Decreased Prescribing of Postoperative Opioids in Pediatric ACL Reconstruction

Trends at a Single Center

Ajith Malige,* MD, Joshua T. Bram,† BS, Kathleen J. Maguire,† MD, Lia W. McNeely,† MA, MSN, CPNP, Theodore J. Ganley,† MD, and Brendan A. Williams,†‡ MD

Investigation performed at Children’s Hospital of Philadelphia, Philadelphia, Pennsylvania, USA

Background: Anterior cruciate ligament (ACL) injury is common in the pediatric population. Pain control after ACL reconstruction (ACLR) presents a unique challenge due to age and early rehabilitation needs. Pain management practices are believed to have evolved in recent years to limit unnecessary exposure to risks associated with opioid use in this vulnerable population.

Purpose: To describe trends in postoperative opioid prescribing and assess factors including obtaining consent for opioid prescribing for minors that may have mitigated excessive prescription of opioids.

Study Design: Cohort study; Level of evidence, 3.

Methods: This is a retrospective review of a consecutive series of pediatric patients (<18 years) undergoing primary ACLR within an urban academic hospital system over a 5-year period (2014-2018). The study period included the gradual introduction of preoperative consenting for opioid use in minors as mandated by state law in 2016. Patient characteristics, surgical details, presence of a signed consent form to prescribe opioid medications, prescribed postoperative medications, prescriber, and indicators of inadequate pain control were collected. Univariate and multivariate analyses were performed to determine factors associated with reduced postoperative opioid prescribing.

Results: This study included 687 patients with a mean age of 15.1 ± 1.9 years, with less than one-third of patients having preoperative consent forms to prescribe opioid medications. Postoperative prescribing trends demonstrated a decline in the number of opioid doses provided and increased utilization of nonopioid medications. Patients who received preoperative opioid counseling and signed a consent form were prescribed fewer opioids and had a smaller number of unscheduled contacts for poorly controlled pain. Univariate analyses identified multiple predictors of the number of opioid doses prescribed postoperatively. Obtaining preoperative consent to prescribe opioids and ambulatory surgery center location were found to be independent predictors of prescribed doses in the multivariate analysis.

Conclusion: The quantity of opioid medication prescribed for pain management after pediatric ACLR at our institution has declined in recent years. This appears to be, in part, related to state-mandated preoperative counseling about opioid use, signing of a consent form by the parent(s) or guardian(s) to prescribe opioids to minors, and encouragement toward the use of nonopioid medications when possible. Preoperative opioid use discussions in the pediatric population may be useful in reducing opioid overprescription and utilization in this population.

Keywords: opioid; anterior cruciate ligament reconstruction; consent of minors; multimodal pain management

Anterior cruciate ligament (ACL) rupture is one of the most common sports-related injuries within the pediatric population. Rates of injury have increased in frequency recently due in part to earlier and greater youth sports participation. In order to prevent the long-term sequelae of an ACL-deficient knee, surgical intervention is common. Perioperative pain management presents a unique challenge in this patient population given the young age and early rehabilitation needs.

The long-term effects of early opioid exposure have been elucidated in the pediatric population. Unused and leftover opioids often serve as a gateway to misuse, particularly in the adolescent population. Reducing unnecessary opioid prescription, therefore, is of pressing importance in this patient cohort given their risk for recurrent exposure due to subsequent repeat or contralateral injury. Orthopaedic surgeons and anesthesiologists are increasing the use of perioperative multimodal analgesic modalities including...
non-steroidal anti-inflammatory medications and peripheral nerve blocks1 to help control pain and facilitate reduced opioid needs. Legal and societal pressures may also play a role in reducing unnecessary prescriptions, as seen with Act 125 of 2016 in Pennsylvania, mandating written consent for prescribing opioid medications to minors.21 However, no standard currently exists for provider prescribing in pediatric sports medicine, leaving surgeons, trainees, and advanced practice providers with little direction about what constitutes a safe but sufficient amount of these controlled substances.

The purpose of this study was to describe the postoperative pain management prescribing practices at a single center for pediatric ACL reconstruction (ACLR) and related procedures. Specifically, we aimed to detail trends in opioid and nonopioid pain medication prescribing at our institution while examining the emergence of preoperative consent for prescribing opioids for minors and its relationship to these prescribing practices. We hypothesized that opioid prescribing would decline over the study period without significant change in the ability to control pain.

METHODS

Patient Selection

Approval for this study was obtained from our hospital institutional review board. Records of all patients aged 18 years or younger who underwent ACLR at a single urban academic center between 2014 and 2018 were collected and assessed for inclusion in the study. Pediatric patients undergoing primary ACLR with or without concurrent procedures (eg, meniscal repair) were included. We excluded patients who underwent revision ACLR and those who were aged 18 years or older at the time of surgery.

