Pain Physician 2021; 24:577-586 • ISSN 1533-3159

Retrospective Study

Patterns of Use of Opioid Sparing Adjuncts for Perioperative Pain Management of Patients on Chronic Opioids

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Disclaimer: There was no external funding in the preparation of this manuscript.

Conflict of interest: Each author certifies that he or she, or a member of his or her immediate family, has no commercial association (i.e., consultancies, stock ownership, equity interest, patent/licensing arrangements, etc.) that might pose a conflict of interest in connection with the submitted manuscript.

Manuscript received: 02-25-2021
Revised manuscript received: 04-19-2021
Accepted for publication: 05-18-2021

Free full manuscript: www.painphysicianjournal.com

Background: Perioperative pain management of patients on chronic opioids is challenging. Although experts recommend regional anesthesia and multimodal analgesics for their opioid sparing effects, their use and predictors of use are unknown.

Objectives: To examine the patterns and predictors of use of regional anesthesia and multimodal analgesics for perioperative pain control of patients on chronic opioids. A secondary objective was to examine the association of patient and surgical factors with 24-hour postoperative opioid use.

Study Design: Retrospective cross sectional.

Setting: Single center tertiary care academic hospital.

Methods: We studied patients with chronic opioid use undergoing painful operations such as abdominal, gynecologic, breast, orthopedic, spine, amputation, and laparoscopic surgeries. Chronic opioid use was identified using the narcotic score – a score generated from the state prescription drug monitoring database via the NarxCare platform. A narcotic score ≥ 320 corresponding to a preoperative home dose of approximately 40 milligram morphine equivalents (MMEs) daily, was chosen as a cutoff since the risk of overdose death increases above 40 MMEs. We reported the use of regional anesthesia and ≥ 3 multimodal analgesics in this cohort (nN = 155) and examined the association of this use with patient and surgical factors such as preoperative narcotic score, age, race, comorbidity index, operative timetime, and intraoperative opioid use. In addition, we examined the association of patient and surgical factors with 24-hour postoperative opioid use.

Results: Out of 2470 patients undergoing painful surgeries between July 2017and- December 2018, 155 patients had a narcotic score ≥ 320. The median narcotic score was 411 (interquartile range (IQR) 351-520), the median preoperative home MME dose was 67.5 (IQR 32-180) mg daily. Regional anesthesia was used in only 9.7% of cases and was associated with intraoperative opioid used, but not the preoperative narcotic score. Patients receiving 1 SD more MMEs intraoperatively had a higher odds of receiving regional anesthesia (OR = 1.57, 95% CI [1.06, 2.32]). Three or more multimodals were used in 83% of cases. Every 10-point increase in narcotic score and every additional hour of operative time was associated with higher odds of receiving ≥ 3 multimodals (OR = 1.05, 95% CI [1.00, 1.11] and OR = 1.49, 95% CI [1.11, 1.99] respectively). Total 24 hour post-operative opioid dose was associated with narcotic score, with an 8.6 higher mean MME for every 10-point increase in narcotic score (mean difference = 8.6, 95% CI [4.1, 13.1]). It was also moderately associated with age, where patients an year older received 4.7 MMEs less (mean difference = - 4.7, 95% CI [-9.3, -0.5]).

Limitations: This was a single center retrospective observational study. We could not adjust for inter-physician or inter-surgery effect on use of regional anesthesia or multimodal analgesics. Since this was one of the first studies to use narcotic scores to identify patients on chronic opioids, comparing the outcomes of interest to a control group was beyond the scope of the current study. Narcotic scores need to be validated to identify chronic opioid use.

Conclusions: Despite consensus guidelines, regional anesthesia remains underutilized. Multimodals

are used frequently and are modestly associated with preoperative narcotic scores.

Key words: Chronic opioid use, preoperative opioid use, postoperative pain, regional anesthesia, multimodal analgesics, opioid sparing adjuncts, narcotic scores, NARX score

IRB approval: Institutional Review Board (IRB) approval was obtained per the University's institutional guidelines.

Pain Physician 2021: 24:577-586

The extensive use of opioids for chronic non-cancer pain, despite questionable long-term efficacy (1,2) has contributed to the widespread misuse of opioids and an exponential increase in overdose deaths (3). As many as 8.8% of patients presenting for elective surgery are on chronic opioids (4). Studies show that preoperative opioid dependence/abuse is independently associated with increased perioperative morbidity and mortality. This includes complications such as surgical site infections, respiratory failure, mechanical ventilation, pneumonia, myocardial infarction, prolonged hospitalization and nonroutine discharge (5). In addition, it is also difficult to manage perioperative pain in this at-risk population (6). Anesthesiologists can optimize perioperative pain management in these patients by maximizing opioid sparing techniques to reduce the risk of opioid related adverse effects.

Surgery is also the first opioid exposure for some patients, giving anesthesiologists a unique opportunity to intervene and possibly prevent future dependence. There is now a strong national impetus for reducing perioperative opioid use and using alternative analgesics for pain control. The American Society of Anesthesiologists (ASA) has endorsed the Perioperative Reduction of Opioids (PRO) Act, introduced by US Department of Health and Human Services Technical Expert Panel (TEP) dedicated to reducing opioid use in the surgical setting and collecting data on perioperative opioid use (7).

Expert guidelines recommend using regional anesthesia and multimodal analgesics to reduce the need for perioperative opioids and improve outcomes (8-11). A small retrospective study to assess compliance with expert recommendations showed that although anesthesiologists correctly identified 94% of opioid-tolerant patients, only half the patients received multimodal analgesics for perioperative pain control (12). Similarly, studies in orthopedic surgeries have identified that regional anesthesia is used in a minority of patients (13).

Despite consensus guidelines for the use of opioid sparing adjuncts, real world patterns and predictors of use are largely unknown. Epidemiological research focused on patients with chronic opioid use remains sparse and lags behind that of the general surgical population. More research is needed to study practice patterns and factors that may affect the utilization of opioid sparing adjuncts in patients on chronic opioids to help identify lacunae in surgical care, to institute changes aimed at improving perioperative outcomes.

