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Original Contributions

ANALGESIA USE IN CHILDREN WITH ACUTE LONG BONE FRACTURES IN THE PEDIATRIC EMERGENCY DEPARTMENT

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☐ **Abstract—Background: Practice variation exists in pain management of children with long bone fractures (LBFs). Objective: The objectives of this study were to describe current pain management in children with LBFs and the factors associated with the undertreatment of pain. Methods: We retrospectively studied children (aged 0–18 years) with a diagnosis of LBF in a pediatric emergency department (PED) from November 2015 through August 2016. Demographic characteristics and quality measures were noted. We determined the impact of PED crowding using the National Emergency Department Overcrowding Scale. Results: A total of 905 patients (63% male, 48% African American) were enrolled. Median age was 6 years (interquartile range [IQR] 7 years), 72% had upper extremity injuries, falls were the most common mechanism (74%), and the majority were discharged (77%). Median time to pain score was 6 min (IQR 14 min). Seventy-two percent received analgesia with a median time to order of 63 min and medication receipt of 87 min. Ibuprofen was the analgesia prescribed most commonly. There were no identified factors associated with oligoanalgesia. Nonuse of narcotics was associated with African-American race, public insurance, single fractures, and arrival via private vehicle. Ambulance arrivals, lower extremity fractures, and disaster mode were associated with receiving analgesia within 60 min. Conclusions: In our study, 28% of children with LBFs did not receive pain medications, especially during normal PED volumes. Additional studies are required to explore triage as a venue for analgesia delivery for LBFs.** © **2019 Elsevier Inc. All rights reserved.**

☐ **Keywords—long bone fracture; analgesia; pediatric; pediatric emergency department**

INTRODUCTION

Pain recognition and management are important components of medical care in the pediatric emergency department (PED). Timely administration of analgesia affects the entire PED visit and can have a lasting impact on a family's reaction to current and future medical care (1). Studies have shown that undertreatment of pain is associated with increased anxiety, avoidance, somatic symptoms, and increased parental distress (1–3). Published guidelines outline the management of pain in children, including anticipation of pain, involving the family and providing adequate analgesia for children of all ages (4). Despite these recommendations, practice variation persists in the PED, and studies have shown that pediatric patients do not receive adequate pain medication in a timely manner (1,5–7). Pain management in children is particularly difficult in the acute care setting as many

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are preverbal, resulting in failure to recognize pain and difficulty in interpreting pain scores (1,8). Further, providers may be hesitant to prescribe analgesics and opioids because of concerns about poor fracture healing, addiction, respiratory depression, tolerance, nausea, sedation, and cognitive impairment (9,10).

Several studies demonstrate inadequate pain management for long bone fractures (LBFs) in children (5,7,11,12). These studies all have looked at the impact of age, perception of pain, and pain score as risk factors for oligoanalgesia. There is a paucity of studies, however, that discuss how ED crowding levels are associated with both delay in treatment and lack of pain control in children, in contrast to the number of studies that discuss this in adults (13–18).

The primary objective of this study was to describe current pain management in children with LBFs and the factors associated with the undertreatment of pain.

MATERIALS AND METHODS

Study Setting

This study was performed at an inner-city, level I pediatric trauma center with an annual census of > 90,000 visits, of which 1,200 visits per year are for acute LBFs.

Study Population and Design

We conducted a descriptive retrospective review of patients who presented to the PED with an LBF between November 1, 2015 and August 31, 2016. All patients < 18 years of age with a diagnosis of an acute LBF were included regardless of disposition (admission or discharge). We excluded open fractures from the study, as the majority of these patients were identified as Emergency Severity Index (ESI) 1 and taken to the trauma bay. The study was approved by the Institutional Review Board.

Data Sources

We extracted data from the Cerner electronic medical record (EMR) based on the International Classification of Diseases (ICD) 9th and 10th Revision codes for LBFs. Our EMR database contains demographic and clinical information on all pediatric patients from their entry into the hospital system since 2006. All data were entered in an Excel (Microsoft, Redmond, WA) spreadsheet by two research assistants who were trained by the principal investigator (PI). Data were then cross-checked independently by the PI for accuracy and validity.