Patients, Surgery, and Prescribing Characteristics

Demographic information (age, sex, and race/ethnicity), anthropomorphic data (height, weight, and body mass index [BMI]), surgical details (graft type, concurrent procedures, and surgery location), and postoperative pain medication prescribing details (prescriber and medications prescribed) were collected for each patient. Patients with uncontrolled pain prompting a telephone call, unplanned clinic return, or emergency department visit were identified as patients requiring an opioid refill for any reason within 30 days of surgery.

With Act 125 of 2016, the state of Pennsylvania established the requirements for prescribing opioids for minors. The caregiver must discuss the risks associated with the opioid medication with the minor patient and the parent(s) or guardian(s), and the patient or representative and the caregiver must sign a standard consent form before the medication can be prescribed.21 The consent process began in early 2017, and by April 1, 2017, all minor patients undergoing ACLR in the current study had the required consent form in their record.

Outcomes of Interest

Our primary outcome of interest was the number of doses of opioid medication prescribed to patients on the day of surgery. No guidelines existed to direct postoperative pain medication prescribing at our institution over the study period; thus, dosage and amount were at the discretion of the prescribing provider. We standardized the number of opioid doses dispensed by dividing the total amount of opioids prescribed by the dose prescribed (or smallest dose if a range was given). Standardized conversions were used to calculate the total morphine milligram equivalent for all opioids prescribed.2 Although liquid opiate prescription data were gathered and reported in descriptive analyses, patients receiving liquid medication comprised less than 10% (60 of 687) of the studied cohort and demonstrated dosing discrepancies from comparable patients prescribed tablet medication limiting dose calculations. To maintain consistency, we elected to exclude patients who received liquid doses from our advanced analyses.

Statistical Analysis

Descriptive statistics were used to analyze patient characteristics, procedural details, and prescribing practice trends over the study period. Differences in these variables were examined among the consenting cohorts using t tests, Mann-Whitney U tests, or Fisher exact tests as appropriate. Factors associated with an increasing number of prescribed opioid doses were determined using univariate and multivariate negative binomial regression analysis and reported as incidence rate ratios (IRRs) and 95% CIs based on data characteristics. Only those variables achieving \( P < .1 \) in univariate analysis and baseline patient characteristics (ie, age and sex) were entered into multivariate regressions. Assuming \( \alpha = .05, \beta = 0.2, \) and an SD of 15, post hoc power analysis identified that a sample size of 79 patients in each consenting group was sufficient to detect a change in prescribing of more than 6 doses.

\(^{1}\)Address correspondence to Brendan A. Williams, MD, Department of Orthopaedics, Children’s Hospital of Philadelphia, 3401 Civic Center Boulevard, Philadelphia, PA 19104, USA (email: williamsba@email.chop.edu).

\(^{2}\)Department of Orthopaedic Surgery, St. Luke’s University Health Network, Bethlehem, Pennsylvania, USA.

\(^{3}\)Department of Orthopaedics, Children’s Hospital of Philadelphia, Philadelphia, Pennsylvania, USA.

Final revision submitted August 1, 2020; accepted August 10, 2020.

One or more of the authors has declared the following potential conflict of interest or source of funding: A.M. has received hospitality payments from Stryker. T.J.G. has received research support from Allosource and Vericel and education payments from Arthrex and Liberty Surgical. B.A.W. has received education payments from Arthrex and hospitality payments from K2M. AOSSM checks author disclosures against the Open Payments Database (OPD). AOSSM has not conducted an independent investigation on the OPD and disclaims any liability or responsibility relating thereto.

Ethical approval for this study was obtained from The Children’s Hospital of Philadelphia (No. 16-013464).
of opioid medication (equaling approximately 1 day of medication based on dosing every 4 hours). Data analyses were performed using SPSS Version 24 Statistics for Windows (IBM Corp). For all analyses, $P \leq .05$ denotes statistical significance.

