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Increasing the use of multimodal analgesia during adult surgery in a tertiary academic anaesthesia department

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ABSTRACT

Objective Multimodal analgesia pathways have been shown to reduce opioid use and side effects in surgical patients. A quality improvement initiative was implemented to increase the use of multimodal analgesia in adult patients presenting for general anaesthesia at an academic tertiary care centre. The aim of this study was to increase adoption of a perioperative multimodal analgesia protocol across a broad population of surgical patients. The use of multimodal analgesia was tracked as a process metric. Our primary outcome was opioid use normalised to oral morphine equivalents (OME) intraoperatively, in the postanaesthesia care unit (PACU), and 48 hours postoperatively. Pain scores and use of antiemetics were measured as balancing metrics.

Methods We conducted a quality improvement study of a multimodal analgesia protocol implemented for adult (≥18 and≤70) non-transplant patients undergoing general anaesthesia (≥180 min). Components of multimodal analgesia were defined as (1) preoperative analgesic medication (acetaminophen, celecoxib, diclofenac, gabapentin), (2) regional anaesthesia (peripheral nerve block or catheter, epidural catheter or spinal) or (3) intraoperative analgesic medication (ketamine, ketorolac, lidocaine infusion, magnesium, acetaminophen, dexamethasone ≥8 mg, dexmedetomidine). We compared opioid use, pain scores and antiemetic use for patients 1 year before (baseline group—1 July 2018 to 30 June 2019) and 1 year after (implementation group—1 July 2019 to 30 June 2020) project implementation.

Results Use of multimodal analgesia improved from 53.9% in the baseline group to 67.5% in the implementation group (p<0.001). There was no significant difference in intraoperative OME use before and after implementation (β_0=44.0, β_2=0.52, p=0.875). OME decreased after the project implementation in the PACU (β_0=34.4, β_2=−3.88, p<0.001) and 48 hours postoperatively (β_0=184.9, β_2=−22.59, p<0.001), while pain scores during those time points were similar.

Conclusion A perioperative pragmatic multimodal analgesic intervention was associated with reduced OME use in the PACU and 48 hours postoperatively.

INTRODUCTION

This country is in the middle of an opioid epidemic and the data demonstrate that chronic opioid use can begin with a short course of opioids prescribed for acute surgical pain.[1] New persistent opioid use after surgery has been reported to range from 5.9% to 6.5%,[2] which makes judicious postoperative opioid prescribing an important measure to combat the opioid epidemic.[3] Higher inpatient opioid use is associated with higher discharge use of opioids, therefore, minimising the need for perioperative opioids is also important.[4]

Enhanced recovery after surgery (ERAS) pathways have been developed for a broad range of surgical procedures. The pathways encompass the perioperative period and care recommendations address surgical, anaesthetic, nursing, physical therapy and nutritional factors. An essential component of most ERAS pathways is the utilisation of multimodal pain management to reduce the quantity of opioids used and their associated side effects. Medications such as acetaminophen, gabapentin, ketamine, magnesium, dexamethasone, non-steroidal anti-inflammatory drugs and lidocaine have been studied as components of a multimodal analgesic approach. Many reports have demonstrated that these multimodal adjuncts can lead to less opioid use while not sacrificing patient satisfaction.[5–7]

Despite mounting evidence demonstrating the benefits of multimodal analgesia and clinical practice guidelines recommending use of multimodal analgesic regimens, studies evaluating specific processes to increase the use of multimodal analgesia during the perioperative period are more limited.[8] In a review of nearly 800 000 patients undergoing four common major surgical procedures between 2007 and 2014, the probability of receiving two or more nonopioid analgesics was only 54%, with 95% of the hospitals ranging from a predicted probability as low as 9% to a few

as high as 93%.[9] Prior efforts to incorporate multimodal analgesia in our health system have been limited to specific surgical populations, encompassing only a small percentage of the total surgical volume.

The purpose of this study was to assess the impact of a quality improvement project in a tertiary academic health system encouraging multimodal analgesia for adult patients on the incidence of intraoperative and postoperative opioid use. Our goal for the project was to increase the adoption of a pragmatic multimodal analgesia protocol among all surgical cases to increase the use of multimodal analgesia by 10% from a baseline of 53.9%.