Objectives

We sought to examine the patterns of use of regional anesthesia and ≥ 3 multimodal analgesics for perioperative pain control of patients on chronic opioids undergoing relatively painful surgeries at a large tertiary academic center. Chronic opioid use was identified using the narcotic score – a score generated from the state prescription drug monitoring database via the NarxCare platform. In addition, we sought to explore which patient and surgical factors were associated with the use of regional anesthesia, ≥ 3 multimodal analgesics and total 24-hour postoperative opioid use.

Methods

Institutional Review Board (IRB) approval was obtained per institutional guidelines. In addition, Joint Data Analytics Team (JDAT) approval was obtained to ensure that none of the patients in the selected cohort had opted out of research. JDAT, comprised of more than 60 informaticists and analysts, centralizes and coordinates all data analytics and supports Helix, our institution's customized data warehouse system. Informed consent was waived per the University's IRB guidelines. This manuscript adheres to the applicable Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement.

Data Source

Between July 2017 to December 2018, the hospital database (Epic Inc.) was queried for:

1. All adult patients between the ages of 18-65 undergoing relatively painful surgeries (open abdominal, gynecologic, breast, orthopedic, spine, amputation, and laparoscopic), identified using Common Procedure Terminology [CPT] codes, with procedure duration > 30 minutes, and hospital stay > 23 hours (See Appendix 1, Supplemental Digital Content 1). The above surgeries were selected based on reported intensity of postoperative pain from prior literature (14). We excluded emergency/trauma/obstetric/cardiothoracic surgeries and patients who had opted out of research per JDAT review.
2. The list was then shortened to patients who had a "NARX score" available in the medical chart. NARXcare (Appriss Health; Louisville, KY) is a platform that uses the state prescription drug monitoring program (PDMP) database to track controlled substance use by patients. Most state governments have now instituted PDMPs that compile data on prescribed controlled substances in an effort to curb the opioid epidemic (15). The NARXcare software quantifies risk with a 3-digit score, termed a "NARX Score," that ranges from 000-999. NARX Scores are computed for 3 different drug types: narcotics, sedatives, and stimulants. In summary, NARX score is a weighted combination of multiple variables (drug equivalents, number of providers, potentiating drugs, number of pharmacies, and number of overlapping prescription days). Half of the weighting is allocated to morphine milligram equivalents (MME) and the rest together, classified as risky behaviors, equal the other half. The score is intended to create a composite risk index, which increases as the value of one or more of the risk factors in a PDMP report increases. The distribution of the scores are such that in any given population, about 75% of scores will fall below 200, 5% will be above 500, and only 1% will be above 650 (16). NARX Score has been studied to predict the risk of unintentional overdose deaths, providing a continuum of risk with increasing odds ratios as the score increases (16). Huizenga et al in their study used red flag cutoffs for the individual risk factors studied in prior literature; the most notable of which was the study by Paulozzi et al (17) that recognized a dose above 40 MME/day average as a risk factor for unintentional overdose deaths [OR of 12.2 (CI 9.2-16.0)] .
3. We reduced our list to patients who had a narcotic score > 200 in order to select the surgical sub-population that may be using chronic opioids. All identified charts were stratified into groups in increments of narcotic scores of 100, similar to what has been done in a previous study (16). For example, all patients with a narcotic score between 200-300 were placed in one group, patients with narcotic score between 300-400 were placed in a subsequent group and so on. The highest group was for patients with narcotic scores > 600. A data biopsy of a randomly selected 10% of the charts in each of the groups was then performed to determine their corresponding preoperative MME dose (See Flowchart, Supplemental Digital Content 2).
4. From the data biopsy, it was observed that a narcotic score ≥ 320 roughly corresponded to MME of 40 mg/day in most patients. We used a cutoff value of 40 MME or narcotic score ≥ 320 to select our final cohort, since the risk of overdose death increases above 40 MMEs, as shown in prior literature utilizing state PDMP data (17). Since neither NARX scores nor the component narcotic scores are independently validated tools to identify chronic opioid use, individual chart review was completed for all the selected patients to verify their exact preoperative MME dose.

Variables Collected

- Patient demographics including age, race, gender, body mass index (BMI), ASA status, and preoperative MME dose.
- Comorbidities from preselected International Classification of Diseases (ICD) codes (See Appendix 2, Supplemental Digital Content 3). The Charlson comorbidity index (CCI) was calculated using the available formula (18). In addition, ICD codes for chronic opioid use were recorded when available (ICD-9 CM codes: 304.0x [Opioid dependence, uncomplicated], 305.5x [Opioid abuse, uncomplicated], 304.7x [Other psychoactive substance dependence, uncomplicated]). The corresponding ICD-10 CM codes for the same diagnoses were also recorded (F11.20 [Opioid dependence, uncomplicated], F19.20 [Other psychoactive substance dependence, uncomplicated], F11.10 [Opioid abuse, uncomplicated]). Lab values (including platelet count, coagulation panel, and creatinine level) that might serve as contraindication for regional anesthesia were also collected, when available.
- Primary anesthetic (general, neuraxial, monitored

anesthesia care), type of surgery (open abdominal, gynecologic, breast, orthopedic, spine, amputation and laparoscopic), duration of surgery, duration of anesthesia, estimated blood loss (when available), transfusions, total intraoperative opioid used (in oral MME), use of any form of regional anesthesia including neuraxial anesthesia, single shot or continuous peripheral nerve blocks, and intraoperative use of multimodal analgesics (acetaminophen, aspirin, celecoxib, clonidine, diclofenac, dexmedetomidine, gabapentin, ibuprofen, ketamine, ketorolac, indomethacin, magnesium sulfate, and pregabalin) were recorded. We excluded lidocaine since almost all patients received lidocaine at induction and none of the patients received it as an infusion for analgesia. In addition, total postoperative opioid dose in the first 24 hours was recorded.

Aims

- The primary aim was to determine percentage utilization of regional anesthesia and ≥ 3 multimodal analgesics for perioperative pain control and explore the association of this utilization with various patient and surgical factors.
- The secondary aim was to explore the association of patient and surgical factors with total 24-hour postoperative opioid dose.
- Patient factors studied were narcotic score, preoperative home MME dose, age, gender, BMI, race, comorbidities measured by CCI, and labs (when available). Surgical factors studied were type of surgery and length of operation. We used length of operation as a predictor since although not known at the time of preoperative planning, an expected length of operation is known from the surgeon's booking sheet and may influence the decision to use opioid sparing adjuncts in order to limit opioid doses.