RESULTS

Study inclusion criteria were met by 687 patients with a mean age of 15.1 $\pm$ 1.9 years and BMI of 23.3 $\pm$ 5.0 (Table 1). Most of our study population were male (53.3%) and White/Caucasian (63.8%), while most also underwent ACLR using hamstring autograft (92.0%) at our main hospital (54.9%) rather than at an ambulatory surgery center (45.1%). Postoperatively, discharge medication prescribing was performed most frequently by nurse practitioners and physician assistants (38.1%), followed by residents (23.8%) and fellows (22.8%). For most patients, a multimodal pain regimen was prescribed for pain control at home, with 97.8% of patients receiving opioid medication, 87.5% of patients receiving acetaminophen, and 75.7% of patients receiving nonsteroidal anti-inflammatory drugs (NSAIDs). A total of 96 patients (14.0%) sought care for uncontrolled pain before their first follow-up visit. Patients made contact either by a telephone call (12.1%) or an emergency department/early clinic visit (1.9%) before their first scheduled postoperative visit. Twenty-eight patients (4.1%) had their opioid prescription refilled. Furthermore, there was no difference in prescribed amounts of opioid between different-aged patients ($P = .737$) (Table 2).

| Variable                        | Total (N = 687) | No Consent (n = 468) | Consent (n = 219) | $P$ Value |
|---------------------------------|----------------|---------------------|------------------|-----------|
| Age, y                          | 15.1 $\pm$ 1.9 | 15.0 $\pm$ 1.9      | 15.2 $\pm$ 1.8   | .159      |
| Weight, kg                      | 65.3 $\pm$ 17.2| 65.2 $\pm$ 17.6     | 65.5 $\pm$ 16.3  | .715      |
| BMI                             | 23.3 $\pm$ 5.0 | 23.2 $\pm$ 5.0      | 23.4 $\pm$ 4.9   | .498      |
| Sex                             |                |                     |                  | .229      |
| Male                            | 366 (53.3)     | 242 (51.7)          | 124 (56.6)       |           |
| Female                          | 321 (46.7)     | 226 (48.3)          | 95 (43.4)        |           |
| Race/ethnicity                  |                |                     |                  | .041      |
| White/Caucasian                 | 438 (63.8)     | 303 (64.7)          | 135 (61.6)       |           |
| Black/African American          | 142 (20.7)     | 102 (21.8)          | 40 (18.3)        |           |
| Hispanic                        | 20 (2.9)       | 15 (3.2)            | 5 (2.3)          |           |
| Other                           | 87 (12.7)      | 48 (10.3)           | 39 (17.8)        |           |
| Graft type                      |                |                     |                  | <.001     |
| Allograft tendon                | 14 (2.0)       | 14 (3.0)            | 0 (0)            |           |
| Bone–patellar tendon—bone      | 7 (1.0)        | 2 (0.4)             | 5 (2.3)          |           |
| Hamstring tendon                | 632 (92.0)     | 444 (94.9)          | 188 (85.8)       |           |
| Quadriceps tendon               | 17 (2.5)       | 2 (0.4)             | 15 (6.8)         |           |
| Iliotibial band                 | 16 (2.3)       | 6 (1.3)             | 10 (4.6)         |           |
| Surgery location                |                |                     |                  | .001      |
| Main hospital                   | 377 (54.9)     | 277 (59.2)          | 100 (45.7)       |           |
| Ambulatory surgery center       | 310 (45.1)     | 191 (40.8)          | 119 (54.3)       |           |
| Discharge prescriber            |                |                     |                  | <.001     |
| Advanced practice providerb     | 262 (38.1)     | 133 (28.4)          | 129 (58.9)       |           |
| Resident                        | 164 (23.8)     | 121 (25.9)          | 43 (19.6)        |           |
| Fellow                          | 157 (22.8)     | 124 (26.5)          | 33 (15.1)        |           |
| Physician                       | 96 (14.0)      | 83 (17.7)           | 13 (5.9)         |           |
| Outpatient medications prescribed |           |                     |                  |           |
| NSAIDs                          | 521 (75.7)     | 329 (70.3)          | 192 (87.7)       | <.001     |
| Acetaminophen                   | 602 (87.5)     | 395 (84.4)          | 209 (94.5)       | <.001     |
| Opioids                         | 673 (97.8)     | 456 (97.4)          | 217 (99.1)       | .154      |
| Opioids prescribed              |                |                     |                  |           |
| Liquid medication (total mL)    | 146.3 $\pm$ 98.3 | 160.6 $\pm$ 105.5 | 99.1 $\pm$ 46.9 | .012     |
| Tablet medication (total mg/dose mg) | 31.4 $\pm$ 13.0 | 34.6 $\pm$ 13.5 | 25.0 $\pm$ 8.7 | <.001     |
| MME                             | 235.0 $\pm$ 100.9 | 259.3 $\pm$ 105.1 | 184.1 $\pm$ 67.6 | <.001     |
| Opioid refill prescribed        | 28 (4.1)       | 24 (5.1)            | 4 (1.8)          | .060      |
| Uncontrolled pain prompting early contact | 96 (14.0) | 77 (16.5) | 19 (8.7) | .006     |
| Telephone call                  | 83 (12.1)      | 66 (14.1)           | 17 (7.8)         | .018      |
| ED or early unplanned clinic visit | 13 (1.9) | 11 (2.4) | 2 (0.9) | .244     |

aData are reported as n (%) or mean ± SD. P values in bold indicate a statistically significant difference between the study groups ($P \leq .05$). BMI, body mass index; ED, emergency department; MME, morphine milligram equivalent; NSAID, nonsteroidal anti-inflammatory drug.