METHODS

Context

This quality improvement project was carried out within an anaesthesia department at an academic tertiary care health system with surgical services spread among four geographically distinct hospitals. Participants included faculty anaesthesiologists, certified nurse anaesthetists and anaesthesia trainees, who worked at one or more of the four hospitals. The department had adopted ERAS protocols specific to a single or small group of similar surgical procedures. The protocols were not developed to be applied to a broad surgical population.

This manuscript adheres to the applicable Standards for Quality Improvement Reporting Excellence 2.0 guidelines.[10]

Patient and public involvement

Patients and/or the public were not involved in the design, conduct, or dissemination plans of this research.

Intervention design and implementation strategy

The goal of our intervention was to create a comprehensive protocol to increase anaesthesia provider use of perioperative multimodal analgesia in adult patients (≥18 years old and ≤70 years old) undergoing non-transplant surgery with general anaesthesia (≥180 min) in the operating rooms. Patients coming to surgery from the intensive care units (ICU) were excluded. Patients coming from the ICU and those undergoing transplant surgery were felt to have a higher likelihood of experiencing organ failure and therefore of having contraindications to the use of some of the multimodal agents. We developed a protocol that allowed providers to select from a list of multimodal analgesic options. Components of multimodal analgesia were defined as (1) preoperative analgesic medication (acetaminophen, celecoxib, diclofenac, gabapentin), (2) regional anaesthesia (peripheral nerve block or catheter, epidural catheter or spinal) or (3) intraoperative analgesic medication (ketamine, ketorolac, lidocaine infusion, magnesium, acetaminophen, dexamethasone ≥8 mg, dexmedetomidine). Patients were considered to have received multimodal analgesia if: (1) they received one preoperative medication and one intraoperative medication or regional anaesthetic or (2) they received one intraoperative medication with a regional anaesthetic or two intraoperative medications. Unlike existing ERAS protocols, this protocol did not specify which multimodal agents should be used, allowing the provider to make a selection based on clinical context (surgical needs, patient characteristics, anaesthesia provider preference). Local anaesthesia infiltration into the wound was not considered as part of this multimodal protocol.

Use of multimodal analgesics were encouraged, but there were no limitations placed on opioid usage intraoperatively, in the postanaesthesia care unit (PACU), or on the acute care floor. We also did not provide guidelines for prescribing pain medications by the surgical teams preoperatively, postoperatively or on discharge.

We used the capability, opportunity, motivation-behaviour (COM-B) model to develop a theoretical understanding of the target behaviour (use of multimodal analgesia) and to design a survey to better understand barriers and facilitators to multimodal analgesia use within our department and inform our intervention strategy. Based on the survey responses from anaesthesia providers and our application of the COM-B model, we selected education, incentivisation, persuasion and enablement as our intervention functions to address barriers in knowledge, access to multimodal analgesics and motivation to adopt multimodal analgesic strategies. Our intervention consisted of an educational curriculum, feedback reports on departmental progress and improved access to multimodal agents.

Educational curriculum

The educational curriculum was developed by a group of anaesthesia residents (the resident quality improvement project leaders) under the guidance of two faculty mentors. This group of residents completed an extensive review of the relevant literature to create each component of the educational curriculum.

The curriculum began with a departmental presentation on 1 July 2019, during which the residents emphasised the contribution of perioperative opioid use to the current opioid epidemic, provided an overview of the literature supporting the use of perioperative multimodal analgesic agents, discussed dosing guidelines and special considerations for each agent, and announced the launch of the project.

Next, the residents created a reference guide, which conveyed the project goals and criteria, defined compliance with the protocol as detailed above, listed the multimodal analgesic agent options and summarised dosing guidelines, adverse effects, contraindications and special considerations for each agent. Anaesthesia technician managers distributed physical copies of these guides to every operating room. The resident project leaders emailed electronic copies of the guide to all anaesthesia providers and our informatics team posted the guide on the departmental website.

