 (9.0%)
Ethnicity†‡			
Hispanic or Latino	34 (22.7%)	25 (35.7%)	9 (11.3%)
Not Hispanic or Latino	116 (77.3%)	45 (64.3%)	71 (88.8%)
BMI categories†‡			
Underweight, <5th percentile	4 (3.8%)	2 (4.2%)	2 (3.4%)
Healthy weight, 5th to 84th percentile	73 (68.9%)	33 (68.8%)	40 (69.0%)
Overweight, 85th to 95th percentile	18 (17.0%)	7 (14.6%)	11 (19.0%)
Obese, >95th percentile	11 (10.4%)	6 (12.5%)	5 (8.6%)
BMI percentile*	61 (28 to 86)	70 (25 to 85)	61 (28 to 86)
Perioperative characteristics			
Preoperative			
Preoperative length of stay* *(hr)*	10.7 (3.9 to 14.2)	9.5 (2.6 to 14.2)	11.2 (6.2 to 13.3)
Preoperative nerve injury†			
No	153 (97.5%)	76 (100%)	77 (95.1%)
Yes	4 (2.5%)	0 (0%)	4 (4.9%)
Operative			
Modified-Gartland classification†			
Type II	67 (42.7%)	37 (48.7%)	30 (37.0%)
Type III	90 (57.3%)	39 (51.3%)	51 (63.0%)
Procedure time* *(min)*	30 (23 to 39)	27 (21 to 36)	34 (25 to 41)
No. of pins†			
2	68 (43.3%)	37 (48.7%)	31 (38.3%)
3	85 (54.1%)	38 (50.0%)	47 (58.0%)
≥4	4 (2.5%)	1 (1.3%)	3 (3.7%)
Pin configuration†			
Lateral entry only	135 (86.0%)	61 (80.3%)	74 (91.4%)
Cross-pinning (medial and lateral)	22 (14.0%)	15 (19.7%)	7 (8.6%)
Postoperative			
Postoperative length of stay* *(hr)*	4.9 (2.8 to 8.1)	5.7 (2.3 to 11.8)	4.9 (3.3 to 7.1)
Postoperative nerve injury†			
No	156 (99.4%)	76 (100%)	80 (98.8%)
Yes	1 (0.6%)	0 (0%)	1 (1.2%)
Immobilization†			
Long arm cast	137 (87.3%)	65 (85.5%)	72 (88.9%)
Long arm posterior splint	20 (12.7%)	11 (14.5%)	9 (11.1%)
Prophylactic cast bivalving† (if applicable)			
No	65 (47.4%)	13 (20.0%)	52 (72.2%)
Yes	72 (52.6%)	52 (80.0%)	20 (27.8%)

*The values are given as the median, with the IQR in parentheses. †The values are given as the number of patients, with the percentage in parentheses. ‡Subjects for whom demographic data were missing from the electronic medical record were not included in these categories in this table.

TABLE III Perioperative Analgesia*

Medication Name	Non-Opioid Cohort† (N = 76)	Opioid Cohort† (N = 81)	P Value‡
Ketorolac	67 (88.2%)	69 (85.2%)	0.584
Morphine or fentanyl	67 (88.2%)	59 (72.8%)	**0.016**
Intravenous acetaminophen	35 (46.1%)	19 (23.5%)	**0.003**
Other§	7 (9.2%)	45 (55.6%)	**<0.001**
Dexamethasone	0	10	
Oral acetaminophen	0	9	
Oral oxycodone	1	12	
Alfentanil	1	1	
Bupivacaine	1	6	
Hydromorphone	5	2	
Lidocaine	0	8	

*Perioperative analgesia was defined as medications received during the operation or within 1 hour after leaving the operating room. †The values are given as the number of patients, with or without the percentage in parentheses. ‡Significant p values are shown in bold. §Some patients had >1 other medication.

that the subjects experienced. Variables with significant differences between the cohorts were included in the model. The interactions of opioid access and time were examined in our model. There was no significant difference in postoperative pain experienced by the opioid cohort compared with the non-opioid cohorts (p = 0.569) (Table V). That is, when controlled