We measured PED occupancy using the National Emergency Department Overcrowding Score (NEDOCS). This is calculated based on the following characteristics: number of PED beds, number of hospital beds, total number of patients in the PED, number of patients on ventilators in the PED, number of admits in the PED, longest waiting time for an admitted patient, and the longest waiting time in the waiting room. NEDOCS is then categorized into the five groups (normal, busy, at capacity, overcrowded, and disaster) based on a score calculated every 4 h to gauge PED crowding (19,20).

Study Definitions

We defined LBFs (displaced and nondisplaced fractures) as fractures involving the radius, ulna, humerus, femur, tibia, or fibula. We defined single fractures as involving only one long bone (ie, just one radius or just one ulna). We defined multiple fractures as involving more than one long bone. Time to analgesia was defined as time of patient registration at triage to first medication order. In the study PED, when a patient arrives they are registered then triaged and assigned an emergency severity code by nursing and then placed in a room. Time to analgesia was defined as time from triage at registration to first medication order.

Medications

Pain medications given in the PED were grouped into two major subtypes: opiate analgesia and nonopiate analgesia. Opiate analgesics included morphine and fentanyl and nonopiate analgesics included acetaminophen and nonsteroidal anti-inflammatory medications, such as ibuprofen and ketorolac.

Outcome Measures

The primary outcome measure was time to analgesia order for patients with LBFs. The secondary outcome was to ascertain the impact of PED overcrowding on analgesia delivery within 60 min for children with an acute LBF. This time is based on the Joint Commission core measures to improve patient care, which are now part of the Specifications Manual for National Hospital Inpatient Quality Measures, used by both the Joint Commission and Centers for Medicare and Medicaid Services (20).

Statistical Methods

We summarized and reported the categorical variables by numbers and percentages. The normality of continuous variables was tested by the Shapiro-Wilk test. We reported normally distributed continuous variables as means and standard deviations, whereas non-normally distributed continuous variables were reported as median

and interquartile range (IQR). Pearson's χ^2 test was used to analyze the distribution of categorical variable by groups, provided no expected frequency was < 1, and no more than 20% of the cell had an expected frequency of < 5, otherwise Fisher's exact test was used for the analysis. Two comparisons for normal continuous variables were conducted using Student's *t*-test, whereas non-normally distributed continuous variables were compared using the Wilcoxon rank-sum test. Simple and multiple logistic regressions were used with factors associated with receipt of analgesia and opioids using adjusted and unadjusted odd ratio with 95% confidence interval. We used SAS, version 9.4 (SAS Institute Inc, Cary, NC) to perform the statistical analyses. Significance level was set at 0.05.

RESULTS

A total of 905 patients were evaluated for LBF in the PED during the study period. The demographic characteristics of these patients are given in Table 1. Almost all patients (98%) received an initial pain score. The median time to first pain score was 6 min (IQR 4 min). The mean pain scores by fracture type and mechanism were as follows: displaced 4.9, nondisplaced 4.7, single 4.6, multiple 5.3, upper extremity 4.7, lower extremity 5.0, falls 4.7, motor-vehicle collision 5.5, sport injuries 6.2, and nonaccidental trauma 1.5. More than 51% of the patients presented with an initial pain score ≥ 5. Overall, 72% of patients who presented to the PED for LBFs were treated with analgesics, with a median time to medication order by a health care provider of 63 min (IQR 75 min). Median time to medication administration was 87 min (IQR 87 min). Only 22% of patients received analgesia within 60 min of arrival. Among those who had an initial pain score of ≥5, 81% were treated with analgesics during the visit and 70% received them within the first hour. Median length of stay was 4 h (IQR 2 h).

Of those who were given an analgesic, non-narcotic medications were prescribed most commonly (n = 390 [60.1%]); ibuprofen was the most common medication (n = 343 [87.9%]). Only 265 (40.8%) patients received narcotics, with morphine being the most commonly prescribed medication (n = 195 [73.5%]).