Provider lack of familiarity with the evidence supporting the use of perioperative multimodal analgesia and general lack of information regarding multimodal agents

had been identified as major barriers to adoption of multimodal analgesia during the planning phases of the intervention. However, these knowledge barriers could not be comprehensively tackled with one presentation. Therefore, the resident project leaders decided to build on the initial departmental educational presentation and address these knowledge barriers using a longitudinal approach. For each multimodal medication, they created an infographic document, which provided detailed but digestible information about pharmacology, dosing, adverse effects and contraindications and also highlighted key evidence demonstrating the potential benefits of the multimodal agent. The residents disseminated a new multimodal agent infographic to the department via email approximately every 6–8 weeks. These infographics were also made available on the departmental website.

Feedback reports

The resident project leaders presented data on compliance with the multimodal protocol at departmental conferences on a quarterly basis and emailed departmental performance reports to all providers on a monthly basis. Our departmental informatics team queried the electronic health record to provide monthly raw data reports on the use of the multimodal agents specified in the project protocol for all patients meeting our inclusion criteria. This raw data was then analysed by the resident project leaders to determine monthly compliance with the protocol.

Improved access to multimodal medications

In July 2019, dexmedetomidine was made available in the anaesthesia medication carts located in every operating room, allowing providers quick access to this medication. Prior to July 2019, anaesthesia providers had to place an order for dexmedetomidine, wait for pharmacy to fulfil the order and arrange for an anaesthesia technician to pick up the order. Infrastructure already in place prior to the intervention included a preoperative order panel to make ordering acetaminophen, celecoxib, diclofenac and gabapentin easier; Medfusion infusion pump (Smiths Medical, Plymouth, Minnesota, USA) profiles with appropriate units and dose ranges for all intraoperative analgesic infusion medications; and ready availability of ketamine, dexamethasone, lidocaine, magnesium and ketorolac.

Measured metrics

The quality improvement project started on 1July 2019 and ended 30 June 2020. A 1-year baseline period (1 July 2019–30 June 2019) was selected to adjust for trends prior to the intervention. We tracked a process metric measuring compliance with the use of multimodal analgesia consistent with the project criteria. The primary outcome, oral morphine equivalents (OME) use intraoperatively, in the PACU and 48 hours postoperatively, was chosen to measure clinical change associated with intervention implementation. Intraoperative OMEs were normalised to case length by reporting as OME per hour. Pain scores in the PACU and up to 48 hours postoperatively were measured as a balancing metric. As a surrogate measure for postoperative nausea and vomiting (PONV), use of antiemetics (aprepitant, fosaprepitant, haloperidol (≤2 mg), ondansetron, prochlorperazine, promethazine) in the PACU and 48 hours postoperatively were abstracted.

Statistical analysis

Continuous variables were evaluated with mean and SD and compared statistically with the t test. Data distributions across groups were compared using χ^2/Fisher's exact tests for categorical variables. Visual Analogue Scale (VAS) pain scores (ordinal variables 0–10) are shown as mean and compared using t-tests. Linear segmented regression analyses were performed for intraoperative, PACU and 48 hours postoperative OME comparing baseline (July 2018–June 2019) and implementation (July 2019–June 2000) groups. For all three outcomes, first-order autocorrelation of the residuals from both of the models was estimated using the Durbin-Watson method and found to be negligible and non-significant; we, thus, report the results from the models assuming uncorrelated error terms for simplicity. A two-sided $p<0.05$ was considered statistically significant. All analyses were performed using Stata software (V.14.1; StataCorp).

RESULTS

Over the course of this initiative, 8090 patients were in the implementation group. The baseline group contained 8411 patients. The characteristics of the baseline and implementation groups were similar and not statistically significantly different in terms of age (50.4±13.9 vs 50.5±13.8 years, p=0.66), gender (45.6% vs 44.5% male, p=0.19) and American Society of Anesthesiologists Physical Status) score (p=0.182). The most common procedures were neurosurgery, orthopaedic surgery and general surgery, followed by genitourology and otolaryngology and head and neck surgery (table 1).