bNurse practitioner or physician assistant.
There was no preoperative consent to prescribe opioid medications obtained for 468 patients (68.1%), whereas consent was obtained for 219 patients (31.9%) (Table 1). The consenting cohorts differed by race/ethnicity (P = .041), graft type used for ACLR (P < .001), surgery location (P = .001), and discharge provider (P < .001). Concurrent prescribing of NSAIDs (P < .001) and acetaminophen (P < .001) was more common in the consented cohort. While there was no statistical difference in the likelihood of opioid prescribing between groups (P = .154), the consented cohort received significantly fewer doses of liquid (P = .012) and tablet (P < .001) opioid medication and lower total morphine milligram equivalent (P < .001). Despite decreased prescribed medication quantity, the opioid consent group had significantly lower rates of early contact for uncontrolled pain (P = .006), with particularly fewer telephone calls to their surgeon (P = .018).

A comparison of patients before Pennsylvania’s Act 125 was passed on November 2, 2016, and after is shown in Table 3. While age, sex, weight, BMI, and race/ethnicity were similar between the 2 groups, surgeries were performed more commonly with hamstring autograft at a main hospital before Act 125. Our surgeons moved toward using a quadriceps tendon autograft at an ambulatory surgery center after this time. Most important, the post–Act 125 cohort had higher amounts of NSAIDs (88% vs 67.8%; P < .001) and acetaminophen (93.8% vs 83.5%; P < .001) prescribed with lower numbers of opioid doses (P < .001) and less early patient contact (P = .006). Interestingly, the amount of total outpatient opioids prescribed was similar between groups.

While there was no change in the rate of opioid use (>95% of patients) over the 5-year period, the mean doses dispensed steadily decreased annually from 38.6 doses in 2014 to 22.9 in 2018 (Figure 1). This was accompanied by an overall increase in the percentage of patients prescribed oral NSAIDs (65.2% to 89.3%) and acetaminophen (77.8% to 98.6%) during that time period. Univariate testing demonstrated that a resident (IRR, 1.561; 95% CI, 1.258-1.937; P < .001), fellow (IRR, 1.311; 95% CI, 1.058-1.625; P = .015), or attending physician (IRR, 1.316; 95% CI, 1.024-1.692; P = .032) discharge provider were significant predictors of prescribing more postoperative opioid doses as compared with advanced practitioners, a finding that was not significant in multivariate regression analysis (Table 4). Univariate testing simultaneously showed that surgery at an ambulatory surgery center (IRR, 0.721; 95% CI, 0.611-0.850; P < .001) and presence of a

### Table 2: Breakdown of Mean Prescribed Tablet Opioid Dose by Age

| Age, y | Patients | Prescribed Opioid Dose, g |
|--------|----------|--------------------------|
| ≤12    | 62       | 33.10 ± 16.02            |
| 13     | 75       | 31.59 ± 12.23            |
| 14     | 115      | 31.84 ± 14.28            |
| 15     | 124      | 30.08 ± 10.24            |
| 16     | 121      | 31.82 ± 12.93            |
| 17     | 99       | 30.90 ± 11.22            |

*Data are reported as n or mean ± SD. Only patients who were prescribed pills were included in this breakdown.

