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Minimally invasive sigmoidectomy for diverticular disease decreases inpatient opioid use: Results of a propensity score-matched study

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ABSTRACT

Background: Patients undergoing gastrointestinal surgery are at high risk for postoperative opioid use.
Methods: We evaluated inpatient opioid use among patients undergoing sigmoidectomy for diverticular disease from the Premier Hospital Database and compared across surgical approaches using propensity score-matching analysis.
Results: After the day of surgery, minimally invasive (MIS) patients were administered significantly lower doses of parenteral opioids (median daily morphine milligram equivalents [MME]: 33.3 versus 48.3, $p < 0.001$). Within MIS, significantly less parenteral opioids were used by the robotic-assisted (RS) than the laparoscopic (LS) group (median daily MME: 30.0 versus 36.8, $p = 0.012$). MIS patients were more likely than open to start oral opioids on the day of surgery (MIS vs. OS: 8.7% vs. 6.6%, $p < 0.001$; RS vs. LS: 12.6% vs. 10.2%, $p = 0.048$).
Conclusion: Minimally invasive sigmoidectomy for diverticular disease was associated with less post-operative parenteral opioid use and starting oral opioids sooner after surgery compared to the open approach.

Introduction

Opioid use for inpatient and outpatient pain management, in combination with prescribing opioids in excess of needs, has contributed to patient dependence and a national epidemic that includes opioid-related deaths.[1–5] Overprescribed opioids provide unused pills that, when not properly disposed of, may be diverted into the community.[5,6] These consequences have heightened recent awareness of opioid overprescribing, especially in the perioperative period.[5,6] Managing acute postoperative pain while minimizing the risk for persistent opioid use following recovery is an important issue and a challenge for providers, as there are knowledge gaps between research and clinical practice.[4,7–9]

Opioids have long played a role in postsurgical pain management and, for many patients, the surgical experience may be their first opioid exposure.[9] This first exposure is not without risk as the rate of persistent opioid use more than 3 months after surgery in opioid-naïve surgical patients is 3–10%.[10,11] A national survey on drug use and health revealed that one new heroin user emerges for every 100 first time prescriptions for opioid-naïve patients.[12] Approximately 10% of patients undergoing surgery develop opioid-related adverse events (ORAE) that are associated with increase inpatient mortality, prolonged length of stay, increased cost of hospitalization, and higher readmission rates.[13,14] Patients undergoing gastrointestinal surgery have moderate to severe pain and are at higher risk for prolonged postoperative use of opioids when compared to other procedures.[2,10] Previous studies have shown that the minimally invasive surgical (MIS) approach is associated with less postoperative pain and analgesic needs than the open approach (OS) in patients with colon or rectal cancer.[15] These studies, however, are limited to a small sample size and a specific patient population. To our knowledge, there are no population-based studies reflecting real-world opioid practice patterns across different hospitals or studies comparing MIS options for sigmoidectomy.

The purpose of this current study was to assess in-hospital opioid pain medication utilization patterns in patients undergoing sigmoid resection for diverticular disease and to compare

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opioid use among MIS and open surgical approaches. We leveraged a large, national database to answer this question and hypothesized that 1) patients undergoing MIS sigmoid resection require lower opioid doses during hospitalization compared to OS and 2) among MIS options, the robotic-assisted (RS) approach is associated with less opioid use than laparoscopy (LS).

Methods

Data source and eligibility criteria

The United States hospital-based Premier Healthcare Database (PHD) was the data source for this study. The PHD maintains cumulative information from more than 750 geographically diverse hospitals including community, teaching, and non-profit facilities.[16] The PHD contains a date-stamped log of billed items (procedures, medications, and laboratory, diagnostic, and therapeutic services) at the individual patient level. Drug utilization information is available by day of inpatient hospital stay and includes details of type, dose, dosage regimen, and route of administration.