After implementation, there was increased use of preoperative acetaminophen (50.5%–57.4%, p<0.001) and gabapentin (33.8%–39.9%, p<0.001). Use of intraoperative multimodal agents (dexamethasone, dexmedetomidine, ketamine, ketorolac, lidocaine and magnesium) and placement of epidurals, nerve blocks and spinals were increased (table 2).

The total percentage of patients that received multimodal analgesia as defined as (1) one preoperative agent and one intraoperative agent or regional technique or (2) one intraoperative agent and one regional technique or two intraoperative agents increased from 53.9% to 67.6% (increase of 929 patients, 25% relative increase) (p<0.001). The control chart is shown in figure 1.

We found that the intraoperative OME/hour use was unchanged between baseline and implementation (44.1 mg/hour vs 44.6 mg/hour) (p=0.875), but PACU

Table 1 Characteristics of patients before and after project implementation

	Baseline		Implementation		
	N=8411	%	N=8090	%	P value
Average age (years)	50.4±13.9		50.5±13.8		0.66
Average surgical case time (min)	314.5±131.7		316.6±137.8		0.32
Gender (% male)	3833	45.6	3604	44.5	0.19
Hospital 1	5140	61.1	4853	60.0	<0.001
Hospital 2	2249	26.7	2421	29.9	
Hospital 3	875	10.4	615	7.6	
Hospital 4	147	1.7	201	2.5	
ASA PS 1	1110	13.2	1067	13.2	0.182
ASA PS 2	4632	55.1	4540	56.1	
ASA PS 3	2431	28.9	2264	28.0	
ASA PS 4	203	2.4	191	2.4	
ASA PS 5	0	0	4	0.05	
	8376		8066		
Breast	277	3.3	340	4.2	<0.001
Cardiac surgery	124	1.5	124	1.5	
Cardiology	18	0.2	9	0.1	
Dentistry	22	0.3	11	0.1	
Gastroenterology	17	0.2	25	0.3	
General surgery	1541	18.3	1356	16.8	
Genitourology	646	7.7	604	7.5	
Gynaecology	423	5.0	410	5.1	
Gynecologyoncology	270	3.2	323	4.0	
Neurosurgery	1542	18.3	1534	19.0	
Orthopaedic	1393	16.6	1461	18.1	
OHNS	884	10.5	749	9.3	
Plastic surgery	481	5.7	367	4.5	
Thoracic surgery	164	1.9	177	2.2	
Transplant	190	2.3	171	2.1	
Vascular surgery	193	2.3	196	2.4	
	8185		7857		

ASA PS, American Society of Anesthesiologists Physical Status score; OHNS, otolaryngology head and neck surgery.

OME use (34.4 mg vs 30.5 mg) (p<0.001) and post 48 hours OME use (184.9 mg vs 162.3 mg) (p<0.001) were decreased by 11.3% and 12.2%, respectively. Parameter estimates, standard errors and p values from the full and most parsimonious segmented regression models predicting mean monthly intraoperative OME/hour, PACU OME and 48 hours postoperative OME are listed in table 3.

As balancing measures, available pain scores and use of antiemetics in the PACU and postoperatively were abstracted. Pain scores were not significantly different clinically. Differences were ≤0.2 VAS scores between baseline and implementation groups (table 4). Administration of antiemetics were used as a surrogate marker for PONV and there were no statistically significant differences.

DISCUSSION

Minimising opioid use during the perioperative period is an opportunity to prevent chronic opioid use especially in opioid-naive patients.[11] Opioid minimising anaesthesia techniques have been shown to provide good patient satisfaction while lowering opioid requirements,[12–14] and simultaneously avoiding adverse effects (nausea/vomiting, sedation, ileus, respiratory depression and tolerance).