### Table 3: Comparison of Patient Characteristics and Opioid Prescription Before and After Pennsylvania’s Act 125

| Variable                                | Before Act 125 | After Act 125 | P     | Value |
|-----------------------------------------|----------------|---------------|-------|-------|
| Age, y                                  | n = 413        | n = 274       |       |       |
| Sex                                     |                |               |       |       |
| Male                                    | 210 (50.8)     | 156 (56.9)    | .117  |       |
| Female                                  | 203 (49.2)     | 118 (43.1)    |       |       |
| Weight, kg                              | 65.0 ± 17.2    | 65.8 ± 17.1   | .439  |       |
| BMI                                      | 23.0 ± 4.9     | 23.6 ± 5.1    | .104  |       |
| Race/ethnicity                          |                |               | .092  |       |
| White/Caucasian                         | 266 (64.4)     | 172 (62.8)    |       |       |
| Black/African American                  | 89 (21.5)      | 53 (19.3)     |       |       |
| Hispanic                                | 15 (3.6)       | 5 (1.8)       |       |       |
| Other                                   | 43 (10.4)      | 44 (16.1)     |       |       |
| Graft type                              |                |               | <.001 |       |
| Allograft tendon                        | 11 (2.7)       | 3 (1.1)       |       |       |
| Bone–patellar tendon—bone               | 2 (0.5)        | 5 (1.8)       |       |       |
| Hamstring tendon                        | 397 (96.1)     | 235 (85.8)    |       |       |
| Quadriceps tendon                       | 0 (0.0)        | 17 (6.2)      |       |       |
| Iliotibial band                         | 3 (0.7)        | 13 (4.7)      |       |       |
| Surgery location                        |                |               | <.001 |       |
| Main hospital                           | 250 (60.5)     | 127 (46.4)    |       |       |
| Ambulatory surgery center               | 163 (39.5)     | 147 (53.6)    |       |       |
| Discharge prescriber                    |                |               | <.001 |       |
| Advanced practice provider              | 103 (25.4)     | 159 (58.2)    |       |       |
| Resident                                | 111 (27.3)     | 53 (19.4)     |       |       |
| Fellow                                  | 109 (26.8)     | 48 (17.6)     |       |       |
| Physician                               | 83 (20.4)      | 13 (4.8)      |       |       |
| Outpatient medications prescribed       |                |               |       |       |
| NSAIDs                                  | 280 (67.8)     | 241 (88.0)    | <.001 |       |
| Acetaminophen                           | 345 (83.5)     | 257 (93.8)    | <.001 |       |
| Opioids                                 | 401 (97.1)     | 272 (99.3)    | .555  |       |
| Opioids prescribed                      |                |               |       |       |
| Liquid medication (total mL)            | 175.2 ± 108.2  | 92.5 ± 39.6   | <.001 |       |
| Tablet medication doses (total mg/dose mg) | 35.0 ± 13.8  | 26.1 ± 9.4    | <.001 |       |
| MME                                     | 260.4 ± 106.3  | 192.5 ± 74.3  | <.001 |       |
| Opioid refill prescribed                | 21 (5.1)       | 7 (2.6)       | .101  |       |
| Uncontrolled pain prompting early contact | 70 (16.9)  | 26 (9.5)      | .006  |       |
| Telephone call                          | 61 (14.8)      | 22 (8.0)      | .008  |       |
| ED or early unplanned clinic visit      | 9 (2.2)        | 4 (1.5)       | .579  |       |

*Data are reported as n (%) or mean ± SD. P values in bold indicate a statistically significant difference between the study groups (P < .05). BMI, body mass index; ED, emergency department; MME, morphine milligram equivalent; NSAID, nonsteroidal anti-inflammatory drug.

<sup>a</sup>Act 125 enacted on November 2, 2016.
<sup>b</sup>Nurse practitioner or physician assistant.
TABLE 4
Regression Analysis of Factors Associated With Prescription of a Greater Number of Postoperative Doses of Opioid Medication

| Variable                                      | Incidence Rate Ratio (95% CI) | P Value | Incidence Rate Ratio (95% CI) | P Value |
|-----------------------------------------------|-------------------------------|---------|-------------------------------|---------|
| Age                                           | 0.982 (0.937-1.030)           | .459    | 0.982 (0.936-1.030)           | .462    |
| Female sex                                    | 1.007 (0.854-1.187)           | .936    | 0.995 (0.844-1.174)           | .956    |
| Weight, kg                                    | 1.000 (0.995-1.005)           | .97     | Not entered                   | —       |
| BMI                                           | 1.004 (0.988-1.020)           | .655    | Not entered                   | —       |
| Underweight/normal weight                     | Reference                     | —       | Not entered                   | —       |
| Overweight                                    | 1.015 (0.825-1.249)           | .886    | Not entered                   | —       |
| Obese                                         | 1.151 (0.850-1.558)           | .363    | Not entered                   | —       |
| Graft type                                     | —                             | —       | —                             | —       |
| Allograft tendon                              | 0.936 (0.523-1.674)           | .824    | Not entered                   | —       |
| Bone–patellar tendon—bone                    | 0.841 (0.370-1.908)           | .678    | Not entered                   | —       |
| Hamstring tendon                              | Reference                     | —       | Not entered                   | —       |
| Quadriceps tendon                             | 1.005 (0.562-1.796)           | .987    | Not entered                   | —       |
| Iliotibial band                               | 1.022 (0.541-1.928)           | .947    | Not entered                   | —       |
| Ambulatory surgery center location            | 0.721 (0.611-0.850)           | <.001   | 0.712 (0.517-0.979)           | .037    |
| Preoperative consent to prescribe opioids obtained | 0.724 (0.608-0.863)     | <.001   | 0.764 (0.634-0.920)           | .005    |
| Acetaminophen prescribed postoperatively      | 0.845 (0.654-1.092)           | .198    | Not entered                   | —       |
| Ibuprofen prescribed postoperatively          | 0.843 (0.694-1.022)           | .083    | 1.014 (0.815-1.260)           | .904    |
| Discharge prescriber                          | —                             | —       | —                             | —       |
| Advanced practice provider                     | Reference                     | —       | Reference                     | —       |
| Resident                                      | 1.561 (1.258-1.937)           | <.001   | 1.102 (0.770-1.574)           | .599    |
| Fellow                                        | 1.311 (1.058-1.625)           | .013    | 0.934 (0.659-1.325)           | .703    |
| Physician                                     | 1.316 (1.024-1.692)           | .032    | 1.186 (0.913-1.541)           | .201    |