Patients with diverticular disease, at least 18 years of age, with a primary procedure code for sigmoid resection that occurred between January 1, 2013 and September 30, 2015 were included in the study population. Cases were stratified by the International Classification of Diseases, 9th Revision, Clinical Modifications (ICD-9-CM) procedure codes into 3 groups based on the type of sigmoidectomy procedure performed: OS (45.76), LS (17.36), or RS (17.42 or 17.44) and included a diagnosis code for diverticular disease (562.10–562.13). We further identified the robotic approach from query of the billing text string for robotic equipment or instrumentation based on previously validated methodology to capture those undercoding RS cases.[17,18] MIS cases (LS or RS) that converted to OS (V64.41) were counted as intention-to-treat by the originally planned approach. Patients with non-elective procedures, diagnoses for malignant colorectal disease, preoperative chronic pain or opioid dependency, and those with outlier operative data (i.e., operative time less than 1 h or greater than 8 h, or without operative time data) or lack of medication-related charges during the hospital stay were excluded from data analysis.

Study variables

The primary outcomes of interest were average daily doses of total opioids (parenteral and/or oral route) on and after the day of surgery. Based on administration route, we recorded average daily doses of parenteral and oral opioids separately as well as days of use after surgery during the hospital stay as secondary outcomes.

Parenteral and oral opioid usage data from admission to discharge were obtained from billing charge records. For each record, we first converted the doses of different opioid products to morphine milligram equivalents (MME; Supplementary Table 1).[19] We then multiplied the MME by the recorded quantity and summed up all opioids in MME by patient to derive the total dose of opioids. Opioid use was categorized for the day of surgery (POD 0, as a proxy for medication use in the operating room and immediate recovery period) and by day in the postoperative period (from the day after surgery [POD 1] until discharge), respectively. For opioid use after the day of surgery, we further calculated the average daily dose of opioids by dividing the total dose by the number of days of use. Use of parenteral and oral opioids was evaluated separately and in combination as a total.

Statistical analysis

Propensity score matching (PSM) (1:1) was used to balance patient, surgeon and hospital-related characteristics when comparing opioid use by surgical modality (MIS vs. OS and RS vs. LS). We used multilevel random-effects logistic regression model to calculate the propensity score that estimated the likelihood that a patient would receive either MIS versus OS or RS versus LS to account for the hospital clustered structure of opioid prescribing patterns.[20] Covariates used to derive propensity score included patient characteristics (age, gender, race, Charlson Comorbidity Index scores [0, 1–2, ≥3], obesity/overweight status, smoking status [current or previous use of tobacco], concomitant procedures [colorectal surgeries, hernia repairs, lysis of adhesions], and insurance type); hospital characteristics (teaching status, urban/rural area, region, and bed size); year of surgery; and surgeon specialty (general surgeon, colorectal surgeon, or other). Additional clinical characteristics obtained were presence of peritoneal abscess or fistula (ICD-9 code 567.2x, 567.89, 567.9, 569.81). The Greedy matching algorithm without replacement was used to generate the matched study samples,[21] and standardized differences for each matching factor was calculated to assess whether the propensity score model had been adequately specified. A threshold of less than 0.1 was assumed to indicate a negligible difference in baseline characteristics between the two comparison arms.[22]

Within each matched pair cohort, chi-square tests and non-parametric Wilcoxon-Mann Whiney tests were used to examine differences among categorical outcomes and continuous outcomes, respectively. Any p-value less than 0.05 was considered statistically significant. To understand the daily utilization pattern of opioids, percentages of patients who received opioids versus those not receiving opioids on the surgical day and by each postoperative day were plotted. All analyses were conducted using SAS version 9.4 (SAS Institute, Cary, NC, USA).

Institutional review board approval was not required for the study because data from PHD are aggregated, de-identified, and compliant with the Health Insurance Portability and Accountability Act privacy rules.

Results

A total of 20,543 adult patients who underwent elective sigmoid resection for diverticulitis or diverticulosis between January 2013 and September 2015 were identified in PHD. After applying exclusion criteria, 17,873 patients were eligible for analysis: 4834 (27.0%) underwent OS, 11,220 (62.8%) underwent LS, and 1819 (10.2%) underwent RS (Fig. 1). Baseline characteristics prior to PSM are shown in Supplementary Table 2. After PSM, 3546 matched patient pairs were identified in the MIS versus OS cohort and 1374 matched pairs were included in the RS versus LS cohort. Patient, surgeon, and hospital characteristics were comparable in both matched sets (with standardized difference <0.1; Table 1).