Logistic regression analysis of factors associated with not receiving analgesia is given in Table 2. There was no single identified factor associated with not giving analgesia. Logistic regression of factors associated with not receiving analgesia and not receiving opioids are provided in Tables 2 and 3, respectively. While there was no single factor associated with oligoanalgesia, African-American race, public insurance, arrival by private vehicle, and presence of a single fracture were associated with not receiving opioids. The only factors associated with receiving analgesia within 60 min were ambulance arrivals, lower extremity fractures, and NEDOCS score indicating disaster mode, as seen in Table 4 d.

Table 1. Patient and Injury Characteristics

Characteristic	Data
Age, years, median (IQR)	6 (7)
Length of stay, h, median (IQR)	4 (2)
Age category n (%)	
< 2 years	69 (8)
2–4 years	191 (21)
5–12 years	502 (55)
> 13 years	143 (16)
Race, n (%)	
African American	437 (48)
Caucasian	189 (21)
Others	279 (31)
Male, n (%)	574 (63)
Arrival route, n (%)	
Ambulance	155 (17)
Private/self	732 (83)
Mechanism of injury, n (%)	
Sport	107 (12)
Falls	669 (74)
Other	103 (11)
Fracture location, n (%)	
Upper extremity	649 (72)
Lower extremity	254 (28)
ED disposition, n (%)	
Admit	211 (23)
Discharge	694 (77)
Operating room, yes, n (%)	198 (22)
Orthopedics consult, yes, n (%)	560 (62)

ED = emergency department; IQR = interquartile range.

DISCUSSION

In our study cohort, nearly one-third of children with LBFs and one-fifth of children with pain scores > 5 did not receive any analgesia in the PED. Additionally, more than half of the children did not receive analgesia for more than 1 h after presentation. These results mirror those of previously published studies and demonstrate

Table 2. Odds Ratios Associated With Not Receiving Analgesia

Effect	OR	95% CI
Race (AA vs. others)	0.87	0.64–1.20
Sex (male vs. female)	1.12	0.82–1.50
Age (≤2 years vs. > 2 years)	1.22	0.87–1.72
Insurance (public vs. private)	1.16	0.81–1.62
Mode of arrival (private vs. EMS)	0.72	0.47–1.00
Mechanism of injury (NAT vs. others)	0.73	0.26–1.96
Fracture (single vs. multiple) (vs. multiple)	1.38	0.95–2.01

AA = African American; CI = confidence interval; EMS = emergency medical services; NAT = nonaccidental trauma; OR = odds ratio.

Table 3. Odds Ratios Associated With Not Receiving Opioids

Effect	OR	95% CI
Race (AA vs. others)	1.60	1.16–2.21
Sex (male vs. female)	0.78	0.56–1.09
Age (≤2 years vs. > 2 years)	1.41	0.95–2.09
Insurance (public vs. private)	1.50	1.05–2.12
Mode of arrival (private vs. EMS)	0.16	0.11–0.24
Mechanism of injury (NAT vs. others)	0.44	0.18–1.07
Fracture (single vs. multiple) (vs. multiple)	2.00	1.38–2.91

AA = African American; CI = confidence interval; EMS = emergency medical services; NAT = nonaccidental trauma; OR = odds ratio.

that pain management in children with LBFs remains inadequate and largely unchanged for the past 3 decades, despite recommendations (7,11,21,22).

Causes of oligoanalgesia can be multifactorial and include parent/patient underreporting of pain, physician's skepticism of reported pain scores, fear of use of opioids in young children, and lack of formal training in pain management, different levels of training, and practice variation (21,23–26).

Assessing for pain in young children poses a challenge, as they are often preverbal or unable to articulate their pain clearly (27). Consequently, both parents and health care providers may underestimate a child's pain (28,29). Therefore, various pain scores are adopted by institutions as a first step toward treatment of pain. Surprisingly, in our study, oligoanalgesia was present, despite > 98% of children having a pain score recorded in triage soon after arrival and > 50% of patients having a pain score of ≥ 5. More than half of these children with high pain scores were not treated in a timely fashion. Although we have made significant improvements in identifying degree of pain in children early via pain scores, timely delivery of analgesia remains a challenge.