*P values in bold indicate statistically significant difference between the study groups (P ≤ .05). BMI, body mass index; —, not applicable.

*Nurse practitioner or physician assistant.
signed consent form for prescribing opioids (IRR, 0.724; 95% CI, 0.608-0.863; \( P < .001 \)) were significant predictors of fewer postoperative opioid doses. In multivariate regression analysis, surgery at an ambulatory surgery center (IRR, 0.712; 95% CI, 0.517-0.979; \( P = .037 \)) and presence of a preoperative consent form for prescribing opioids (IRR, 0.764; 95% CI, 0.634-0.920; \( P = .005 \)) were significant predictors of a lower number of opioid doses prescribed.

**DISCUSSION**

This study sought to detail trends in postoperative pain medication prescribing and its relationship to the emergence of preoperative consent to prescribe opioid medications for minors. Postoperative pain management continues to be a challenging and patient-specific endeavor that is perpetually evolving.\(^9\),\(^11\),\(^19\) For pediatric patients undergoing ACLR, safe but adequate pain management is important due to their age and rehabilitation needs.\(^13\) Tripp et al\(^27\) found that controlling immediate postoperative pain in this group is more difficult than in adults due to higher subjective reports of pain, catastrophizing, and increased anxiety, forcing many prescribers to rely more heavily on opioid medications to decrease these symptoms. The recent emphasis on decreasing the use of opioid medication in order to reduce to their negative effects has led to an increase in the use of multimodal analgesia including perioperative peripheral blocks and postoperative NSAIDs.\(^6\),\(^12\),\(^14\) Our study identified a decreasing volume of opioids dispensed postoperatively over the study period without evidence of worsening pain control. This coincided with growing utilization of formal prescriptions for multimodal pain management therapies including ibuprofen and acetaminophen. We found that an ambulatory surgery center location and a preoperative consent form for prescribing opioids were associated with lower total doses of prescribed opioids.

The overall trends in postoperative prescribing patterns at our center are very encouraging, especially across a diverse group of prescribers and without formal guidelines for prescribing in place. While we continue to rely on opioids as part of a pain management regimen in the vast majority of patients (>95%), the number of opioid doses steadily decreased between 2014 and 2018. This could be related to a number of factors including achieving adequate pain control using multimodal analgesia, obtaining preoperative consent to prescribe opioids, and providing better patient pre-education on pain management.\(^16\) This not only leads to better patient outcomes and satisfaction, but some have found it can also lower health care costs and burden on the health care system.\(^2\)

In 2016, Act 125 was enacted by Pennsylvania’s legislation in an effort to help physicians constantly evaluate and reduce the amount of opioids being prescribed to minors. Among other mandates, physicians must discuss pain management and have the parent(s) or guardian(s) sign a consent form before prescribing these medications to a minor. While other studies have identified decreased prescribing after state-legislated prescribing limits,\(^22\) to our knowledge, this is the first work exploring the relationship between the preoperative consenting process and postoperative prescribing in pediatric sports medicine. We believe the discussion resulting from the consenting process likely affected opioid prescribing in a number of ways. Most importantly, it forced a preoperative discussion about postoperative pain management as well as the risks and benefits of utilizing opioid medications.\(^9\) For providers, it required they acknowledge the importance of opioid stewardship with families and patients on a regular basis and placed greater focus on the amount and duration of medication prescribed. For patients and families, it forced a discussion that was not routinely carried out before mandated consenting, educating them about the risks and hazards of opioid misuse and overdose.