Overall, approximately 95% of patients received at least one dose of parenteral or oral opioid medication following sigmoidectomy regardless of surgical approach. Fentanyl, hydromorphone, and morphine were the most commonly used parenteral opioids, whereas oxycodone and hydrocodone were frequently used via oral administration (Supplementary Table 1). Fig. 2 demonstrates the utilization patterns of parenteral or oral opioids by each day of the hospital stay comparing MIS to OS and RS to LS surgical approaches. Parenteral opioid use decreased dramatically after POD 0, while oral opioids became increasingly used for postoperative pain control over time. A lower percentage of parenteral opioid use was observed each postoperative day among patients receiving MIS relative to OS. Patients in the MIS group started oral opioids earlier and were discharged from hospitals sooner than those in the OS group.

Parenteral and oral opioid use including total dose, average daily

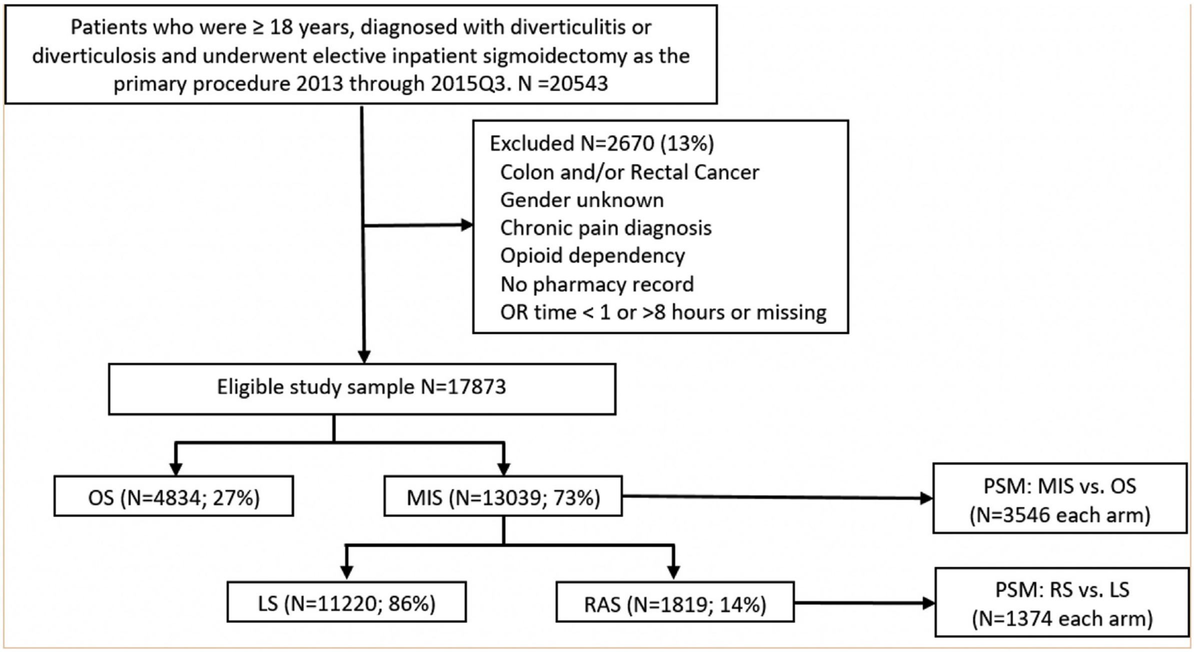

Fig. 1. Flow chart.

dose, and duration of use on and after the day of surgery is presented in Table 2. In the MIS versus OS cohort comparison, a similar total (parenteral and/or oral) opioid utilization pattern was observed on POD 0, but significantly less opioids were used by the MIS group than the OS group after the day of surgery (88.6% vs. 91.5%; $p < 0.001$), with significantly lower total (median MME: 125.0 vs. 200.0; $p < 0.001$) and lower average daily doses (median MME: 37.5 vs. 45.6; $p < 0.001$). In addition, the duration of opioid use after the day of surgery was significantly shorter in the MIS group (median 3 vs. 4 days; $p < 0.001$). The differences in *parenteral* opioid use are similar to the above *total* (parenteral and/or oral opioid) use when comparing MIS and OS groups. Patients in the MIS group were more likely to start oral opioids on the day of surgery than OS (8.7% vs. 6.6%, $p < 0.001$).