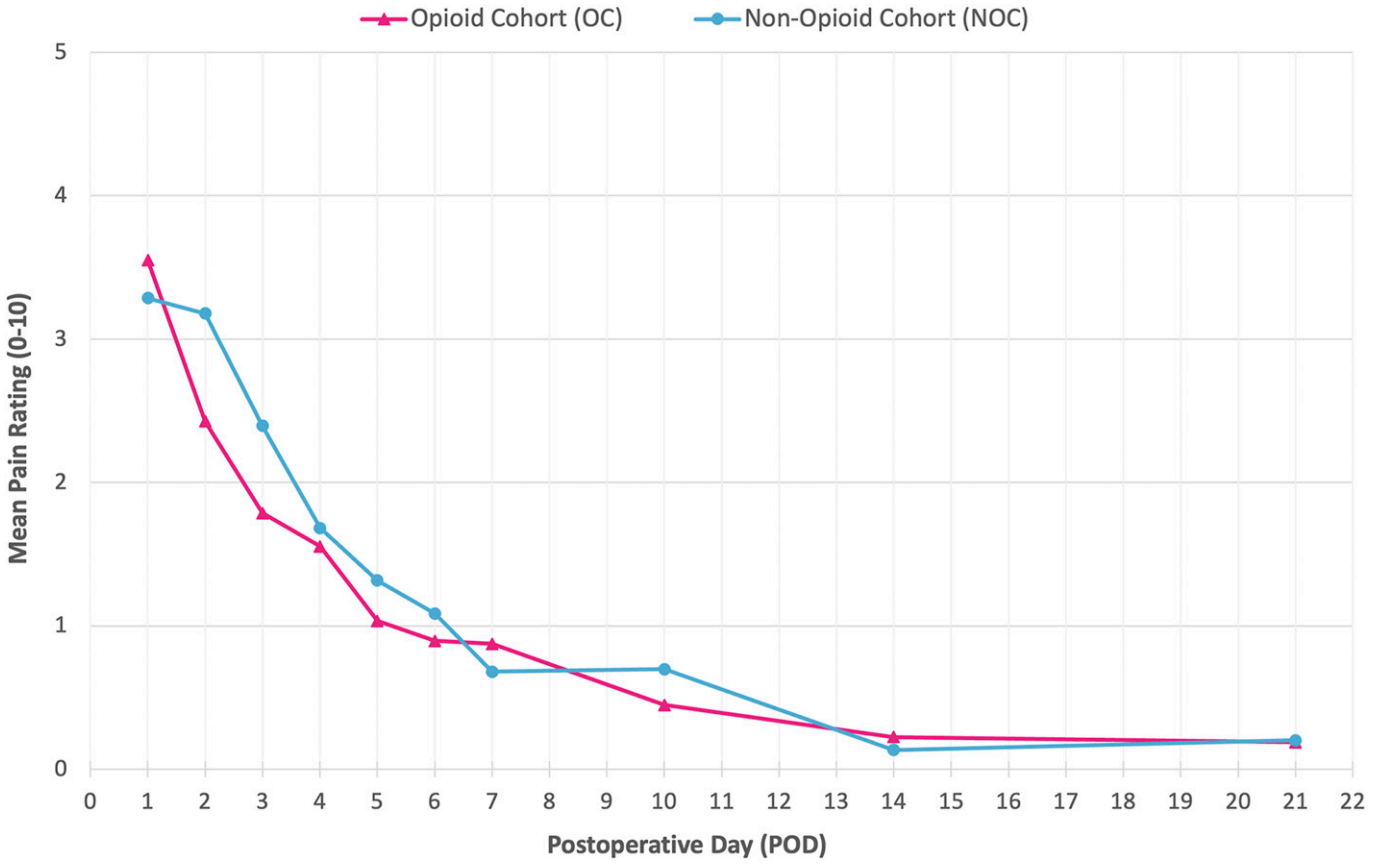

Fig. 2
Mean daily pain ratings in the non-opioid cohort and the opioid cohort.