Our findings demonstrated a significant reduction in the number of doses prescribed to patients in the “opioid consenting” era without an apparent increase in early telephone calls, unplanned clinic visits, or returns to the emergency department. Aside from consent, prescribing of opioids appears closely tied to surgery location. Younger patients tended to receive opioids in liquid form for which doses appeared more liberally prescribed. This may be in part due to the electronic medical record, which has recommended dispensing volumes, possibly causing prescribers to round volumes up to larger numbers. In the consenting era, there appeared to be greater attention paid to this. Differences in prescribing volume based on location of surgery could be related to the reliance on the main hospital for cases believed to be longer or more complex, potentially resulting in greater analgesic requirements. These findings indicate that we might benefit from guidelines provided by an institutional education program similar to what has been provided successfully at other institutions.\(^25\)

At our institution, advanced practitioners, rotating residents, orthopaedic pediatric fellows, and attending physicians all participate in the discharge of a patient, with advanced practitioners discharging a majority of our patients. Rotating orthopaedic residents (postgraduate years 2 through 4 at our institution) may have varying levels of familiarity with pain management practices in the pediatric population. Without institutional guidelines in place, residents likely rely on prescribing practices in other (ie, nonpediatric) areas of orthopaedics, where opioid utilization may be greater. Findings from this and related work from our institution are helping to establish best practice recommendations for pain management. These serve to standardize opioid-prescribing practices across our institution to better guide all providers toward safe and effective prescribing in this patient population. It should also be noted that, while graft type was not a risk factor for higher opioid prescription amounts, 92% of our cohort had hamstring autografts used in their ACLR. The relatively low number of all other graft types can skew this analysis and hide a true difference in pain levels between groups that could have higher opioid requirements.

Many providers have turned to multimodal analgesia to help manage patient-reported pain. This has been gaining popularity, both in the pediatric and adult
populations, as an effective method of decreasing opioid requirements postoperatively.\textsuperscript{10,23} Our study noted a formal increase in the prescription of nonopioid medication at the same time that there was more careful management of opioids by the providers. While the use of acetaminophen and ibuprofen as alternatives to opioids is not new, written prescription of these medications is not routine in all practices. Some providers may rely on verbal instruction to patients and families because these medications can be obtained over the counter in different formulations. Our findings identified a significant shift toward formally prescribing these opioid alternatives over the study period, which we believe likely helped enable the shift in opioid prescribing without compromising pain control. We believe this represents an important consideration for providers aiming to refine their opioid-prescribing practices.

Most limitations of this study exist because of its single-center, retrospective design. Although pain management was provided by a large number of caregivers with diverse training, the methods described may not be generalizable to other treatment centers. While our patient cohort was diverse across the spectrum of pediatric ACL injury, as a tertiary referral center it may have included more patients with medically or surgically complex cases and unusual pain control needs. With regard to the assessment of the adequacy of prescribed medication, a retrospective collection of data about unplanned visits and the need for medication refills is limited. Finally, the study design is not ideally suited for evaluation of the actual medication utilization by patients. Future work using prospective, survey-based data capture will seek to identify the needs and actual consumption of opioids during the postoperative period.

CONCLUSION

The amount of prescribed postoperative opioids at our institution for pain management in pediatric ACLR has declined in recent years. This appears to be, in part, related to state-mandated preoperative opioid counseling, signing of a consent form by the parent(s) or guardian(s) for prescribing opioids, and encouragement toward the use of nonopioid medications when possible. Continued efforts should be made to optimize the use of these medications in order to mitigate the long-term issues related to misuse, overdose, and addiction.

ACKNOWLEDGMENT

The authors acknowledge Divya Talwar, PhD, MPH, BDS (clinical outcomes research manager for the Division of Orthopaedics at The Children’s Hospital of Philadelphia) for her assistance with the statistical analyses performed in this manuscript.