Statistical Methods

Descriptive statistics were calculated to characterize demographics for all extracted clinical variables. We summarized the characteristics using means and standard deviations (SD) for quantitative variables and frequencies with percentages, for categorical variables.

We examined the outcomes: use of regional anesthesia, use of ≥ 3 multimodal analgesics, and total 24-hour post-operative opioids used (in MME). Logistic regression was used to investigate the associations between the outcomes for the use of regional anesthesia and use of 3 or more multimodals. A linear regression model was used for the total 24-hour post-op opioids used outcome. We included the following preoperative and intraoperative variables in the logistic regression models: narcotic score, operative time (in hours), age (in years), white race (y/n), Charleston Comorbidity Index (CCI), and intraoperative opioid dose (MME). All regression models used Huber-White standard error (SE) estimates. These estimates and the corresponding statistical tests tend to be robust to minor violations of standard modeling assumptions (e.g., variance misspecification). We investigated the impact of missing data by performing sensitivity analyses using multiple imputation. All hypothesis tests, *P* values, and confidence intervals are 2-sided. The *P* values are not adjusted for multiple comparisons. All analyses were conducted using the Stata statistical package (StataCorp. 2019. Release 16. College Station, TX).

Sample Size Considerations

The recruitment goal of approximately 155 patients was based on the following considerations: (1) To obtain a sample size with sufficient number of patients that were administered regional anesthesia; (2) To obtain a heterogeneous sample of patients with regard to type of surgery and the type of multimodals used; (3) To have diverse representation regarding patients' ages and race.

Results

Our final cohort consisted of 155 patients. The flowchart (Supplemental Digital Content 2) describes the procedure for arriving at this cohort. Table 1 lists demographic variables for the patient population. Caucasians constituted 78.1% of all patients, and African Americans comprised 18.7%. Most of our patients had severe systemic disease, with 74.6% patients given an ASA score of IV and a mean CCI score of 5.7 (SD 3.9). There was only one patient in the cohort who had a formal ICD code diagnosis reflecting chronic opioid use. This underscores the possibility of missing a significant number of patients on chronic opioids if ICD codes alone were used for cohort selection. The mean narcotic score was 441 (SD 97), with a median of 411 (IQR 351-520). The mean preop home MME dose was 134 mg/day (SD 166) with a median of 67.5 mg/day (IQR 32-180).

Open abdominal surgeries (27.1%) and amputations (18.7%) constituted 45.8% of cases (Fig. 1). Laparoscopic surgeries including diagnostic laparoscopy,

Table 1. *Descriptive statistics with patient demographics, preoperative, intraoperative, postoperative variables, and surgical /anesthetic factors.*

n = 155		
Preoperative Characteristics		
Demographics	Age (years)	51‡
	Gender (female)	56.1%
	BMI	30.4 (8.0) ‡
	CCI	5.7 (3.9) ‡
Race (n = 155)	Caucasian	121 (78.1%)
	Black/African American	29 (18.7%)
	Other/Not listed	5 (3.2%)
ASA score (n = 118)	I	1 (0.8%)
	II	9 (7.6%)
	III	20 (16.9%)
	IV	88 (74.6%)
Labs (preop)	PTT (n = 63)	29.4 (16.6) ‡
	Platelets (n = 130)	287.1 (122.1) ‡
	Creatinine (n = 130)	1.4 (1.9) ‡
Intraoperative Characteristics		
Anesthesia (n = 155)	General	146 (94.2%)
	MAC	7 (4.5%)
	Regional	1 (0.6%)
	Spinal	1 (0.6%)
	Operation time (hrs)	2.6 (1.9) ‡
	Estimated blood loss (mL)	240.9 (298.9) ‡
	Blood transfusion	44 (28.4%)
Pain Management		
Preoperative	Preop Narcotic Score	440.9 (97.0) ‡, 411 (351-520)*
	Preop MME (mg)	134.2 (166.3) ‡, 67.5 (32 - 180)*
Intraoperative	Intraop MME (mg)	105.4 (98.3) ‡, 87.5 (60 - 115)*
	Multimodals (number)	3.8 (1.5) ‡
	Regional Anesthesia	15 (9.7%)
Postoperative	Total Postop MME (mg)	245.9 (236.7) ‡, 162 (88.5 - 308.4)*
Hospitalization		
	Length of stay (hours)	129 (74.5 - 289) *
	Readmission within 30 days	55.5%

Abbreviations: BMI, Body Mass Index; CC, Charlson Comorbidity Index; ASA, American Society of Anesthesiology; PTT, Partial Thromboplastin Time; MME, Milligram Morphine Equivalents; MAC, Monitored Anesthesia Care
‡ = Reported as mean (standard deviation)
* = Reported as median (interquartile range)

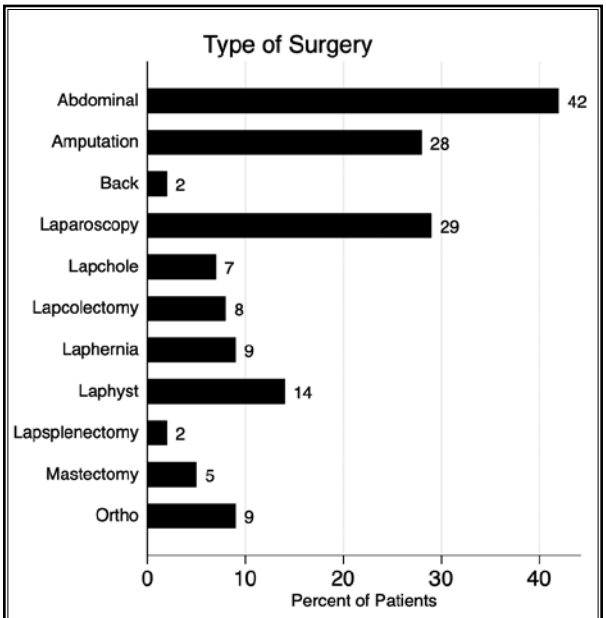

Fig. 1. *Surgery location.*
Lapchole: Laparoscopic cholecystectomy; Lapcolectomy: Laparoscopic colectomy; Laphernia: Laparoscopic hernia repair; Laphyst: Laparoscopic hysterectomy; Lapsplenectomy: Laparoscopic splenectomy.

laparoscopic cholecystectomy, laparoscopic colectomy, laparoscopic hernia repair, laparoscopic hysterectomy and laparoscopic splenectomy constituted another 44.4% of surgeries. General anesthesia was utilized in 94.2% of cases.