In the RS versus LS comparison, significantly lower doses of total opioids (parenteral and/or oral) were used by the RS group than the LS group on the day of surgery (median MME: 145.0 vs. 160.0; $p = 0.005$); after the day of surgery, RS group received non-significantly lower doses of total opioids (median average daily MME: 38.1 vs. 40.8, $p = 0.117$). When we assessed opioids separately by route of administration, significantly lower doses of parenteral opioids were used on POD 0 in the RS group compared to the LS cohort (median MME: 140.0 vs. 160.0, $p = 0.004$) as well as after POD 0 (median total MME: 60.0 vs. 70.0, $p = 0.010$; median daily MME: 30.0 vs. 36.8, $p = 0.012$), while there was no significant difference in number of days of in-hospital opioid use. More patients in the RS group used oral opioids on POD 0 than LS (12.6% vs. 10.2%, $p = 0.048$), but a similar utilization pattern of oral opioids was observed after the day of surgery until discharge (Table 2).

Discussion

In this large database study, approximately 95% of patients undergoing sigmoid resection for diverticular disease were exposed to opioids during hospitalization, suggesting that narcotic-free colorectal surgery was still in its infancy during the study period. Our surgical approach comparison of inpatient opioid use demonstrates that postoperative parenteral opioid requirements are less for MIS than for OS patients. Patients in the MIS group transition to oral opioids sooner in the postoperative period and were discharged from the hospital sooner than OS patients. Within MIS, the RS group received lower doses of parenteral opioids and transitioned to oral opioids sooner than the LS group in the days following surgery.

The opioid crisis has reached a critical impasse, as both short-term ORAE and long-term persistent use are associated with dependency, respiratory depression-associated deaths, distribution of opioids into communities, and significant costs to patients, hospitals, and society. In a study of 135,379 surgical patients having a wide variety of procedures and endoscopy, inpatient opioid use resulted in 11%–14% ORAE and was associated with increased inpatient mortality, an increase in hospital length of stay (LOS), higher 30-day readmission rate, and an $8225 increase in hospital episode cost.[14] Another study found that patients who were prescribed opioids after low-risk surgery were 44% more likely to receive opioids one year postoperatively compared to those not receiving opioids.[23] Though opioid-prescribing patterns are likely to vary among hospitals and surgeons, we found that the MIS approach in sigmoid resection reduced both the dose of opioids received and the duration of combined opioid use (parenteral and/or oral) in the perioperative period. A previous study also suggested that MIS techniques in colorectal surgery may attenuate the risk for postoperative opioid use greater than 30 days by 39%, after controlling for other risk factors.[23] These findings suggest that the adoption of the MIS approach in colorectal surgery may mitigate some of the potential adverse opioid events and improve both clinical and financial long-term outcomes,[24] and may aid patients and surgeons discussing operative approach choices that include multimodal pain management options.

In the present study, more patients in the MIS group received oral opioids on POD 0 and demonstrated a quicker transition to oral opioids after surgery compared to OS. This is likely because MIS patients tolerated oral intake sooner. The American Pain Society clinical guidelines recommend oral rather than intravenous

Table 1
Patient, surgeon and hospital-related characteristics after propensity score matching.

