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Opioid-free Laparoscopic Appendectomy: Quality Improvement Project

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ABSTRACT

Introduction: This quality improvement project has tracked postoperative measures for more than 5 years as we implement an opioid-free laparoscopic appendectomy protocol. **Methods:** We used statistical process control charts to analyze real-world data captured from the medical record. Outcome measures included postanesthesia care unit (PACU) length of stay (LOS), 24-hour maximum pain scores, PACU intravenous opioid medication administration, hospital LOS, and postoperative day 1 morphine milliequivalent requirement. We monitored this family of measures in all appendectomy patients as our team adopted the opioid-free protocol; in addition, we rationally subgrouped patients into the opioid-receiving group versus the opioid-free group. **Results:** A total of 2,483 pediatric laparoscopic appendectomies were performed between January 1, 2017, and June 30, 2023. Starting in 2017, we encouraged anesthesia providers to follow an opioid-free protocol for laparoscopic appendectomy. By October 2019, a ~50% adoption rate of intraoperative opioid-free anesthetic management had occurred. In total, 1,486 patients received opioids and 997 patients did not (opioid-free). No special cause variation was observed for the measured outcomes, including maximum 24-hour pain scores or PACU rescue opioid administration. We did notice reduced hospital LOS in addition to a reduced postoperative day 1 morphine milliequivalent requirement in the opioid-free group. **Conclusions:** This quality improvement project implemented an opioid-free laparoscopic appendectomy protocol for pediatric patients without adversely affecting pain scores, rate of PACU rescue opioids, or hospital LOS.
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INTRODUCTION

Problem Description

Laparoscopic appendectomies are one of the most common pediatric surgeries annually.[1,2] Laparoscopic appendectomies are the third most common pediatric procedure performed at Seattle Children's Hospital (SCH) after tonsillectomy adenoidectomy and myringotomy with tympanostomy tube placement. Intraoperative pain management and postoperative prescribing patterns for this surgery remain heterogeneous.[3,4] Institutions that have made significant efforts to reduce the heterogeneity of intraoperative anesthetic care provided have observed many benefits, including improved efficiency and process reliability, more consistent outcomes, and cost savings.[5] Recently, there has been growing interest in limiting the use of opioids for perioperative analgesia due to increased awareness that opioid-free anesthesia (OFA) can provide noninferior analgesia with the added benefit of avoiding untoward side effects, such as constipation, nausea, and respiratory depression.[6] These side effects can also be associated with a prolonged postanesthesia care unit (PACU) recovery and delayed hospital discharge.[7]

Available Knowledge

Our institution has implemented and published our experience with other opioid-free protocols for common procedures, including strabismus surgery, hernia repair, and tonsillectomy adenoidectomy, all with beneficial effects.[8,9] Our tonsillectomy adenoidectomy quality improvement (QI) project demonstrated similar pain scores and PACU length of stay (LOS) when utilizing dexmedetomidine

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and ketorolac as compared with morphine and acetaminophen, as well as improved postoperative nausea and vomiting medication rescue rates.[9]

Rationale

This QI project enables us to understand the impact of implementing an OFA protocol on our patients undergoing the most common surgical emergency operation performed in pediatrics. The included subgroup analyses comparing opioid-free versus opioid-receiving anesthetics for laparoscopic appendectomies give us insight into the real-world effectiveness of this protocol beyond the immediate postoperative period in PACU because laparoscopic appendectomy patients are often admitted postoperatively.

Specific Aims

To create an OFA protocol for pediatric laparoscopic appendectomies and reduce intraoperative variation, deliver more consistent outcomes, and improve the quality of care for these patients. We selected PACU LOS, 24-hour maximum pain scores, PACU intravenous opioid administration, hospital LOS, and postoperative day 1 (POD1) morphine milliequivalent (MME) requirement as primary outcome measures.

METHODS

Context

SCH is a pediatric facility affiliated with the University of Washington School of Medicine. It has 407 licensed beds, 26 operating rooms, and 8 procedure suites. In 2022, Seattle Children's performed 11,250 outpatient surgeries and 3,902 inpatient surgeries. During the opioid shortage of 2017–2018 and continued issues around the short supply of intravenous opioid medications, alternative intraoperative techniques using multimodal nonopioid medications were explored for various procedures, including laparoscopic appendectomies.

SCH implemented its original electronic medical record (EMR) system using Cerner Corporation (Kansas City, Mo.), which included deploying its Surginet application for documenting in the operating room in 2014. In 2017, SCH implemented AdaptX (Seattle, Wash.) as their adaptive clinical management solution for driving QI. In 2020, SCH switched its EMR vendor to EPIC (Verona, Wis.).