Regional anesthesia including neuraxial anesthesia and peripheral nerve blocks were used in 9.7% of cases (15/155). Multimodal analgesics, specifically ≥ 3 multimodals were used in 83.2% (129/155) of cases, with acetaminophen being used in almost all cases (97%). Gabapentin, ketorolac, and ketamine were used in 50%, 45% and 33% of cases respectively (Fig. 2). Gabapentin was used most frequently in amputation and open abdominal surgeries. Ketorolac was used more often in open abdominal surgeries, and ketamine was used more commonly in laparoscopic surgeries (Fig. 3).

Table 2 displays the results of the regression analyses of the 3 outcomes. The use of regional anesthesia was associated with intraoperative opioid dose, where patients who received one SD more MME's had 1.57 higher odds of receiving regional anesthesia (OR = 1.57, 95% CI = [1.06, 2.32], P = 0.026). Use of ≥ 3 multimodals was associated with longer operative times and modestly associated with narcotic scores. An hour longer operative time was associated with an

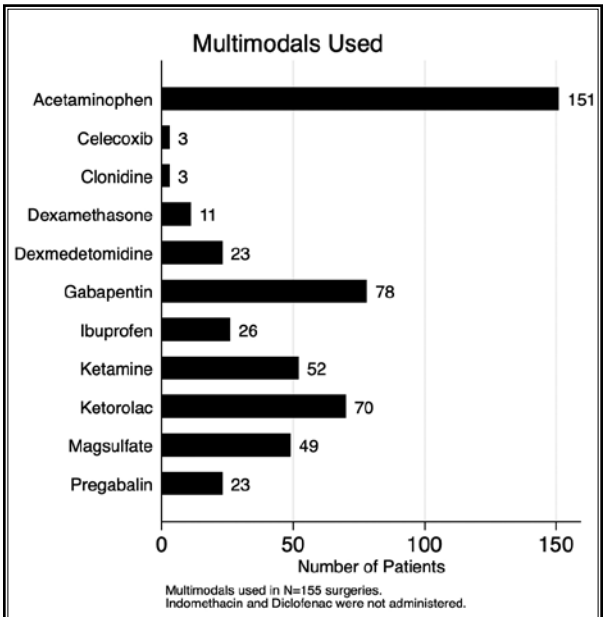

Fig. 2. *Rates of use of individual multimodals.* n = 155

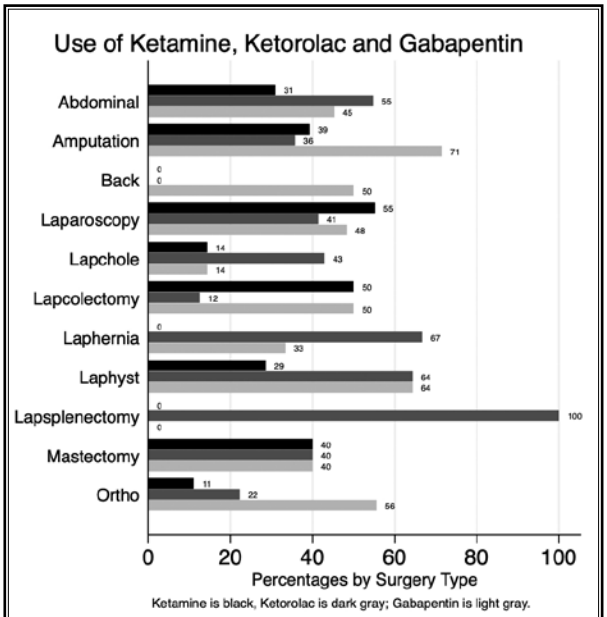

Fig. 3. *Top 3 Multimodals (except Acetaminophen) by surgery type.*

Table 2. *Set of predictors and outcomes in regression model.*

Predictors →	**n**	**Operation time (hrs)**	**Narcotic Score**	**Age (yrs)**	**White race**	**CCI**	**Intraop MME**
Outcomes ↓							
Regional Anesthesia	152	1.22 (95% CI 0.97, 1.53)	0.996 (95% CI 0.990, 1.001)	0.99 (95% CI 0.95, 1.04)	5.40 (95% CI 0.51, 57.7)	0.93 (95% CI 0.79, 1.09)	1.57* (95% CI 1.06, 2.32)
≥ 3 Multimodals	152	1.49** (95% CI 1.11, 1.99)	1.005 (95% CI 1.00, 1.11)	0.96 (95% CI 0.90, 1.01)	1.35 (95% CI 0.46, 3.97)	0.94 (95% CI 0.83, 1.08)	1.41 (95% CI 0.96, 2.06)
Total 24 hour post-op MME	154	11.4 (95% CI -5.15, 28.0)	8.6*** (95% CI 4.1, 13.1)	-4.7** (95% CI -9.34, -0.51)	29.5 (95% CI -49.4, 108.4)	-5.31 (95% CI -183.7, 353.6)	

*$P < 0.05$, **$P < 0.01$, ***$P < 0.001$

Abbreviations: CCI, Charlson Comorbidity Index; MME, Morphine Milligram Equivalents; CI, Confidence Intervals.