TABLE IV Postoperative Pain Ratings for Each Cohort

	Non-Opioid Cohort		Opioid Cohort		
Postoperative Day	Pain Rating*	Response Rate	Pain Rating*	Response Rate	P Value
1	3.3	84.2%	3.6	86.4%	0.361
2	3.2	92.1%	2.4	92.6%	0.060
3	2.4	88.2%	1.8	92.6%	0.088
4	1.7	86.8%	1.6	92.6%	0.802
5	1.3	89.5%	1.0	88.9%	0.627
6	1.1	84.2%	0.9	87.7%	0.864
7	0.7	84.2%	0.9	88.9%	0.114
10	0.7	82.9%	0.5	81.5%	0.585
14	0.1	78.9%	0.2	82.7%	0.310
21	0.2	75.0%	0.2	79.0%	0.969

*The values are given as the mean.

for clinical and demographic differences, access to an opioid did not significantly impact the mean postoperative pain experienced by the subjects (Table V).

Upper outliers were defined as pain scores above the 95th percentile of responders in our data set. On postoperative days 1 to 2, pain scores of >6.0 out of 10 were found to be outliers. On postoperative days 3 to 7, pain scores of >4.0 were outliers; after postoperative day 7, pain scores of >2.0 were outliers. There were no significant differences in the number of outliers between the non-opioid cohort and the opioid cohort.

Postoperative analgesia followed similar trends as pain, with most medications taken on postoperative days 1 to 2 (Fig. 3). On postoperative day 1, the non-opioid cohort took a mean of 0.7 more doses of ibuprofen ($p = 0.030$) (Table VI) and 0.4 fewer doses of acetaminophen ($p < 0.001$) (Table VII) compared with the opioid cohort. Children in the opioid cohort took a mean of 0.9 doses of oxycodone on postoperative day 1 (mean morphine milligram equivalents [MME] per day = 0.1) (Table VIII). After postoperative day 1, there were no significant differences in ibuprofen use between the cohorts (Table VI). There were significant but minimal differences in

TABLE V Results of Repeated-Measures Mixed-Model Multivariable Analysis

Predictors for Subjects' Mean Postoperative Pain*	Coefficient†	P Value
Prophylactic cast bivalving		
No	Reference	—
Yes	0.38 ± 0.27 (−0.15 to 0.91)	0.160
Pin configuration		
Lateral entry only	Reference	—
Cross-pinning	−0.26 ± 0.37 (−0.99 to 0.47)	0.484
Operative time, per minute	0.01 ± 0.01 (−0.01 to 0.02)	0.482
Patient ethnicity		
Not Hispanic or Latino	Reference	—
Hispanic or Latino	0.31 ± 0.28 (−0.23 to 0.85)	0.267
Access to opioids		
No (i.e., non-opioid cohort)	Reference	—
Yes (i.e., opioid cohort)	0.12 ± 0.35 (−0.48 to 0.87)	0.569

*Patient demographic and operative variables that were significant on bivariate analysis (see the Results section) were included in the multivariable analysis. The model was also tested for interactions of the variable access to opioids with the time variable (postoperative day), and we found no collinearity. †The values are given as the coefficient and the standard error, with the 95% confidence interval in parentheses.