Intervention

Beginning in 2017, we encouraged anesthesia providers taking care of patients undergoing laparoscopic appendectomy at SCH to follow a standardized opioid-free protocol. During this time, the SCH ambulatory surgery center began a series of rapid QI projects which led to the development of numerous opioid-free protocols for common outpatient surgeries including, but not limited to, tonsillectomies, hernia repairs, strabismus correction, anterior cruciate ligament reconstruction, circumcision, and buried penis repair. Success in the ambulatory surgery center encouraged a shift within the department to utilize opioid-sparing and opioid-free techniques on the main campus. To encourage the adoption of the opioid-free protocol, we used a macro in the EMR to remind anesthesia providers of medication choice, sequence, and dosing.

The opioid-free protocol at SCH includes dexmedetomidine intravenous (IV) 0.5 μg/kg (maximum dose 30 μg) at the start of the case and repeated as necessary, ketorolac IV 0.5 mg/kg (maximum dose 30 mg) at the end of the case, and acetaminophen IV 12.5 mg/kg (maximum 1 g) at the end of the case.

Study of the Intervention

In this QI project, we reviewed the clinical outcomes of all laparoscopic appendectomies performed at SCH between January 1, 2017, and June 30, 2023. Inclusion criteria were patients between 1 and 18 years of age with an American Society of Anesthesiologists (ASA) score of 3 or less, including patients (ASA 1e, 2e, and 3e) who underwent an emergency laparoscopic appendectomy. The opioid-free laparoscopic appendectomy group included patients who did not receive intraoperative opioids. The control group included patients who received any intraoperative opioids.

Measures

Outcome measures included maximum PACU LOS, 24-hour maximum pain scores, PACU intravenous opioid medication administration, hospital LOS, and POD1 MME requirement. We chose 24-hour maximum pain scores and hospital LOS to determine whether prolonged sedation from dexmedetomidine administration delayed reported pain treatment after patients left the PACU.

Analysis

Data were automatically extracted and converted to statistical process control (SPC) charts using AdaptX, which provides aggregated de-identified linked data pulled from the EMR. These data enable clinicians to quantify outcome variations and practice changes displayed over a specific time frame. Medical record numbers are locatable for data validation purposes, but no protected health information was used to generate the aggregate data for this QI project. The QI project is a nonrandomized, observational before-and-after study design that leveraged real-world data displayed as SPC charts.[10] The SPC charts allow clinicians to distinguish between common cause variation and assignable (special) cause variation (SCV). Common cause variation is random variation (noise) inherent within a system over time.[10] SCV is when there is variation in a system that can be attributed to assignable causes (signal). Examples of SCV include but are not limited to 8 sequential points above or below the centerline, a single data point outside the 3 sigma control limits, or 6 or greater sequential points increasing or decreasing. All SPC charts are displayed as X-bar charts or P-charts,

depending on the outcome measure displayed. S charts associated with each X-bar chart are available (**Appendix Figure 2, Supplemental Digital Content 2, http://links.lww.com/PQ9/A638**; **Appendix Figure 3, Supplemental Digital Content 3, http://links.lww.com/PQ9/A639**; **Appendix Figure 4, Supplemental Digital Content 4, http://links.lww.com/PQ9/A640**; **Appendix Figure 5, Supplemental Digital Content 5, http://links.lww.com/PQ9/A641**).

Table 1. Demographics of Patients Who Had a Laparoscopic Appendectomy

Demographics	Laparoscopic Appendectomy (Received Opioids) (N = 1,486)	Laparoscopic Appendectomy (Opioid-free) (N = 997)
Age groups, n (%)		
Childhood (6–12 y)	822 (55.32)	538 (53.96)
Adolescence (13–18 y)	456 (30.69)	317 (31.8)
Preschool (4–5 y)	128 (8.61)	81 (8.12)
Toddler (1–3 y)	80 (5.38)	61 (6.12)
ASA score, n (%)		
1E	660 (44.41)	394 (39.52)
1	320 (21.53)	294 (29.49)
2	257 (17.29)	179 (17.95)
2E	178 (11.98)	107 (10.73)
3	49 (3.3)	17 (1.71)
Other	22 (1.48)	6 (0.6)
Patient sex assigned at birth, n (%)		
Male	870 (58.55)	574 (57.57)
Female	615 (41.39)	423 (42.43)
Unknown	1 (0.07)	
Patient race and ethnicity, n (%)		
Non-Hispanic White	701 (47.17)	498 (49.95)
Hispanic	383 (25.77)	230 (23.07)
Asian	116 (7.81)	72 (7.22)
Unknown/refused	96 (6.46)	70 (7.02)
Black or African American	76 (5.11)	32 (3.31)
Other	114 (7.67)	95 (9.53)