While studies have shown benefit for particular multimodal regimens used during individual surgeries, there are other studies that show lack of benefit of particular regimens for certain patient populations or surgical procedures.[15] The specific combination of drugs we evaluated here have not previously been tested together among

Table 2 Pattern of multimodal analgesia use before and after project implementation

	Baseline		Implementation		
Preoperative	**n**	**%**	**n**	**%**	**P value**
Acetaminophen	4246	50.5	4646	57.4	<0.001
Celecoxib	285	3.4	135	1.7	<0.001
Diclofenac	458	5.4	431	5.3	0.74
Gabapentin	2842	33.8	3227	39.9	<0.001
Intraoperative					
Acetaminophen	1319	15.7	1309	16.2	0.38
Dexamethasone	2936	34.9	3563	44.0	<0.001
Dexmedetomidine	257	3.1	677	8.4	<0.001
Ketamine	1833	21.8	1939	24.0	0.001
Ketorolac	786	9.3	828	10.2	0.05
Lidocaine	2463	29.3	2514	31.1	0.012
Magnesium	1346	16.0	1753	21.7	<0.001
Blocks					
Epidural	382	4.5	692	8.6	<0.001
Nerve block	251	3.0	844	10.4	<0.001
Spinal	40	0.5	127	1.6	<0.001

all patients receiving an anaesthetic, but each individual drug or anaesthetic technique has been shown to reduce opioid need in the perioperative period.[16] Currently available evidence does not suggest they would be harmful or ineffective when administered together.

We did not provide specific education to our anaesthesia providers regarding minimising opioid use in the operating room, which may have contributed to the lack of change in OME use intraoperatively. When surgeons implemented an evidence-based opioid prescribing