Table 4. Odds Ratios Associated With Not Receiving Analgesia Within 60 Minutes of Arrival to the Pediatric Emergency Department

Effect	OR	95% CI
Race (AA vs. others)	0.84	0.61–1.16
Sex (male vs. female)	1.24	0.89–1.72
Age (≤2 years vs. > 2 years)	1.06	0.73–1.55
Insurance (public vs. private)	0.63	0.42–0.93
Location of injury (UE vs. LE)	0.77	0.53–1.11
Mode of arrival (private vs. EMS)	1.41	0.89–2.24
NEDOCS	0.78	0.57–1.08
Mechanism of injury (NAT vs. others)	0.82	0.34–1.97
Fracture (single vs. multiple) (vs multiple)	1.08	0.73–1.60

AA = African American; CI = confidence interval; EMS = emergency medical services; LE = lower extremity; NAT = nonaccidental trauma; NEDOCS = National Emergency Department Overcrowding Score; OR = odds ratio; UE = upper extremity.

Institutional practice variations dictate the location of analgesia delivery (triage or rooms). In our PED, although pain scores are documented in triage, the medication delivery occurs only after the patient is placed in a room. Quality improvement protocols that incorporate both pain assessment and delivery of analgesia (eg, via nursing action protocols) in triage may be beneficial for improving timeliness of medication delivery.

Similar to Kircher et al., we found that health care providers preferred ibuprofen as analgesia for fracture pain management and used opioids sparingly (30). This contrasts with Dong et al.'s study that demonstrated opiates were the most commonly used drugs in the treatment of children with LBFs (12). Dong et al.'s study, however, included only children admitted for LBFs, which could explain the increased use of opiates in their cohort.

Contrary to studies reported previously, we did not identify any single risk factors associated with oligoanalgesia (31). However, there was a discrepancy in delivery of opioids for children on public insurance, African-American race, those who arrived by private vehicle, and single fractures. In our institution, children who present via emergency medical services and those with multiple fractures are typically given a higher ESI score and assigned to a higher acuity pod. This may be an explanation for why these children are more likely to receive opioids. Our study found that African-American race and those on public insurance were less likely to receive opioids for pain management; reasons for this are unclear and should be explored in future studies.

An interesting finding in our study was that analgesia delivery was delayed during normal PED census compared to during overcrowded or disaster times. This is contrary to what was reported by Mills et al., who found that timeliness to analgesia was decreased during overcrowding times (15). One possible explanation for our study results could be that our PED tends to have more staff and resources allocated to help decompress during high volumes. This improves overall efficiency, including delivery of medications.

Limitations

This study has limitations inherent in a retrospective chart review that included charts pulled from a billing database using the ICD codes of the discharge diagnosis. Hence, it is limited by dependence on the quality of documentation and abstractor bias and eliminates the chief complaint as a source. However, all data were extracted by trained research assistants and cross-checked and verified by the PI to minimize abstractor bias. This was a single-center study at a free-standing children's hospital, and conclusions of this study may not apply to other PEDs.

CONCLUSIONS

Analgesia for LBFs in children remains inadequate, with 28% of children not receiving any pain medications. Significant disparities exist in pain management, especially in the use of opioids. Future studies should focus on quality improvement projects that implement protocols in the triage of PED to ensure quality pain control in children with LBF.

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ARTICLE SUMMARY

1. Why is this topic important?

Long bone fractures in children cause pain and distress and there is wide practice variation in pain management.

2. What does this study attempt to show?

This study describes the factors associated with delay in pain control for children who present to a pediatric emergency department with long bone fractures.

3. What are the key findings?

One-third of children with long bone fractures did not receive any analgesia on presentation to a pediatric emergency department with an annual volume > 90,000 annual visits.

4. How is patient care impacted?

The retrospective study provides groundwork for future quality initiative projects aimed at reducing time to analgesia for children who present to a pediatric emergency department with long bone fractures.