REFERENCES

1. Adams AJ, Muhly WT, Gurnaney HG, Kerr JC, Wells L. Short-term outcomes in pediatric patients managed with peripheral nerve blockade for arthroscopic anterior cruciate ligament reconstruction and/or meniscus surgeries. Cureus. 2018;10(6):e2852.
2. Aronowitz ER, Kleinbart FA. Outpatient ACL reconstruction using intraoperative local analgesia and oral postoperative pain medication. Orthopedics. 1998;21(7):781-784.
3. Au K, Zhang D-A, McCoy E, et al. Eighty-nine percent of opioids prescribed for outpatient pediatric surgery go unused. Plast Reconstr Surg Glob Open. 2019;7:115.
4. Beck NA, Lawrence JTR, Nordin JD, DeFor TA, Tompkins M. ACL tears in school-aged children and adolescents over 20 years. Pediatr. 2017;139(3):e20161877.
5. Centers for Disease Control and Prevention. Opioid oral morphine milligram equivalent (MME) conversion factors. Published 2016. Accessed July 30, 2019. https://www.cdc.gov/drugdependency/Pages/Opioid-MorphineEQ-Conversion-Factors-Aug-2017.pdf
6. Chung CP, Callahan ST, Cooper WO, et al. Outpatient opioid prescriptions for children and opioid-related adverse events. Pediatrics. 2018;142(2):e20172156.
7. Dautremont EA, Ebramzadeh E, Beck JJ, Bowen RE, Sangiorgio SN. Opioid prescription and use in adolescents undergoing orthopaedic surgery in the United States: a systematic review. JBJS Rev. 2017;5(8):e6.
8. DeFrancesco CJ, Storey EP, Flynn JM, Ganley TJ. Pediatric ACL reconstruction and return to the operating room: revision is less than half of the story. J Pediatr Orthop. 2019;39(10):516-520.
9. Frizzell KH, Cavanaugh PK, Herman MJ. Pediatric perioperative pain management. Orthop Clin North Am. 2017;48(4):467-480.
10. Hajewski CJ, Westermann RW, Holte A, Shamrock A, Bollier M, Wolf BR. Impact of a standardized multimodal analgesia protocol on opioid prescriptions after common arthroscopic procedures. Orthop J Sports Med. 2019;7(9):23259671987075.
11. Harbaugh OM, Vargas G, Streur CS, et al. Eliminating unnecessary opioid exposure after common children’s surgeries. JAMA Surg. 2019;154(12):1154.
12. Khoury CEL, Dagher C, Ghanem I, Naccache N, Jawish D, Yazbeck P. Combined regional and general anesthesia for ambulatory peripheral orthopedic surgery in children. J Pediatr Orthop B. 2009;18(1):37-45.
13. Kruse LM, Gray B, Wright RW. Rehabilitation after anterior cruciate ligament reconstruction. J Bone Joint Surg Am. 2012;94(19):1737-1748.
14. Kuo C, Edwards A, Mazumdar M, Memtsoudis SG. Regional anesthesia for children undergoing orthopedic ambulatory surgeries in the United States, 1996-2006. HSS J. 2012;8(2):133-136.
15. Lee B, Schug SA, Joshi GP, et al. Procedure-Specific Pain Management (PROSPECT) — an update. Best Pract Res Clin Anaesthesiol. 2018;32(2):101-111.
16. Lovecchio F, Derman P, Stepan J, et al. Support for safer opioid prescribing practices: a catalog of published use after orthopaedic surgery. J Bone Joint Surg Am. 2017;99(22):1945-1955.
17. McCabe SE, West BT, Boyd CJ. Leftover prescription opioids and nonmedical use among high school seniors: a multi-cohort national study. J Adolesc Health. 2013;52(4):480-485.
18. Miech R, Johnston L, O’Malley PM, Keyes KM, Heard K. Prescription opioids in adolescence and future opioid misuse. Pediatrics. 2015;136(5):e1169-e1177.
19. Monitto CL, Hsu A, Gao S, et al. Opioid prescribing for the treatment of acute pain in children on hospital discharge. Anesth Analg. 2017;125(6):2113-2122.
20. Noonan B, Chung KS. A practical review of the mechanisms of pain and pain management following ACL reconstruction. Orthopedics. 2006;29(11):999-1005.
21. Prescribing Opioids to Minors, Imposing Powers and Duties and Imposing Penalties, Health and Safety (35 PA.C.S.) ch 52A. 2016. Accessed April 6, 2019. https://www.legis.state.pa.us/cfdocs/legis/li/uconsCheck.cfm?yr=2016&sessInd=0&act=125
22. Reid DBC, Shah KN, Shapiro BH, Ruddell JH, Akelman E, Daniels AH. Mandatory prescription limits and opioid utilization following orthopaedic surgery. *J Bone Joint Surg Am*. 2019;101(10):e43.

23. Shah SA, Guidry R, Kumar A, White T, King A, Heffernan MJ. Current trends in pediatric spine deformity surgery: multimodal pain management and rapid recovery. *Global Spine J*. 2020;10(3):346-352.

24. Stanitski CL. Pediatric and adolescent sports injuries. *Clin Sports Med.* 1997;16(4):613-633.

25. Stepan JG, Lovechio FC, Premkumar A, et al. Development of an institutional opioid prescriber education program and opioid-prescribing guidelines: impact on prescribing practices. *J Bone Joint Surg Am*. 2019;101(1):5-13.

26. Tepolt FA, Feldman L, Kocher MS. Trends in pediatric ACL reconstruction from the PHIS database. *J Pediatr Orthop.* 2018;38(9):e490-e494.

27. Tripp DA, Stanish WD, Reardon G, Coady C, Sullivan MJL. Comparing postoperative pain experiences of the adolescent and adult athlete after anterior cruciate ligament surgery. *J Athl Train.* 2003;38(2):154-157.