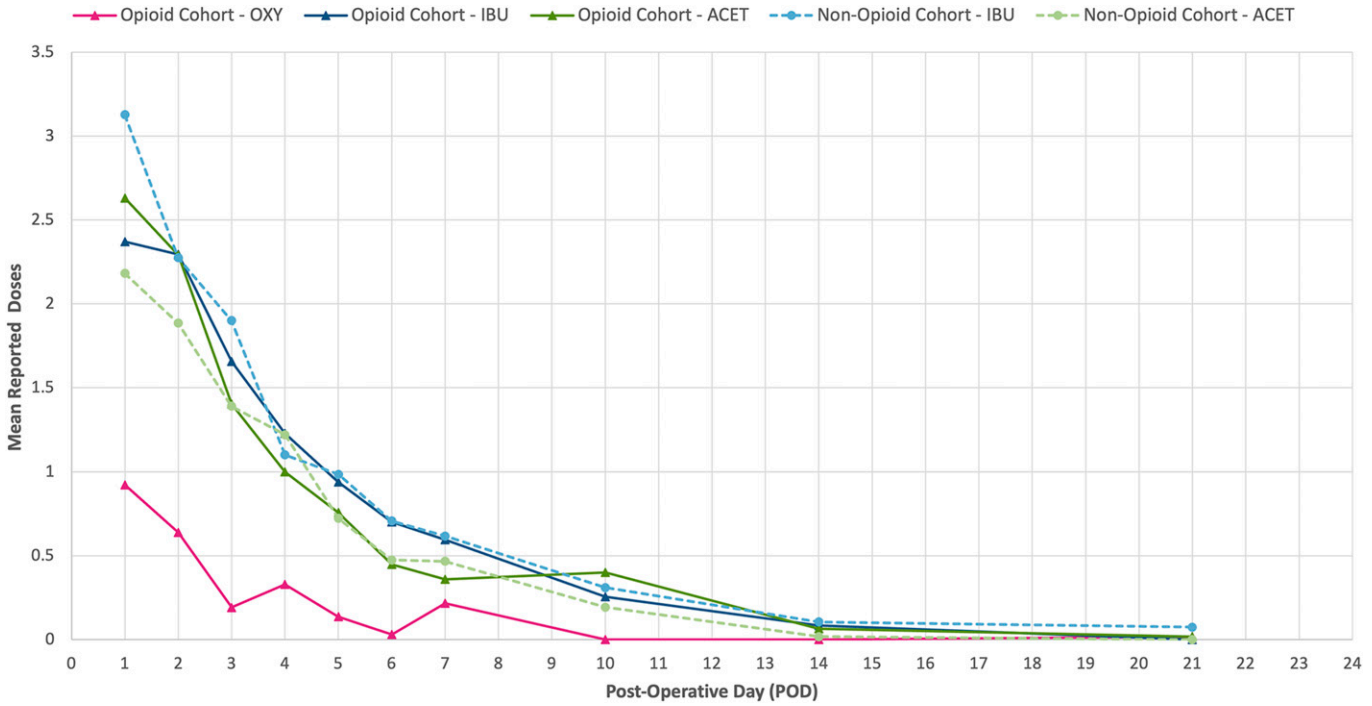

Fig. 3

Mean daily use of oxycodone (OXY), ibuprofen (IBU), and acetaminophen (ACET) in the non-opioid cohort and the opioid cohort.

acetaminophen use between the cohorts on postoperative days 2 and 6 (Table VII).

In the opioid cohort, the mean daily oxycodone use fell to <0.5 doses after postoperative day 2 (Fig. 3). Twenty-eight children (34.6%) took no oxycodone, and 40 children (49.4%) took 1 to 3 total doses (Fig. 4). On average, 75.7% of prescribed opioids were unused. Only 3 (3.7%) of the 81 children reported taking >7 doses of oxycodone, although, on chart review, none of these families requested oxycodone refills. Only 1 child (1.3%) in the non-opioid cohort, a 9-year-old girl with a Type-II supracondylar humeral fracture, required rescue opioids. The child presented to the emergency department on postoperative day 1 reporting stinging pain, worst in the hand and wrist. To address the symptoms, the cast was bivalved and the patient received an oxycodone prescription. Her medication use was not consistently recorded, but, at the first outpatient orthopaedics visit, the family reported that she had discontinued all medications by postoperative day 5.

TABLE VI Mean Daily Ibuprofen Use for Each Cohort

	Non-Opioid Cohort		Opioid Cohort		
Postoperative Day	Ibuprofen Doses*	Response Rate	Ibuprofen Doses*	Response Rate	P Value†
1	3.1	72.4%	2.4	76.5%	**0.030**
2	2.3	81.6%	2.3	84.0%	0.979
3	1,9	78.9%	1.7	82.7%	0.535
4	1.1	78.9%	1.2	86.4%	0.458
5	1.0	81.6%	1.0	81.5%	0.940
6	0.7	76.3%	0.7	82.7%	0.723
7	0.6	78.9%	0.6	79.0%	0.584
10	0.3	76.3%	0.3	72.8%	0.479
14	0.1	75.0%	0.1	74.1%	0.910
21	0.1	71.1%	0.0	70.4%	0.073

*The values are given as the mean. †Values shown in bold are significant.