	Surgical Modality, N (%)			Surgical Modality, N (%)		
	MIS (N = 3546)	OS (N = 3546)	Standardized Differences	RS (N = 1374)	LS (N = 1374)	Standardized Differences
Age Groups						
18-45	437 (12.3%)	470 (13.3%)	0.03	210 (15.3%)	206 (15.0%)	0.01
45-55	764 (21.5%)	765 (21.6%)	<0.01	354 (25.8%)	359 (26.1%)	0.01
55-65	994 (28.0%)	1005 (28.3%)	0.01	406 (29.5%)	411 (29.9%)	0.01
≥65	1351 (38.1%)	1306 (36.8%)	0.03	404 (29.4%)	398 (29.0%)	0.01
Gender						
Female	2009 (56.7%)	2013 (56.8%)	<0.01	756 (55.0%)	765 (55.7%)	0.01
Male	1537 (43.3%)	1533 (43.2%)	<0.01	618 (45.0%)	609 (44.3%)	0.01
Race						
White	2983 (84.1%)	2963 (83.6%)	0.01	1139 (82.9%)	1138 (82.8%)	<0.01
Black	173 (4.9%)	199 (5.6%)	0.03	75 (5.5%)	67 (4.9%)	0.03
Others	390 (11.0%)	384 (10.8%)	0.01	160 (11.6%)	169 (12.3%)	0.02
Insurance Type						
Medicare	1395 (39.3%)	1352 (38.1%)	0.02	403 (29.3%)	407 (29.6%)	0.01
Medicaid	215 (6.1%)	224 (6.3%)	0.01	70 (5.1%)	71 (5.2%)	<0.01
Commercial/Private	1728 (48.7%)	1753 (49.4%)	0.01	826 (60.1%)	830 (60.4%)	0.01
Others	208 (5.9%)	217 (6.1%)	0.01	75 (5.5%)	66 (4.8%)	0.03
Charlson Comorbidity Score						
0	2149 (60.6%)	2201 (62.1%)	0.03	949 (69.1%)	984 (71.6%)	0.05
1-2	1185 (33.4%)	1153 (32.5%)	0.02	380 (27.7%)	343 (25.0%)	0.06
≥3	212 (6.0%)	192 (5.4%)	0.03	45 (3.3%)	47 (3.4%)	0.01
Obese or Overweight	660 (18.6%)	675 (19.0%)	0.01	246 (17.9%)	225 (16.4%)	0.04
Current or Former Smoker	1252 (35.3%)	1225 (34.5%)	0.02	401 (29.2%)	402 (29.3%)	<0.01
Concomitant Colorectal Surgery	62 (1.7%)	56 (1.6%)	0.01	12 (0.9%)	15 (1.1%)	0.02
Concomitant Hernia Repairs	166 (4.7%)	168 (4.7%)	<0.01	32 (2.3%)	37 (2.7%)	0.03
Presence of Adhesions	478 (13.5%)	482 (13.6%)	<0.01	198 (14.4%)	182 (13.2%)	0.03
Surgeon Specialty						
Colorectal	503 (14.2%)	511 (14.4%)	0.01	423 (30.8%)	437 (31.8%)	0.02
General surgery	2744 (77.4%)	2732 (77.0%)	0.01	863 (62.8%)	863 (62.8%)	<0.01
Others	299 (8.4%)	303 (8.5%)	<0.01	88 (6.4%)	74 (5.4%)	0.04
Teaching hospital	1375 (38.8%)	1362 (38.4%)	0.01	598 (43.5%)	605 (44.0%)	0.01
Region						
Rural	358 (10.1%)	336 (9.5%)	0.02	63 (4.6%)	54 (3.9%)	0.03
Urban	3188 (89.9%)	3210 (90.5%)	0.02	1311 (95.4%)	1320 (96.1%)	0.03
Geographic Region						
Midwest	873 (24.6%)	869 (24.5%)	<0.01	265 (19.3%)	249 (18.1%)	0.03
Northeast	437 (12.3%)	469 (13.2%)	0.03	292 (21.3%)	299 (21.8%)	0.01
South	1606 (45.3%)	1583 (44.6%)	0.01	615 (44.8%)	607 (44.2%)	0.01
West	630 (17.8%)	625 (17.6%)	0.01	202 (14.7%)	219 (15.9%)	0.03
Hospital Bed Size						
0-299	1249 (35.2%)	1268 (35.8%)	0.01	380 (27.7%)	362 (26.3%)	0.03
300-499	1340 (37.8%)	1283 (36.2%)	0.03	441 (32.1%)	455 (33.1%)	0.02
500+	957 (27.0%)	995 (28.1%)	0.02	553 (40.2%)	557 (40.5%)	0.01
Year of Surgery						
2013	1348 (38.0%)	1326 (37.4%)	0.01	391 (28.5%)	359 (26.1%)	0.05
2014	1320 (37.2%)	1301 (36.7%)	0.01	517 (37.6%)	543 (39.5%)	0.04
2015	878 (24.8%)	919 (25.9%)	0.03	466 (33.9%)	472 (34.4%)	0.01