RESULTS

From January 1, 2017, to June 30, 2023, 2,483 patients underwent a laparoscopic appendectomy, with 1,486 patients receiving intraoperative opioids and 997 patients who did not. Table 1 shows the demographic breakdown of the data for each group. In October 2019, there was a transition to approximately 50% of laparoscopic appendectomies being performed opioid-free (**Appendix Figure 1, Supplemental Digital Content 1, http://links.lww.com/PQ9/A637**). This time point will be illustrated in the charts moving forward to demonstrate how the transition to ~50% opioid-free management impacted other patient outcomes.

Figure 1 shows the average PACU LOS for all patients undergoing laparoscopic appendectomy. Following October 2019, when approximately ~50% of cases were completed using the opioid-free technique, we noticed an increase in average PACU time. The SPC chart demonstrated SCV, and therefore, the centerline was recalculated. Looking at the subgroup analysis in Figure 1, we can see the breakdown of cases comparing patients who received opioids versus those who did not. This figure demonstrated SCV in the opioid-receiving. Due to the SCV in the opioid-receiving group, the centerline mean was recalculated.

In Figure 2, we examine the average maximum pain scores over 24 hours for all patients who underwent laparoscopic appendectomy. We chose to use maximum pain

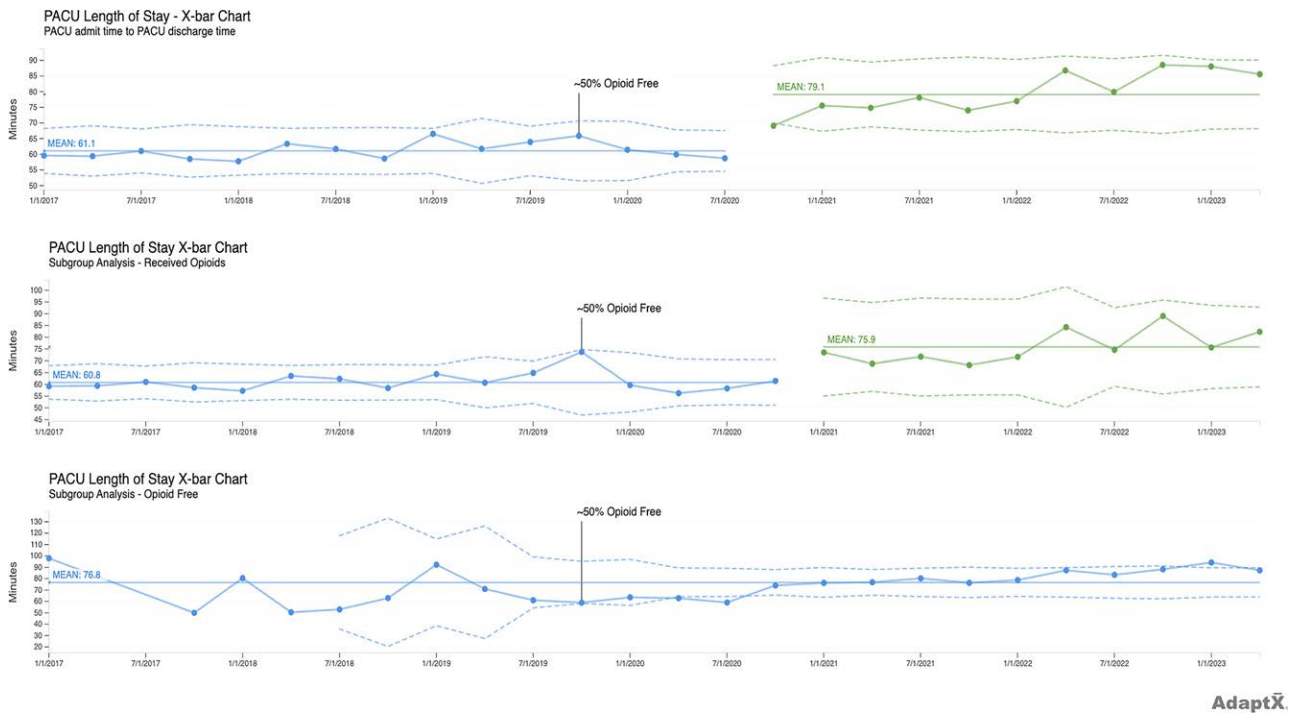

Fig. 1. PACU length of stay and subgroup analysis.

Fig. 2. Postoperative maximum pain score over 24 hours.