TABLE VII Mean Daily Acetaminophen Use for Each Cohort

	Non-Opioid Cohort		Opioid Cohort		
Postoperative Day	Acetaminophen Doses*	Response Rate	Acetaminophen Doses*	Response Rate	P Value†
1	2.2	76.5%	2.6	72.4%	**<0.001**
2	1.9	85.2%	2.3	81.6%	**0.01**
3	1.4	82.7%	1.4	82.9%	0.279
4	1.2	86.4%	1.0	73.7%	0.973
5	0.7	81.5%	0.8	80.3%	0.856
6	0.4	82.7%	0.5	73.7%	**0.038**
7	0.5	79.0%	0.4	75.0%	0.118
10	0.2	74.1%	0.4	72.4%	0.187
14	0.0	75.3%	0.1	73.7%	0.349
21	0.0	70.4%	0.0	59.2%	0.335

*The values are given as the mean. †Values shown in bold are significant.

Including the cast pain that required rescue opioids, a total of 6 postoperative complications (3.8%) were noted. Cast bivalving due to postoperative swelling was required in 2 additional children (1 in the opioid cohort and 1 in the non-opioid cohort). The non-opioid cohort had 3 superficial pin-site infections that required antibiotics; 1 of these patients returned to the operating room on postoperative day 15 for irrigation and debridement. Clinical healing was within the expected course, occurring within 6 weeks after the date of the surgical procedure, for all patients.

Discussion

Postoperative Pain: Expectations and Exceptions to the Rule

In accordance with previous reports[3,5], we found that children had overall mild pain following CRPP for supracondylar humeral fractures, with the greatest pain and analgesia needs reported in the first 48 hours. There were no significant differences in pain between the opioid cohort and the non-opioid cohort from postoperative days 1 to 21. On multivariable analysis controlling for time and clinical and demographic variables, access to an opioid prescription did not impact the mean postoperative pain that subjects experienced. The greatest observed difference in pain between the cohorts was noted on postoperative day 2 and was <1 point on the Wong-Baker FACES scale; this fails to reach the minimal clinically important difference (MCID) for this scale[16,17]. Taken together, these results support retaining our null hypothesis that children with an opioid prescription have similar postoperative pain compared with children without opioids prescribed following this procedure.

Whether or not children were prescribed an opioid, daily postoperative pain was low (mean, <4 of 10), even on postoperative day 1. Surgeons who wish to continue prescribing opioids should recognize that pain is low after postoperative day 3, and opioid

TABLE VIII Mean Daily Oxycodone Use for the Opioid Cohort

Postoperative Day	Oxycodone Doses*	Response Rate	Mean MME per Day†
1	0.9	77.8%	0.1
2	0.6	85.2%	0.1
3	0.2	84.0%	<0.1
4	0.3	86.4%	<0.1
5	0.1	81.5%	<0.1
6	0.0	82.7%	<0.1
7	0.2	80.2%	<0.1
10	0.0	74.1%	<0.1
14	0.0	75.3%	<0.1
21	0.0	70.4%	<0.1

*The values are given as the mean. †Calculated assuming that the maximum study dosage of 0.1 mg per kg per dose of oxycodone was taken. MME = morphine milligram equivalents.