The estimates and confidence intervals for regional anesthesia and ≥ 3 multimodals used are presented as odds ratios (OR). The estimates presented for opioids used are presented as mean differences.

almost 50% higher odds of receiving ≥ 3 multimodals (OR = 1.49, 95% CI = [1.11, 1.99], $P = 0.008$). Patients with 10-point higher narcotic scores had a 5% higher odds of receiving ≥ 3 multimodals (OR = 1.05, 95% CI = [1.00, 1.11], $P = 0.066$). Total 24-hour post-operative opioid use was associated with narcotic score, with an 8.6 higher mean MME for every 10-point increase in narcotic score (mean difference = 8.6, 95% CI = [4.1, 13.1], $P < 0.001$). Total post-operative opioid use was also modestly associated with patient age, where patients a year older were administered approximately 4.7 MME's less (mean difference = -4.7, 95% CI = [-9.3, -0.5], $P = 0.048$).

Discussion

This was a retrospective study conducted at a large tertiary care academic center, evaluating perioperative utilization of regional anesthesia and ≥ 3 multimodal analgesics in patients on chronic opioids undergoing relatively painful surgeries. Our cohort, consisting mostly of patients taking > 40 MME daily, had significant comorbidities, with 74% of patients given an ASA score of IV and a mean CCI of 5.7. With these considerations in view, one would expect robust utilization of opioid sparing adjuncts. This was true for use of multimodal analgesics, but not for regional anesthesia.

The most commonly used multimodal analgesics were acetaminophen (97%), gabapentin (50%), ketorolac (43%) and ketamine (33%). This is similar to a prior study on opioid tolerant patients where acetaminophen, non-steroidal anti-inflammatory drugs (NSAIDs) and pregabalin were administered in 51% of the patients, and 43% of patients had ketamine used intraoperatively (12). Use of ≥ 3 multimodals was modestly associated with preoperative narcotic score, but more so with the operative time. This could reflect anesthesiologists' recognition of higher analgesic needs for this patient population, especially as the length of operation increases. Our findings are in line with expert guidance for utilizing opioid sparing medications in opioid tolerant patients (10,11). NSAIDs are shown to be as efficacious as opioids in the perioperative period without an increased risk of bleeding (11,19,20). NSAIDs are also shown to be efficacious in reducing post-operative opioid requirements with rest and movement related pain (21-24). Perioperative ketamine infusions reduce the average pain scores (25) and opioid consumption in the immediate postoperative period (26). For some surgeries, the effects of ketamine appear to last for several weeks postoperatively (9,26). More recent evidence has called the widespread use of gabapentinoids into question. A recent metanalysis of 281 randomized controlled trials comparing gabapentinoids with controls found an insignificant reduction in 24-hour opioid consumption. No clinically meaningful difference in acute, subacute, or chronic pain was noted, while adverse effects were significant (27). A prior study on the use of perioperative multimodal analgesia in patients undergoing amputations, knee replacements, colectomies, or lobectomies found tremendous variation, which was not accounted for by patient or hospital characteristics, rather by hospital policies and culture (28). To our knowledge, our study is one of the first to evaluate the association of patient and surgical factors with the use of regional anesthesia and multimodal analgesics in patients on chronic opioids.

Regional anesthesia has similarly been shown to reduce opioid consumption in multiple studies, especially in orthopedic procedures (29,30). Widespread use of epidurals in ERAS pathways for open abdominal surgeries has shown enhanced early recovery and decreased opioid-related adverse effects (31,32). A variety of fascial plane blocks, including transversus abdominal plane (TAP), rectus sheath, and quadratus lumborum blocks are being used for abdominal surgeries with a paradigm shift towards promoting an opioid free anesthetic (33-36). With evidence supporting its use, the specific reasons for the apparent under-utilization of regional anesthesia are not clear.

The utilization of regional anesthesia was associated with intraoperative opioid use, but not the preoperative narcotic score. It is possible that providers anticipated higher intraoperative opioid needs in some patients, with resultant utilization of regional anesthesia. Alternatively, it is possible that high doses of opioids used intraoperatively may have led to the decision to perform a regional anesthetic postoperatively. Nevertheless, the association of regional anesthesia use with intraoperative opioid dose is difficult to explain due to the small number of patients who received a regional anesthetic. There were possibly relative contraindications to regional anesthesia that our dataset failed to capture, especially given missing lab values. Moreover, not all surgical procedures are amenable to regional anesthesia, and factors such as surgeon or patient refusal may not have been captured. Missing information remains a major limitation of observational studies, and the results should be interpreted in the context of this inherent limitation. Barring missing information, it is possible that an institutional bias may be one of the reasons for under-utilization of regional anesthesia. Factors that warrant further exploration are knowledge, attitudes and beliefs regarding use of regional anesthesia for both surgeons and anesthesiologists at the institutional level, to determine if provider preference and operating room flow play a role in this decision making.

Limitations

Our study has several strengths and limitations. Our study is one of the first to leverage the NARXcare platform to identify patients with chronic opioid use. Platforms such as NARXcare are now being used more frequently to predict outcomes such as readmissions, reoperations, patient satisfaction and length of stay (37,38). Although ICD codes have been used in previous studies to identify patients with opioid abuse/dependence (39-42), they may grossly underestimate the actual number of patients on chronic opioids. Only 1/155 patients in our cohort carried a formal ICD diagnosis, which reaffirms this fact. Possible explanations for such under-coding could be that opioid use disorder among patients on prescription opioids (especially older individuals) may be difficult to identify (43) and primary care physicians may be uncomfortable making the diagnosis (44).

A major limitation of individual platforms such as NARXcare is that it may not be available in all states and centers, and is not an independently validated tool, which limits the reproducibility of our study. Nevertheless, there is increasing acceptance of PDMPs across the country, given its effect on regulation of opioid prescribing and a resultant reduction in opioid related overdose deaths (45-47). Narcotic scores may therefore be useful to alert clinicians of a patient's opioid exposure, that is known to contribute to worse perioperative outcomes. Another limitation of our study is that we used a cutoff of 320 for Narcotic score that correlated with home MME of approximately 40 mg daily, while the FDA defines opioid tolerance as use of > 60 MME daily for more than one week. A home MME dose > 40 mg daily has been associated with increased risk of unintentional opioid overdose in previous studies that utilized NARX scores, which led us to use a smaller dose for cutoff, while maximizing our cohort size. We were able to reliably shortlist a significant number of patients on chronic opioids who would have otherwise been missed had we used a higher cutoff or relied solely on ICD codes for opioid use/dependence. Since this was one of the first studies to utilize narcotic scores to identify patients using chronic opioids, comparing the outcomes of interest with a control group was beyond the scope of this study. However, future work aimed at this comparison is underway.