MIS: minimally invasive surgery; OS: open surgery; LS: laparoscopy; RS: robotic-assisted surgery.
Standardized difference: values < 0.1 assumed to indicate negligible difference.

administration of opioids for postoperative pain management in patients who can use the oral route.[7] Early oral intake in the immediate postoperative period allows optimization of multimodal pain regimens that include oral non-opioid pain medications, thereby minimizing the need for opioid analgesia.[25,26] Prior studies have shown shorter hospital LOS for MIS compared to open colorectal surgery, and shorter LOS for RS compared to LS groups.[27–30] The shorter LOS for MIS compared to open groups, and RS compared to LS groups, is likely multifactorial, but less parenteral opioids and quicker postoperative transition to oral intake result in earlier return of gastrointestinal activity, less ileus, and earlier discharge.[31]

Within MIS, our study showed less parenteral opioid requirements in the RS group compared to the LS group. The type of extraction site or the use of intracorporeal anastomosis may explain such differences. More pain would be expected from midline incisional specimen extraction sites when compared to incisions off-midline, and more pain from extracorporeal when compared to intracorporeal MIS techniques.[32,33] We could not determine if these differences impacted this study as specimen extraction site location and anastomosis technique data were not available in the PHD dataset. A Danish randomized trial comparing RS and LS approaches to rectal cancer showed that RS patients received less opioid during surgery. The authors suggested that the lower need for opioid during robotic-assisted surgery may be due to the higher conversion rate in the LS group and the ergonomic wristed-instrument robotic advantage that allows less abdominal wall traction when operating in the pelvis.[34] Further studies are warranted to evaluate reasons for differences in opioid use between minimally invasive options.

Health care providers, public health consortiums, and regional and federal legislators have implemented strategies to limit opioid prescribing in situations that may increase opioids in the community after discharge.[6,32] Patients undergoing gastrointestinal