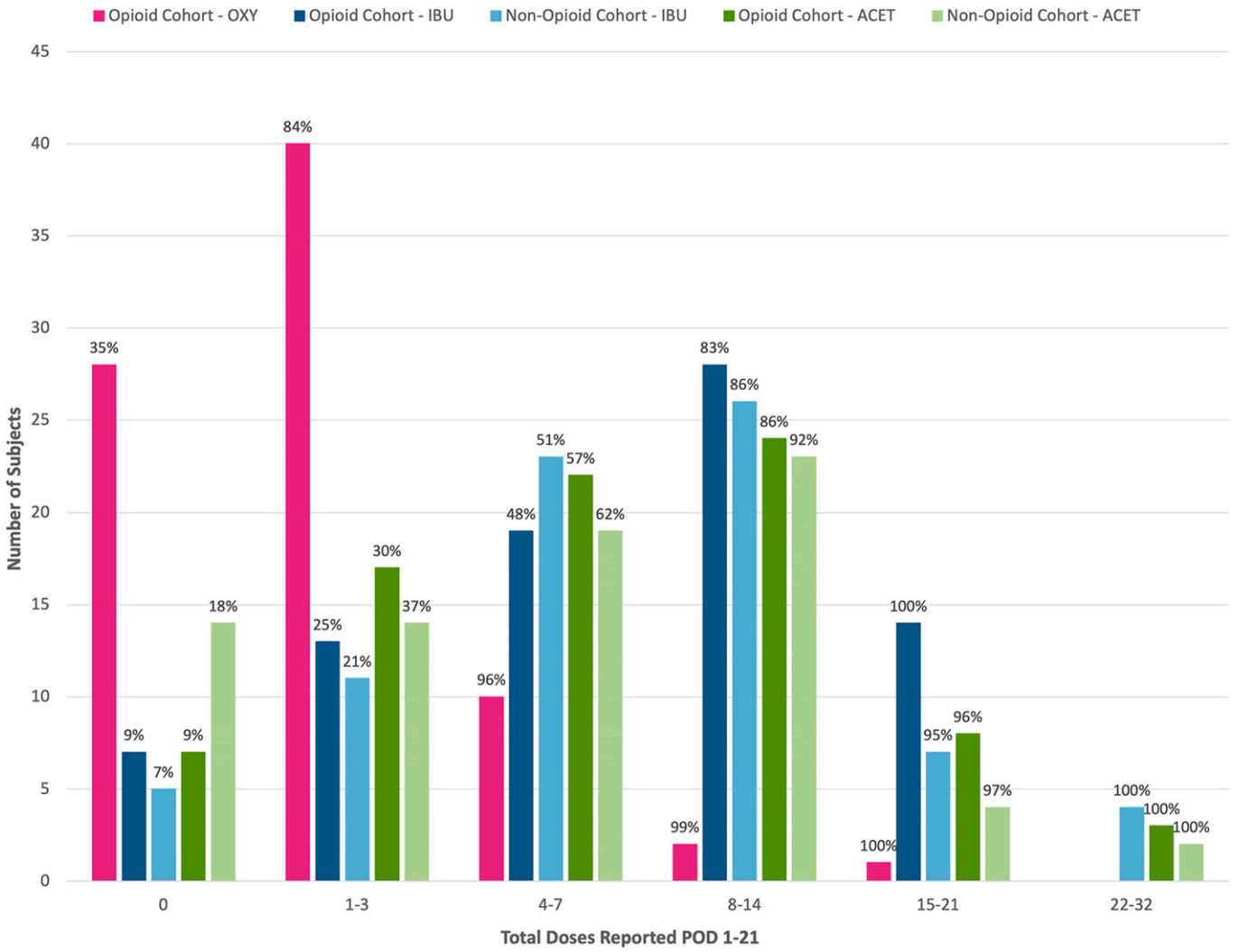

Fig. 4

Cumulative postoperative medication use among study subjects. Total oxycodone (OXY), ibuprofen (IBU), and acetaminophen (ACET) taken from postoperative days (PODs) 1 to 21 are reported. The percentages reported above each bar represent the cumulative percentage of patients who took that number of doses, or fewer, across the study period.

prescriptions should be accordingly limited. As a secondary finding, postoperative pain was not related to the modified-Gartland fracture type, number or configuration of pins, postoperative immobilization type, or any other patient demographic variables. This evidence reaffirms prior retrospective reports[5]. Ultimately, clinicians need not vary postoperative medication prescriptions based on patient demographic or injury characteristics.

Pain is a common driver of unplanned emergency department visits after pediatric ambulatory surgery[18]. Establishing evidence-based thresholds for normative pain after procedures helps clinicians and families to set expectations for postoperative pain management. We found that mean pain scores of >6 out of 10 across the first 48 hours were outliers; this aligns with previous reports[3,5]. Clinicians should be advised that persistent pain of >6 out of 10 after CRPP is abnormal; these children merit a callback to assess for swelling, cast tightness, elevated compartment pressures, or other potentially serious complications. In this study, only 1 child in the non-opioid cohort required rescue opioids; however, that child's symptoms were most consistent with cast discomfort due to swelling. In instances of immobilization discomfort, family education on the recommended amount and frequency of ibuprofen and acetaminophen doses, strict elevation, and other pain relief strategies may avoid unnecessary visits and opioids.