While our analyses were pre-planned, they were exploratory in nature. We evaluated several outcomes of opioid utilization to determine which, if any, patient characteristics and intraoperative variables were associated with these outcomes. The correlates identified should each be specifically and thoroughly investigated in independent investigations. We could not adjust for inter-physician or inter-surgery effect on utilization of regional anesthesia and multimodal analgesics. The retrospective nature of the data and limited number of clinical variables collected can result in significant confounding. Coding bias and completeness of the data collected could also be additional concerns. Since it is impossible to account for unobserved confounders in observational studies, the findings can only be informative to suggest associations rather than causality.

Conclusions

In this single center study of patients on chronic opioids undergoing relatively painful surgeries, regional anesthesia was used in < 10% of cases. Multimodal analgesics were used frequently and were modestly associated with preoperative narcotic scores. Larger multicenter studies specifically focused on patients with chronic opioid use are needed to examine national trends and barriers, if any, to utilization of opioid sparing adjuncts in the perioperative period.

Acknowledgments

We would like to acknowledge the assistance of JDAT team members for data acquisition from Epic: Krishna Daggula MS and Richard Hintz, Yale School of Medicine, New Haven, CT, USA

Supplemental material available at www.painphysicianjournal.com

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Supplemental Digital Content 1. ***Appendix 1, lists CPT codes used to select elective abdominal, laparoscopic, gynecologic, breast, orthopedic, amputation and spine surgeries.***

CPT Code	**CPT description**	**CPT Code**	**CPT description**
AMP		COLO	
27590	Amputation, thigh, through femur, any level;	44140	Colectomy, partial; with anastomosis
27592	Amputation, thigh, through femur, any level; open, circular (guillotine)	44141	Colectomy, partial; with skin level cecostomy or colostomy
27880	Amputation, leg, through tibia and fibula;	44143	Colectomy, partial; with end colostomy and closure of distal segment (Hartmann type procedure)
27889	Ankle disarticulation	44144	Colectomy, partial; with resection, with colostomy or ileostomy and creation of mucofistula
28805	Amputation, foot; transmetatarsal	44145	Colectomy, partial; with coloproctostomy (low pelvic anastomosis)
BILI		44146	Colectomy, partial; with coloproctostomy (low pelvic anastomosis), with colostomy
47120	Hepatectomy, resection of liver; partial lobectomy	44147	Colectomy, partial; abdominal and transanal approach
48140	Pancreatectomy, distal subtotal, with or without splenectomy; without pancreaticojejunostomy	44150	Colectomy, total, abdominal, without proctectomy; with ileostomy or ileoproctostomy
48153	Pancreatectomy, proximal subtotal with near-total duodenectomy, choledochoenterostomy and duodenojejunostomy (pylorus-sparing, Whipple-type procedure); with pancreatojejunostomy	44151	Colectomy, total, abdominal, without proctectomy; with continent ileostomy
47562	Laparoscopy, surgical; cholecystectomy	44155	Colectomy, total, abdominal, with proctectomy; with ileostomy
47600	Cholecystectomy;	44156	Colectomy, total, abdominal, with proctectomy; with continent ileostomy
FUSN		44157	Colectomy, total, abdominal, with proctectomy; with ileoanal anastomosis, includes loop ileostomy, and rectal mucosectomy, when performed
22800	Arthrodesis, posterior, for spinal deformity, with or without cast; up to 6 vertebral segments	44158	Colectomy, total, abdominal, with proctectomy; with ileoanal anastomosis, creation of ileal reservoir (S or J), includes loop ileostomy, and rectal mucosectomy, when performed
FX		44160	Colectomy, partial, with removal of terminal ileum with ileocolostomy
25515	Open treatment of radial shaft fracture, includes internal fixation, when performed	44211	Laparoscopy, surgical; colectomy, total, abdominal, with proctectomy, with ileoanal anastomosis, creation of ileal reservoir (S or J), with loop ileostomy, includes rectal mucosectomy, when performed
27244	Treatment of intertrochanteric, peritrochanteric, or subtrochanteric femoral fracture; with plate/screw type implant, with or without cerclage	44212	Laparoscopy, surgical; colectomy, total, abdominal, with proctectomy, with ileostomy
27248	Open treatment of greater trochanteric fracture, includes internal fixation, when performed	44213	Laparoscopy, surgical, mobilization (take-down) of splenic flexure performed in conjunction with partial colectomy (List separately in addition to primary procedure)
27269	Open treatment of femoral fracture, proximal end, head, includes internal fixation, when performed	44227	Laparoscopy, surgical, closure of enterostomy, large or small intestine, with resection and anastomosis
27758	Open treatment of tibial shaft fracture (with or without fibular fracture), with plate/screws, with or without cerclage	44320	Colostomy or skin level cecostomy;
27236	Open treatment of femoral fracture, proximal end, neck, internal fixation or prosthetic replacement	44625	Closure of enterostomy, large or small intestine; with resection and anastomosis other than colorectal