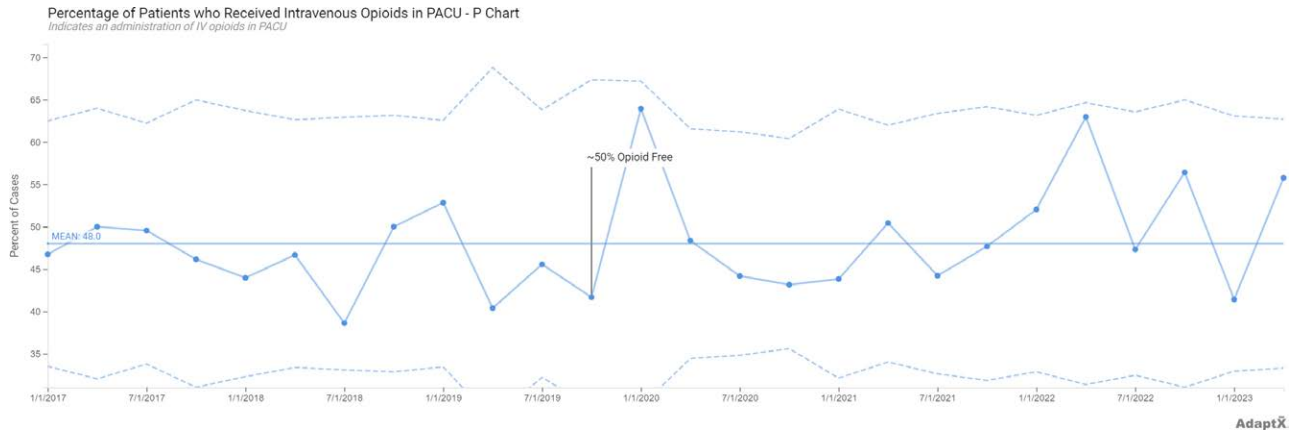

Fig. 3. Percentage of patients who received intravenous opioids in PACU.

scores over 24 hours as a clinical balancing measure to address concerns that dexmedetomidine may prolong sedation and possibly result in delayed postoperative pain. Following the initiation of ~50% opioid-free laparoscopic appendectomies, we did not notice any SCV in 24-hour maximum pain scores.

Figure 3 looks at the rate of opioid rescue medication in the PACU. This measure is stable throughout, with no SCV in the data.

Figure 4 demonstrates the average postsurgery hospital LOS in all laparoscopic appendectomy patients. A few quarters after ~50% initiation of opioid-free cases, the SPC chart demonstrated SCV; therefore, the centerline was recalculated. Rational subgrouping allows us to compare the cohorts separately in Figure 4. The average hospital LOS for the opioid-free group was lower at 1.7 days compared with 2.7 days in the opioid-receiving group.

Figure 5 examines the amount of opioids received on POD1 in MME in both patients who did and did not receive opioids during their intraoperative course. The mean MME on POD1 was 2 times lower in the opioid-free group at 0.03 compared with 0.06 in the opioid-receiving group. Extending the mean of the opioid-receiving group, we see all of the data points fall below the extended mean for the opioid-free data. MME data were not tracked at our institution until 2020. Therefore, these data only reflect the experience of patients after the transition to ~50% opioid-free laparoscopic appendectomies.

DISCUSSION

This project examined a family of clinical outcome measures of patients undergoing laparoscopic appendectomies during a substantial shift in our group's clinical practice—the adoption of OFA. No SCV was identified in the patients undergoing laparoscopic appendectomies after transitioning to ~50% opioid-free surgery for the following variables: 24-hour pain score and PACU IV rescue opioids. We did identify SCV in PACU time and hospital LOS following the transition to ~50% opioid-free.

The opioid-free group had reduced hospital LOS by approximately 1 day. We hypothesized that this could be explained by an increased number of patients discharged directly from PACU during the observed period. However, our data did not show a change in the number of patients designated as "day surgery" or "inpatient." Over that period, our general surgery add-on block

Fig. 4. Postsurgery hospital length of stay and subgroup analysis.