Postoperative Analgesia: A Call for Opioid Stewardship

At the provider level, reducing the amount of opioids prescribed, via standardized order sets and family education, is critical to reduce opioid misuse. Previous work by this study team demonstrated that children take <25% of prescribed opioids after CRPP (mean [and standard deviation], 4.8 ± 5.6 doses used compared with 19.8 ± 7.1 doses prescribed)[3]. Expanding on

these results, our current investigation shows that, when only 7 doses of oxycodone were provided with instructions to take a dose only for breakthrough pain, 84% of children took ≤3 total doses and 76% of prescribed doses remained unused. Although pediatric volumes of liquid oxycodone are unlikely to be abused, there remains the potential for diversion or accidental ingestion and poisoning in young children, especially given that families tend to store unused opioids in unlocked locations with no immediate plan for disposal[19]. Counseling on safe opioid disposal methods and institutional pathways to return unused opioids should remain a focus for pediatric orthopaedics.

Regarding the importance of family education, children in this study were instructed to take ibuprofen every 6 hours (4 daily doses) and acetaminophen every 4 hours (6 daily doses). However, medication tracking revealed that, on average, children in both cohorts were taking fewer than the recommended maximum daily doses at every time point. This suggests that families were not maximizing non-opioid analgesia before administering oxycodone. This highlights the importance of standardized order sets and counseling by providers regarding appropriate postoperative analgesia strategies, both of which have been demonstrated to reduce opioid use after orthopaedic surgery[7,20-22]. When families are informed partners in postoperative pain management, unnecessary opioid exposure in children may be avoided.

At the policy level, practices such as prescription drug monitoring programs, state-mandated preoperative opioid informed consent, and electronic prescribing are increasingly widespread[23]. Some reports in the literature have indicated positive effects of these programs in decreasing rates of opioid prescriptions overall[24,25] and specifically in pediatric orthopaedics[26,27], reducing overdoses[28], and decreasing prescriptions for unnecessarily high doses[29]. However, others have reported mixed results and poor implementation[30-33]. Our investigation showed that non-opioid analgesia was effective following CRPP for pediatric supracondylar humeral fractures; thus, electronic prescribing pathways and standardized institutional protocols could be updated such that oxycodone prescriptions are not automatically prompted for these patients.

Limitations and Future Directions

A limitation of this study was the lack of randomization and the potential for selection bias. Selection bias may have been partially mitigated by selecting 4 geographically diverse hospitals. Nevertheless, the nonrandomized design of the study resulted in cohort-level differences in patient characteristics (ethnicity) and surgical characteristics (procedure time, pin configuration, decision for a postoperative cast bivalving). The overall difference in ethnicity between the cohorts likely reflects underlying demographic differences between the populations served by the 4 hospitals. Decisions for cross-pinning, postoperative immobilization, and prophylactic cast bivalving were outside the scope of our study design and were left to the treating surgeon's discretion. However, the cohort-level differences in these variables had no correlations with postoperative pain or medication use and were not significant on multivariable analysis; thus, they were unlikely to have impacted the study results.

Additionally, this investigation was not designed to provide guidelines for inpatient analgesia. In this study, perioperative analgesia varied between cohorts, reflecting differences in anesthesia practices. This lack of standardization may have impacted postoperative pain, particularly on postoperative day 1. Additional investigations in these areas could permit expanding our recommendations to include standardization of inpatient medications.

A final consideration is generalizability. It is unlikely that CRPP for other upper-extremity fractures would be more painful than CRPP for supracondylar humeral fractures. Thus, it is plausible that there is no utility for routine opioid prescriptions for these patients. In the orthopaedic literature, adult patients undergoing most upper-extremity ambulatory procedures demonstrated low opioid needs and high overprescription rates[34]; these procedures in children would benefit from further prospective investigation. Research into more invasive pediatric orthopaedic procedures and adolescent populations may demonstrate additional areas for improving opioid stewardship. Investigation into these areas will ultimately improve the quality, safety, and value of surgical care in pediatric orthopaedics.

Conclusion

This prospective, multicenter, comparative cohort study supports the hypothesis that, compared with children who take opioid analgesia, children who take non-opioid analgesia report similar postoperative pain following CRPP for supracondylar humeral fractures. No substantial benefit to opioid analgesia was found in this population. To improve opioid stewardship for this archetypical pediatric procedure, providers and institutions should consider discontinuing the routine prescription of opioids following CRPP for supracondylar humeral fractures. ■

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