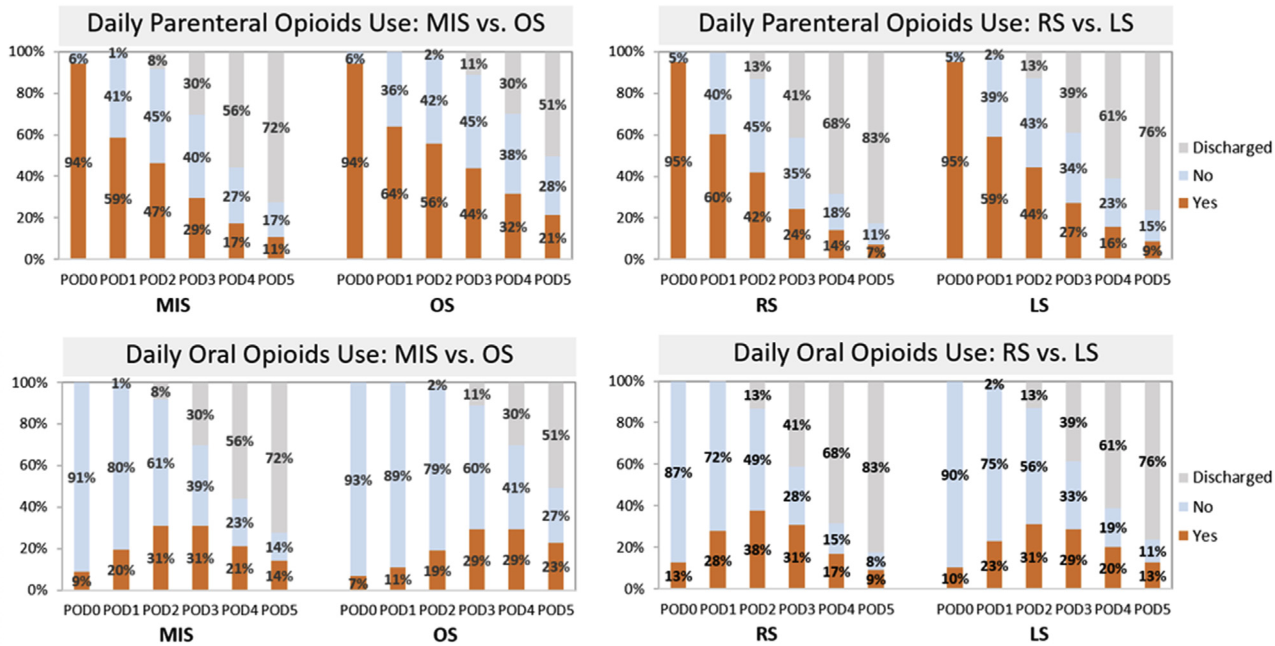

Fig. 2. Percentages of patients who received parenteral or oral opioids by each postoperative day in propensity score-matched cohorts.

surgery are at higher risk for prolonged postoperative use of opioids,[2,10] and for many patients, the perioperative period is often their first exposure to opioids. The risk for persistent opioid use therefore begins during and shortly after surgery, and this is the focus of our study. Enhanced recovery pain management plans are intended to decrease perioperative opioid needs. Varying protocols may include elements such as acetaminophen, nonsteroidal anti-inflammatory medications, gabapentin, transversus abdominis plane blocks, and intrathecal or epidural analgesia options.[35] The PHD dataset does not identify which institutions had established enhanced recovery pathways with multimodal pain management strategies[25,26] and so the impact of these pathways on decreasing or obviating inpatient opioid use could not be determined in our study.[25,26] However, we implemented a multilevel random-effects

Table 2
Parenteral and/or Oral Opioids Use in Propensity Score Matched Cohorts.

	Surgical Modality, N (%)			Surgical Modality, N (%)		
	MIS (N = 3546)	OS (N = 3546)	P-value	RS (N = 1374)	LS (N = 1374)	P-value
PARENTERAL AND/OR ORAL OPIOIDS USE						
Day of Surgery (POD 0)						
Yes, N (%)	3349 (94.4%)	3340 (94.2%)	0.644	1309 (95.3%)	1316 (95.8%)	0.518
Daily Dose (MME), Median (Q1, Q3)	150.0 (90.0, 260.0)	150.0 (85.0, 270.0)	0.703	145.0 (85.0, 259.6)	160.0 (95.0, 275.0)	0.005
After Day of Surgery (POD > 0)						
Yes, N (%)	3143 (88.6%)	3244 (91.5%)	<.001	1223 (89.0%)	1236 (90.0%)	0.419
Total Dose (MME), Median (Q1, Q3)	125.0 (37.5, 305.0)	200.0 (70.0, 475.0)	<.001	120.0 (37.5, 270.0)	130.0 (40.0, 310.0)	0.074
Duration (days)	3.0 (2.0, 5.0)	4.0 (2.0, 6.0)	<.001	3.0 (2.0, 4.0)	3.0 (2.0, 4.0)	0.327
Average Daily Dose (MME), Median (Q1, Q3)	37.5 (15.0, 74.0)	45.6 (20.6, 87.5)	<.001	38.1 (15.0, 73.4)	40.8 (17.5, 76.7)	0.117
PARENTERAL OPIOIDS USE ONLY						
Day of Surgery (POD 0)						
Yes, N (%)	3335 (94.0%)	3336 (94.1%)	0.960	1304 (94.9%)	1307 (95.1%)	0.793
Daily Dose (MME), Median (Q1, Q3)	150.0 (90.0, 255.0)	150.0 (80.0, 270.0)	0.543	140.0 (80.0, 255.0)	160.0 (90.0, 270.0)	0.004
After Day of Surgery (POD > 0)						
Yes, N (%)	2532 (71.4%)	2826 (79.7%)	<.001	958 (69.7%)	982 (71.5%)	0.315
Total Dose (MME), Median (Q1, Q3)	75.0 (0.0, 240.0)	140.0 (20.0, 375.0)	<.001	60.0 (0.0, 180.0)	70.0 (0.0, 240.0)	0.010
Duration (days)	1.0 (0.0, 3.0)	2.0 (1.0, 4.0)	<.001	1.0 (0.0, 3.0)	1.0 (0.0, 3.0)	0.213
Average Daily Dose (MME), Median (Q1, Q3)	33.3 (0.0, 80.0)	48.3 (10.0, 102.9)	<.001	30.0 (0.0, 77.5)	36.8 (0.0, 88.6)	0.012
ORAL OPIOIDS USE ONLY						
Day of Surgery (POD 0)						
Yes, N (%)	310 (8.7%)	233 (6.6%)	<.001	173 (12.6%)	140 (10.2%)	0.048
Daily Dose (MME), Median (Q1, Q3)	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	<.001	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.062
After Day of Surgery (POD > 0)						
Yes, N (%)	2603 (73.4%)	2613 (73.7%)	0.788	1038 (75.5%)	1041 (75.8%)	0.894
Total Dose (MME), Median (Q1, Q3)	30.0 (0.0, 75.0)	30.0 (0.0, 90.0)	0.001	33.8 (5.0, 80.0)	30.0 (5.0, 75.0)	0.297
Duration (days)	2.0 (0.0, 3.0)	2.0 (0.0, 3.0)	<.001	2.0 (1.0, 3.0)	2.0 (1.0, 3.0)	0.391
Average Daily Dose (MME), Median (Q1, Q3)	15.0 (0.0, 26.3)	15.0 (0.0, 28.3)	0.095	15.0 (5.0, 30.0)	15.0 (5.0, 28.8)	0.418