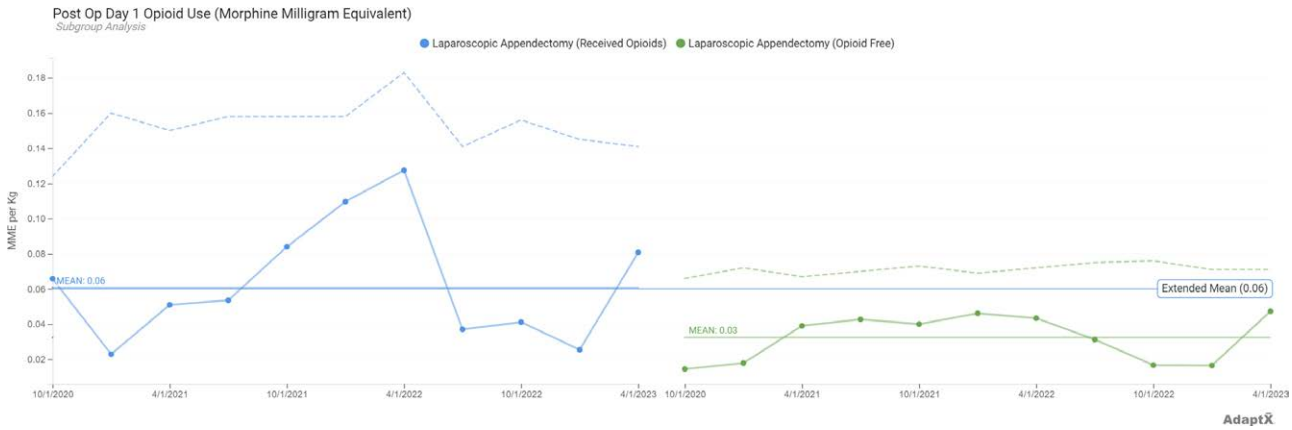

Fig. 5. Postoperative day 1 opioid use (morphine milligram equivalent)—a subgroup analysis.

shifted from the afternoon to the morning. This shift could contribute to patients undergoing their surgery earlier and being discharged home within the same day. Pain scores and rate of rescue opioids in PACU were similar in both groups, with no SCV or signals in the data. Perhaps the most interesting finding was a 2-fold reduction in opioid MME requirements on POD1 compared with the opioid-receiving group. Extending the mean of the opioid-receiving group demonstrated that all the data points in the opioid-free patients were below the extended mean, as shown in Figure 5. This finding is consistent with Olausson's meta-analysis, where they studied 1,934 patients over 26 randomized control trials and found postoperative opioid consumption was significantly lower in the opioid-free group.[11] This was an important finding to reassure our group that shifting to an opioid-free protocol was not causing our patients to have delayed pain after they were admitted to the floor.

Although PACU time increased after the transition to ~50% opioid-free laparoscopic appendectomies, this increase occurred in the opioid-receiving group as well. No SCV was demonstrated in the opioid-free group; however, the average PACU time of 76 minutes is clinically similar to the shifted mean for both the overall laparoscopic appendectomy patients (79 min) and the opioid-receiving patients (76 min). The overall increase in PACU LOS could relate to the increased use of dexmedetomidine at our institution, which may result in prolonged sedation and an increased PACU stay. Appendix Figure 5 in the appendix demonstrates the significant increase in dexmedetomidine use in laparoscopic appendectomies at SCH. This observation could be due to the cultural shift in our department to use alternative pain medications as well as the ease of access to dexmedetomidine when the pharmacy began supplying premade syringes.

A limitation of the study is our group's precision in the execution of the opioid-free protocol. The opioid-free group received no intraoperative opioids. However, it is difficult to determine how closely the protocol was followed regarding the dosing and combination of the nonopioid analgesics. Through discussions with our colleagues, we understand there is variation in dexmedetomidine dosing, which ranges from 0.5 to 1 μg/kg, with total dosing in larger teenage patients sometimes closer

to the 50- to 60-μg range. There is also inconsistent use of other analgesic medications, such as ketamine, and inconsistent choice of premedication (combinations of midazolam, dexmedetomidine, and ketamine). Because this was a QI initiative, we did not attempt to account for confounding variables, and there was no randomization of patients. In keeping with QI methodology, we make no claims to the generalizability of our clinical approach to moving towards an OFA technique for these patients.

A technical limitation was that MME was not tracked at SCH until 2020, so the data presented detailing this outcome measure is shorter than our other data. We also did not differentiate cases of perforated appendicitis, which likely impact measures such as hospital LOS and pain scores.

Moving forward, we will continue to leverage our EMR data to improve care for patients undergoing emergency appendectomies. We can further subgroup our data at the clinician level to identify individual clinicians at our institution who consistently have the best outcomes and refine our protocol through another series of plan-do-study-act cycles.

CONCLUSIONS

By leveraging real-world data collected through the EMR via SPCs, we could track the gradual adoption of OFA for laparoscopic appendectomies. By monitoring not only the adoption of OFA but also a family of clinical outcome measures, we observed decreased hospital LOS and overall unchanged opioid requirements and pain scores in patients receiving OFA.

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