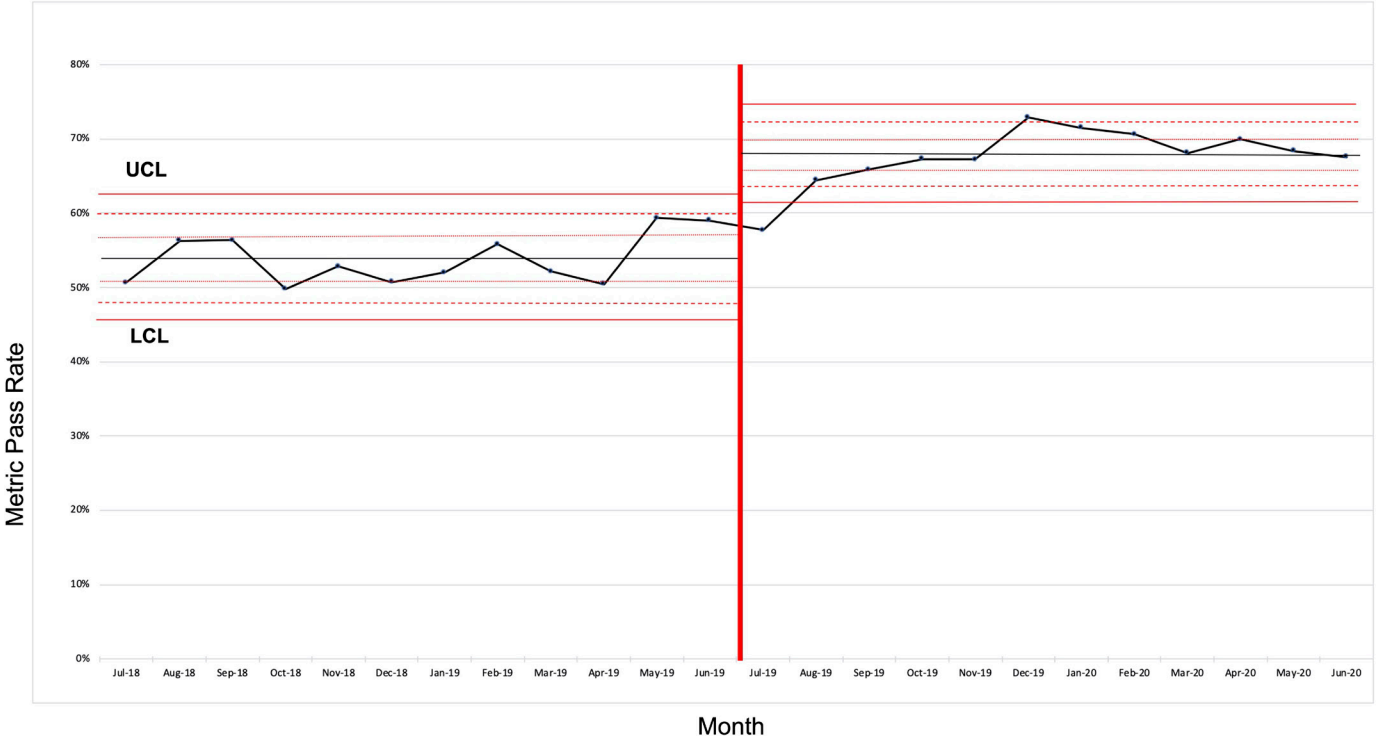

Figure 1 Control chart of the multimodal QI project metric pass rate. A control chart showing metric pass rate by month for the baseline (1 July 2018 to 30 June 2019) and implementation (1 July 2019 to 30 June 2020) groups. Solid vertical line delineates the start of the project. QI, quality improvement; UCL, upper control limit; LCL, lower control limit.

Table 3 Parameter estimates, SEs and p values from the full and most parsimonious segmented regression models predicting mean monthly intraoperative OME/hour, PACU OME and 48 hours postoperative OME

	Intraoperative OME/hour				PACU OME				48 hours postoperative OME			
	Coefficient	SE	t-statistics	P value	Coefficient	SE	t-statistics	P value	Coefficient	SE	t-statistics	P value
Parsimonious regression model												
intercept β0	44.05	2.34	18.86	<0.001	34.36	0.52	66.24	<0.001	184.93	3.34	55.39	<0.001
intervention effect β 2	0.52	3.34	0.16	0.875	−3.88	0.74	−5.24	<0.001	−22.59	4.77	−4.74	<0.001
Full segmented regression model												
Intercept β 0	44.66	4.39	10.15	<0.001	35.51	0.98	36.4	<0.001	177.92	6.28	28.34	<0.001
Baseline trend β 1	0.11	0.67	0.16	0.87	0.21	0.15	1.39	0.165	−1.27	0.96	−1.32	0.188
Intervention effect β 2	2.97	6.51	0.46	0.649	−4.84	1.45	−3.35	0.001	−19.81	9.31	−2.13	0.033
Trend after intervention β2	−0.49	0.67	−0.73	0.465	−0.03	0.15	−0.2	0.844	0.68	0.96	0.71	0.479

OME, oral morphine equivalents; PACU, postanaesthesia care unit.

guideline post–laparoscopic cholecystectomy, they were able to reduce the total amounts of opioid prescribed,[17] and the same has been shown to be feasible for intraoperative opioid use.[18 19] It could be that this educational component may have reduced intraoperative OME use, but specifics on types of cases, patient characteristics, and intraoperative nociception monitoring are in their infancy,[20] so we did not add this to the project.

For any given surgical procedure, multiple multimodal combinations are possible and appropriate, depending on the surgical site, clinical considerations and provider/patient preferences. In this quality improvement project, we demonstrated that a pragmatic multimodal analgesia protocol can be implemented among a diverse perioperative patient population, a wide range of surgical procedures and variable anaesthesia provider opinions regarding analgesia. This protocol resulted in improved use of multimodal analgesia and reduced OME in the PACU and 48 hours postoperatively without increasing patient VAS scores in the PACU and on the acute care floors up through 48 hours postoperatively.

The strength of this study is its pragmatic design and generalisability to all surgical procedures. There was no demonstrable increase in pain scores in the postoperative period through 48 hours despite the application of a generic multimodal analgesic regimen, and there was a slight statistically significant decrease in OME use. The measures implemented are easily adapted to other institutional workflows with very little expenditure and can increase the use of multimodal analgesia without increasing the number of separate distinct ERAS protocols required.

Limitations

Our study has limitations intrinsic to a large, retrospective cohort analysis. These limitations include bias from time-dependent confounding variables, including evolving opioid prescribing patterns and other institutional changes occurring during the implementation period that were not captured. There are likely also other unmeasured confounders, such as baseline differences in the pre and post patient populations, but the relative stability in the patient demographics across the time periods provides assurance for comparability of the cohorts.