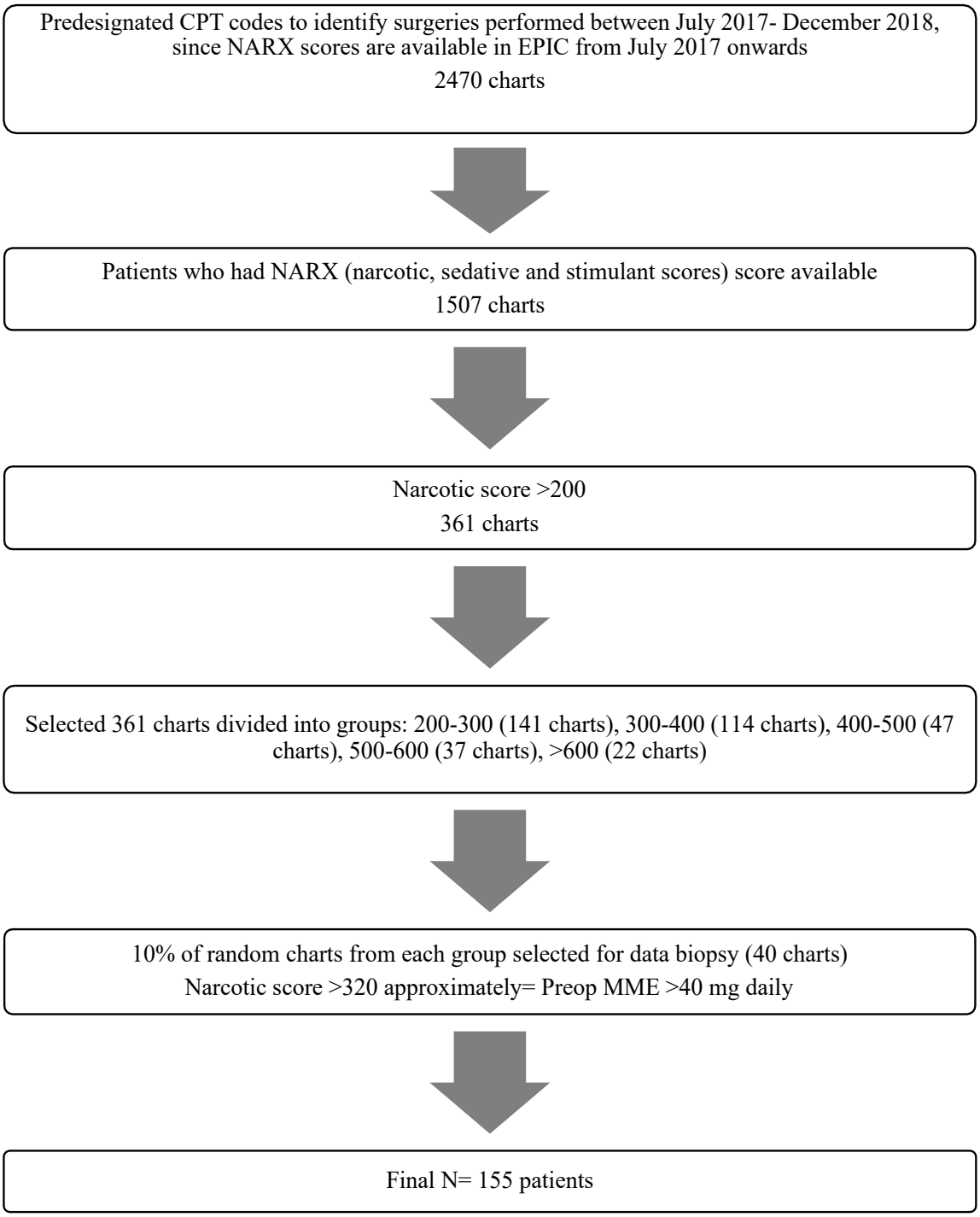
Supplemental Digital Content 1. ***Appendix 1 con't, lists CPT codes used to select elective abdominal, laparoscopic, gynecologic, breast, orthopedic, amputation and spine surgeries.***

KPRO		44626	Closure of enterostomy, large or small intestine; with resection and colorectal anastomosis (eg, closure of Hartmann type procedure)
27440	Arthroplasty, knee, tibial plateau	REC	
LAM		45110	Proctectomy; complete, combined abdominoperineal, with colostomy
63005	Laminectomy with exploration and/or decompression of spinal cord and/or cauda equina, without facetectomy, foraminotomy or discectomy (eg, spinal stenosis), 1 or 2 vertebral segments; lumbar, except for spondylolisthesis	45111	Proctectomy; partial resection of rectum, transabdominal approach
XLAP		45112	Proctectomy, combined abdominoperineal, pull-through procedure (eg, colo-anal anastomosis)
49320	Laparoscopy, abdomen, peritoneum, and omentum, diagnostic, with or without collection of specimen(s) by brushing or washing (separate procedure)	45113	Proctectomy, partial, with rectal mucosectomy, ileoanal anastomosis, creation of ileal reservoir (S or J), with or without loop ileostomy
49321	Laparoscopy, surgical; with biopsy (single or multiple)	45114	Proctectomy, partial, with anastomosis; abdominal and transsacral approach
SPLE		45116	Proctectomy, partial, with anastomosis; transsacral approach only (Kraske type)
38120	Laparoscopy, surgical, splenectomy	45119	Proctectomy, combined abdominoperineal pull-through procedure (eg, colo-anal anastomosis), with creation of colonic reservoir (eg, J-pouch), with diverting enterostomy when performed
VHYS		45120	Proctectomy, complete (for congenital megacolon), abdominal and perineal approach; with pull-through procedure and anastomosis (eg, Swenson, Duhamel, or Soave type operation)
58260	Vaginal hysterectomy, for uterus 250 g or less	45121	Proctectomy, complete (for congenital megacolon), abdominal and perineal approach; with subtotal or total colectomy, with multiple biopsies
58290	Vaginal hysterectomy, for uterus greater than 250 g	45126	Pelvic exenteration for colorectal malignancy, with proctectomy (with or without colostomy), with removal of bladder and ureteral transplantations, and/or hysterectomy, or cervicectomy, with or without removal of tube(s), with or without removal of ovary(s), or any combination thereof
HYST		45395	Laparoscopy, surgical; proctectomy, complete, combined abdominoperineal, with colostomy
58150	Total abdominal hysterectomy (corpus and cervix), with or without removal of tube(s), with or without removal of ovary(s)	45397	Laparoscopy, surgical; proctectomy, combined abdominoperineal pull-through procedure (eg, colo-anal anastomosis), with creation of colonic reservoir (eg, J-pouch), with diverting enterostomy, when performed
58553	Laparoscopy, surgical, with vaginal hysterectomy, for uterus greater than 250 g	45562	Exploration, repair, and presacral drainage for rectal injury
58570	Laparoscopy, surgical, with total hysterectomy, for uterus 250 g or less	45563	Exploration, repair, and presacral drainage for rectal injury; with colostomy
58572	Laparoscopy, surgical, with total hysterectomy, for uterus greater than 250 g	57307	Closure of rectovaginal fistula; abdominal approach, with concomitant colostomy
58956	Bilateral salpingo-oophorectomy with total omentectomy, total abdominal hysterectomy for malignancy	PRST	
HER		55810	Prostatectomy, perineal radical