MIS: minimally invasive surgery; OS: open surgery; LS: laparoscopy; RS: robotic-assisted surgery.
*p-values are from chi-square tests for categorical variables and non-parametric Wilcoxon-Mann Whiney tests for continuous variables (medians).

regression model to control for hospital-level clustering of opioid prescribing patterns and the results support less inpatient opioid use in MIS patients.

Compared to prior publications[15] limited by sample size and a specific population (colorectal cancer), this study benefits from the use of a large, national database reflecting opioid practice patterns following sigmoid resection from a heterogeneous sample of hospitals and surgeons. It is a retrospective study with inherent limitations, including the inability to adjust for unobserved covariates and the dependence on accurate coding. The results of this study may not be generalizable to other colorectal procedures. Patients using opioids prior to surgery constitute 8.8% of the elective surgery population and have complex pain management needs.[4] We excluded patients with an opioid dependency or chronic pain diagnosis to decrease a significant confounder for perioperative opioid use. Targeting this patient population for further study will likely be an important part of addressing the opioid crisis. This study was focused on in-hospital opioid use. Further investigation is warranted to determine the impact of in-hospital opioid use on persistent opioid use after discharge. Finally, subjective pain scores are not captured in the PHD, and opioid usage derived from billing records may not directly reflect postoperative pain level.

Conclusions

For patients undergoing sigmoid resection, the inpatient perioperative period is often the first exposure to opioids and an opportunity for healthcare providers to intervene and address the opioid crisis. This large database study composed of hospitals and surgeons with varying expertise and focused specifically on sigmoid resection for diverticular disease, shows advantages to the minimally invasive approach with respect to less parenteral opioid use after surgery and starting oral opioids sooner after surgery. These results may inform patients and providers evaluating opioid-reduction pain management strategies and deciding on operative approaches for sigmoidectomy. Further study will be required in this patient population to determine if decreased inpatient opioid use in the perioperative period is associated with less persistent opioid use after discharge.

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Declaration of competing interest

Drs. Bastawrous and Cleary receive honoraria from Intuitive Surgical, Inc. for educational speaking, outside the submitted work. I-Fan Shih and Yanli Li are employed by Intuitive Surgical, Inc.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.amjsurg.2019.11.030.

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