Second, the decision to administer multimodal analgesia is complex and difficult to measure in a retrospective study, although we designed the quality improvement project to minimise the patients who would have contraindications to the use of multimodal analgesia. Ultimately the use of multimodal analgesia was at the discretion of the anaesthesia providers, and different providers will have different preferences of drugs to use. Currently, the literature does not show an obvious advantage of one multimodal agent versus another. Our multimodal analgesia protocol may have had more impact if anaesthesia practices had been more tightly protocolised.

Table 4 Balancing metrics: including highest and lowest pain scores in the PACU and 50 hours postoperatively, average pain scores at 6, 12, 24 and 48 hours postoperatively, and antiemetic use in PACU and for 48 hours postoperatively.

	Baseline		Implementation		
VAS pain scores	**N**	**Mean(±SD)**	**N**	**Mean(±SD)**	**P value**
Highest PACU	5135	5.6 (±3.3)	4667	5.4 (±3.3)	0.042
Lowest PACU	5135	2.6 (±2.6)	4667	2.5 (±2.5)	0.424
Last PACU	5135	3.3 (±2.5)	4667	3.3 (±2.5)	0.084
Highest, 50 hours postoperative	7819	6.9 (±2.8)	7387	6.8 (±2.8)	0.007
Lowest, 50 hours postoperative	7819	1.3 (±1.9)	7387	1.4 (±2)	0.008
Postoperative 6 hours	5183	4.3 (±2.9)	4736	4.2 (±2.9)	0.939
Postoperative 12 hours	4923	4.1 (±2.8)	4457	4.2 (±2.9)	0.136
Postoperative 24 hours	4174	4.5 (±2.8)	3878	4.4 (±2.8)	0.105
Postoperative 48 hours	3119	4.3 (±2.8)	2840	4.3 (±2.8)	0.759
Antiemetic use	**Baseline**	**N (%)**	**Implementation**	**N (%)**	
PACU	8411	1360 (16.2%)	8090	1255 (15.5%)	0.240
48 hours postoperatively	8411	3482 (41.4%)	8090	3322 (41.1%)	0.647

PACU, postanaesthesia care unit; VAS, visual analogue scale.

Third, we did not track data on patients with a history of chronic pain and therefore cannot assess the success of multimodal analgesia on different chronic pain patient populations. Also, we did not have outpatient opioid prescribing data, and postoperative opioid prescribing was at the discretion of the surgical team.

Next steps

Increased emphasis on the use of multimodal analgesia along with efforts to educate providers about multimodal analgesic agents and simplify drug availability and delivery led to a successful quality improvement project. Our general goal was to disseminate current best practice standards to deliver multimodal analgesia to more patients inclusively and sustainably. The project suggests that adopting a generic multimodal analgesia plan during anaesthesia is feasible and achievable with tools readily available in the current operating rooms without need for multiple individual ERAS pathways.

However, implementation of an intraoperative multimodal analgesia pathway does not automatically decrease intraoperative or postoperative opioid prescribing without focus on multiple other facets of care addressed by the ERAS pathways. Strategies to educate or focus anaesthesia providers on appropriately minimising opioid use are the next key steps. Studies to determine the efficacy of perioperative protocols to minimise opioid use will continue to need to encompass the entire perioperative period and involve multiple disciplines, but a generic multimodal analgesia plan is one easy step that can be adopted by anaesthesia providers.

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Contributors AVO: This author helped design and conduct the study and intervention, analysed and interpreted the data, and drafted, revised and approved the final manuscript. SS: This author helped acquire, analyse and interpret the data, and revised, reviewed and approved the final manuscript. CKB: This author helped analyse and interpret the data and reviewed, revised and approved the final manuscript. JMC: This author helped design the study and intervention, and reviewed and approved the final manuscript. GM: This author helped design and conduct the study and intervention, and reviewed and approved the final manuscript. ARL: This author helped design and conduct the study and intervention, and reviewed and approved the final manuscript. M-CL: This author helped acquire, analyse and interpret the data, and reviewed and approved the final manuscript. LLL: This author helped design and conduct the study and intervention, analysed and interpreted the data and drafted, revised and approved the final manuscript.

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REFERENCES

1 Johnson SP, Chung KC, Zhong L, *et al*. Risk of prolonged opioid use among Opioid-Naïve patients following common hand surgery procedures. *J Hand Surg Am* 2016;41:947–57.