Supplemental Digital Content 1. ***Appendix 1 con't, lists CPT codes used to select elective abdominal, laparoscopic, gynecologic, breast, orthopedic, amputation and spine surgeries.***

49651	Laparoscopy, surgical; repair recurrent inguinal hernia	55812	Prostatectomy, perineal radical; with lymph node biopsy(s) (limited pelvic lymphadenectomy)
49652	Laparoscopy, surgical, repair, ventral, umbilical, spigelian or epigastric hernia (includes mesh insertion, when performed); reducible	55815	Prostatectomy, perineal radical; with bilateral pelvic lymphadenectomy, including external iliac, hypogastric and obturator nodes
49654	Laparoscopy, surgical, repair, incisional hernia (includes mesh insertion, when performed); reducible	55821	Prostatectomy (including control of postoperative bleeding, vasectomy, meatotomy, urethral calibration and/or dilation, and internal urethrotomy); suprapubic, subtotal, 1 or 2 stages
BRST		55831	Prostatectomy (including control of postoperative bleeding, vasectomy, meatotomy, urethral calibration and/or dilation, and internal urethrotomy); retropubic, subtotal
19301	Mastectomy, partial (eg, lumpectomy, tylectomy, quadrantectomy, segmentectomy);	55840	Prostatectomy, retropubic radical, with or without nerve sparing;
19303	Mastectomy, simple, complete	55842	Prostatectomy, retropubic radical, with or without nerve sparing; with lymph node biopsy(s) (limited pelvic lymphadenectomy)
19307	Mastectomy, modified radical, including axillary lymph nodes, with or without pectoralis minor muscle, but excluding pectoralis major muscle	55845	Prostatectomy, retropubic radical, with or without nerve sparing; with bilateral pelvic lymphadenectomy, including external iliac, hypogastric, and obturator nodes
OVRY		55866	Laparoscopy, surgical prostatectomy, retropubic radical, including nerve sparing, includes robotic assistance, when performed
58661	Laparoscopy, surgical; with removal of adnexal structures (partial or total oophorectomy and/or salpingectomy)		
58740	Lysis of adhesions (salpingolysis, ovariolysis)		

Supplemental Digital Content 2. ***Flowchart, describes the procedure for arriving at the selected cohort of 155 patients.***



Supplemental Digital Content 3. ***Appendix 2, Lists ICD codes used to calculate Charlsonfig comorbidity index.***

Condition	**ICD 10 codes**
MI	I21.x, I22.x, I25.2
CHF	I11.0, I13.0, I13.2, I25.5, I42.0, I42.5x, I42.6x, I42.7x, I42.8x, I42.9, I43.x, I50.x, P29.0
PVD	I70.x, I71.x, I73.1, I73.8, I73.9, I77.1, I79.0, 179.1, 179.8, K55.1, K55.8, K55.9, Z95.8, Z95.9
CVA or TIA	G45.x, G46.x, H34.0x, H34.1x, H34.2x, I60.x - I68.x
Dementia	F01.x, F02.x, F03.x, F04, F05, G13.2, G13.8, G30.x, G31.0x, G31.1, G31.2, G31.83, R41.81, R54
COPD	J40.x, J41.x, J42.x, J43.x, J44.x, J45.x, J46.x, J47.x, J60.x, J61.x, J62.x, J63.x, J64.x, J65.x, J66.x, J67.x, J68.4, J70.1, J70.3
Connective Tissue Disease	M05.x, M06.x, M31.5, M32.x - M34.x, M35.1, M35.3, M36.0
PUD	K25.x, K26.x, K27.x, K28.x
Hemiplegia	G04.1, G11.4, G80.0, G80.1, G80.2, G81.x, G82.x, G83.0 - G83.4, G83.9
Mild CKD	I12.9, I13.0, I13.10, N03.x, N05.2 -N05.7, N18.3, N18.4
Mod/Severe CKD	I12.0, I13.11, I13.2, N18.5, N18.6, N19.x, N25.0, Z49.x, Z99.2
Leukemia/Lymphoma/non-skin non-metastatic solid tumor	C0x.x, C1x.x, C2x.x, C30.x, C31.x, C32.x, C34.x, C37.x, C38.x, C39.x, C40.x, C41.x, C43.x, C45.x C46.x, C47.x, C48.x, C49.x, C50, C51-C58.x, C60.x- C63.x, C76.x, C81.x - C85.x, C88.x, C9x.x,
Metastatic solid tumor	C77.x, C78.x, C79.x, C80.0, C80.2 C80.x
HIV	B20.x
AIDS	B20.x AND one of: B37.x, C53.x, B38.x, B45.x, A07.2, B25.x, G93.4x, B39.3, A07.3, C46.x, C81-C96, A31.x, A15-A19, B59, Z87.01, A81.2, A02.1, B58.x, R64
Mild Liver Disease	B18.x, K70.0, K70.1, K70.2, K70.3, K70.9, K71.3, K71.4, K71.5, K71.7, K73.x, K74.x, K76.0, K76.2, K76.3, K76.4, K76.8, K76.9, Z94.4
Severe Liver Disease	I85.x, I86.4, I98.2, K70.4x, K71.1x, K72.1x, K72.9x, K76.5, K76.6, K76.7
DM (Uncomplicated)	E08.0x, E08.1x, E08.6x, E08.8x, E08.9x, E09.0x, E09.1x, E09.6x, E09.8x, E09.9x, E10.0x, E10.1x, E10.6x, E10.8x, E10.9x, E11.0x, E11.1x, E11.6x, E11.8x, E11.9x, E13.0x, E13.1x, E13.6x, E13.8x, E13.9x
DM (+end organ damage)	E08.2x, E08.3x, E08.4x, E08.5x, E09.2x, E09.3x, E09.4x, E09.5x, E10.2x, E10.3x, E10.4x, E10.5x, E11.2x, E11.3x, E11.4x, E11.5x, E13.2x, E13.3x, E13.4x, E13.5x