2 Brummett CM, Waljee JF, Goesling J, *et al*. New persistent opioid use after minor and major surgical procedures in US adults. *JAMA Surg* 2017;152:e170504.
3 Kolodny A, Frieden TR. Ten steps the federal government should take now to reverse the opioid addiction epidemic. *JAMA* 2017;318:1537–8.
4 Bartels K, Mayes LM, Dingmann C, *et al*. Opioid use and storage patterns by patients after hospital discharge following surgery. *PLoS One* 2016;11:e0147972.
5 Bakan M, Umutoglu T, Topuz U, *et al*. Opioid-free total intravenous anesthesia with propofol, dexmedetomidine and lidocaine infusions for laparoscopic cholecystectomy: a prospective, randomized, double-blinded study. *Braz J Anesthesiol* 2015;65:191–9.
6 Steyaert A, Lavand'homme P. Prevention and treatment of chronic postsurgical pain: a narrative review. *Drugs* 2018;78:339–54.
7 Beverly A, Kaye AD, Ljungqvist O, *et al*. Essential elements of multimodal analgesia in enhanced recovery after surgery (ERAS) guidelines. *Anesthesiol Clin* 2017;35:e115–43.
8 Chou R, Gordon DB, de Leon-Casasola OA, *et al*. Management of postoperative pain: a clinical practice guideline from the American pain Society, the American Society of regional anesthesia and pain medicine, and the American Society of Anesthesiologists' Committee on regional anesthesia, executive Committee, and administrative Council. *J Pain* 2016;17:131–57.
9 Ladha KS, Patorno E, Huybrechts KF, *et al*. Variations in the use of perioperative multimodal analgesic therapy. *Anesthesiology* 2016;124:837–45.
10 Ogrinc G, Davies L, Goodman D, *et al*. Squire 2.0 (standards for quality improvement reporting excellence): revised publication guidelines from a detailed consensus process. *BMJ Qual Saf* 2016;25:986–92.
11 Alam A, Gomes T, Zheng H, *et al*. Long-term analgesic use after low-risk surgery: a retrospective cohort study. *Arch Intern Med* 2012;172:425–30.
12 Wu CL, King AB, Geiger TM, *et al*. American Society for enhanced recovery and perioperative quality initiative joint consensus statement on perioperative opioid minimization in Opioid-Naïve patients. *Anesth Analg* 2019;129:567–77.
13 McLaughlin DC, Cheah JW, Aleshi P, *et al*. Multimodal analgesia decreases opioid consumption after shoulder arthroplasty: a prospective cohort study. *J Shoulder Elbow Surg* 2018;27:686–91.
14 Yung EM, Brull R, Albrecht E, *et al*. Evidence basis for regional anesthesia in ambulatory anterior cruciate ligament reconstruction: Part III: local instillation analgesia-A systematic review and meta-analysis. *Anesth Analg* 2019;128:426–37.
15 Maheshwari K, Avitsian R, Sessler DI, *et al*. Multimodal analgesic regimen for spine surgery: a randomized placebo-controlled trial. *Anesthesiology* 2020;132:992–1002.
16 Kumar K, Kirksey MA, Duong S, *et al*. A review of Opioid-Sparing modalities in perioperative pain management. *Anesth Analg* 2017;125:1749–60.
17 Howard R, Waljee J, Brummett C, *et al*. Reduction in opioid prescribing through evidence-based prescribing guidelines. *JAMA Surg* 2018;153:285–7.
18 Soffin EM, Wu CL. Regional and multimodal analgesia to reduce opioid use after total joint arthroplasty: a narrative review. *Hss J* 2019;15:57–65.
19 Brandal D, Keller MS, Lee C, *et al*. Impact of enhanced recovery after surgery and Opioid-Free anesthesia on opioid prescriptions at discharge from the hospital: a Historical-Prospective study. *Anesth Analg* 2017;125:1784–92.
20 Lavand'homme P, Estebe J-P. Opioid-free anesthesia. *Curr Opin Anaesthesiol* 2018;31:556–61.