Surgical Endoscopy (2019) 33:1959–1966
https://doi.org/10.1007/s00464-018-6477-5

2018 SAGES ORAL

Opioid-free colorectal surgery: a method to improve patient & financial outcomes in surgery

Deborah S. Keller[1] · Jianying Zhang[2] · Manish Chand[3]

Received: 14 April 2018 / Accepted: 11 October 2018 / Published online: 17 October 2018

Abstract

Background Opioids are a mainstay for postsurgical pain management, but have associated complications and costs, and contribute to the opioid epidemic. While efforts to reduce opioid use exist, little study has been done on opioid utilization and its impact across surgical approaches. Our goal was to evaluate the impact of opioid utilization on quality measures and costs after open and laparoscopic colorectal surgery.

Methods The Premier database was reviewed for inpatient colorectal procedures from January 01, 2014, to September 30, 2015. Procedures were stratified into open and laparoscopic approaches, then "opioid" and "opioid-free" groups within each approach. Univariate analysis compared demographics, outcomes, and cost by opioid use and surgical approach. In the "opioid" groups, opioid consumption and duration were assessed across platforms. Multivariate regression analyzed the association between opioid use and surgical approach on costs and quality outcomes.

Results 50,098 procedures were evaluated—40.4% laparoscopic and 59.6% open. 6.6% of laparoscopic and 5.3% of open cases were "opioid free." Across both approaches, patients over 65 were most likely opioid free, while the obese and cancer patients were most likely to use opioids. Length of stay was shorter, and post-discharge nursing needs and total costs were lower in the "opioid-free" group in both approaches (all $p < 0.001$). The median daily and total opioid consumption were lower with a laparoscopic approach ($p < 0.001$), which also had a shorter duration of use versus open cases ($p < 0.001$). Opioids were 20% more likely in open cases. Total costs were 16% greater with opioids and 24% greater in open surgery. Complications were 89% more likely in open surgery. Readmissions were increased by 14% with both opioid use and open surgery.

Conclusions Opioid-free colorectal surgery results in improved outcomes, and laparoscopy further improves these results. Continued efforts to increase laparoscopy are key for reducing opioids and improving outcomes as we transition to value-based care.

Keywords Opioids · Opioid-free pain management · Laparoscopic colorectal surgery · Readmissions · Complications · Healthcare costs · Healthcare outcomes

There is an opioid epidemic in the USA, and the epidemic continues to worsen. The rate of opioids prescribed, distributed, and deaths from opioid overdoses continue to increase steadily [1–3]. In 2016, prescription opioids contributed to 116 fatal overdoses per day [4, 5]; these now exceed deaths from car crashes, gun violence, and heroin and cocaine combined [5, 6]. In addition to fatal overdose, prescription opioids have the costs of abuse, dependence, diversion of unused medication, and can serve as a gateway to other illegal substances [7–9]. Currently, 11.5 million people in the USA are reported to misuse opioid prescriptions annually, more than 2.1 million report a prescription opioid use disorder, and 170,000 try heroin [5]. The economic burden of prescription opioid misuse alone has been estimated at $78.5 billion per year, with the total economic impact of the opioid crisis estimated at $504.0 billion annually and growing [9, 10]. With this widespread impact, further work to identify the root causes and develop solutions is needed.

Opioid use often begins with treatment of acute postoperative pain, and the inpatient surgical episode can be a 'gateway' to the opioid crisis. The reasons for the widespread use

Podium Presentation, SS29: ERAS Session, The Society of Alimentary and Gastrointestinal Surgeons 2018 Annual Meeting, April 11–14, 2018, Seattle, WA.

✉ Deborah S. Keller
debby_keller@hotmail.com

Extended author information available on the last page of the article

are multifactorial, but include the promotion of opioids as non-addictive for pain management by the pharmaceutical companies, with a massive increase in opioid prescribing by providers, the addition of pain as the "5th Vital Sign", the Joint Commission mandate to include pain and pain under-treatment questions on HCAHPS, and the financial incentives for hospitals to maintain high patient satisfaction scores [11–14]. These factors contributed to ubiquitous use among hospitalized patients undergoing surgical procedures, such as colectomy [15].

In the acute inpatient setting, opioids add the additional risk of opioid-related adverse events (ORAE), which are reported in approximately 20% of cases, and significantly increase complications, length of stay, and costs [15–18]. Furthermore, among opioid-naïve patients, persistent use after surgery occurs in 6–10% [19–21]. Thus, the postoperative period provides an opportunity to prevent chronic opioid use and its associated costs [22]. Enhanced recovery after surgery (ERAS) protocols embrace the strategy of opioid and ORAE reduction with multimodal pain management, and the evidence supporting its efficacy in colorectal surgery is strong [17, 23–25]. A laparoscopic approach is a cornerstone of ERAS, and the two elements work in synergy to optimize outcomes, costs, and surgical value [22, 26–29]. While use of a laparoscopic technique is an inpatient element in most ERAS protocols, little study has been performed on the impact of a laparoscopic compared to open approach on postoperative opioid utilization and associated outcomes.

Our goal was to evaluate the impact of opioid utilization across quality measures and costs after open and laparoscopic colorectal surgery. Our hypothesis was that increasing laparoscopic colorectal surgery is a value proposition to reduce opioid use and its associated costly complications. As the USA shifts to a value-based care model, these inpatient strategies to reduce opioid consumption may improve both clinical and financial outcomes.

Materials and methods

A review of the Premier Inpatient Database™ was performed to identify patients undergoing an elective colorectal resection with an inpatient admission between January 01, 2014, and September 30, 2015. The data source covers over 45 million inpatient visits, representing approximately one out of every five inpatient discharges in the USA. The data source contains a day-stamped log of all billed items including procedures, medications, laboratory, diagnostic, and therapeutic services at the individual patient level in addition to the standard data elements available in most hospital discharge files [30]. Hospitals included in the database are a national representation in terms of regional distribution, urban versus rural hospital, teaching versus non-teaching institutions, and hospital bed size. Discharge-level data include information on patient and provider characteristics, International Classification of Diseases 9th revision Clinical Modification (ICD-9-CM) diagnosis and procedure codes, hospital resource utilization, such as specific device usage, medications and laboratory services, and charges/cost data on all entries.

Laparoscopic and open cases were identified by International Classification of Diseases Ninth Edition (ICD-9) procedure codes for colorectal resections in the primary position of the claim. Codes included are seen in Appendix 1. Cases were excluded if the patients were < 18 years of age or if the procedure was performed with robotic assistance. In addition, to ensure cases were appropriate for either laparoscopic or open surgery, metastatic cancer cases (identified from metastatic ICD-9 diagnosis codes on the inpatient surgery claim) were excluded.

Data fields evaluated included the surgical approach (open or laparoscopic), demographics, length of stay (LOS), overall complications (identified by ICD-9-CM codes, Appendix 2), readmission episodes within 30 days of discharge, daily opioid consumption, total opioid consumption, days of opioid consumption, and the average cost across the open and laparoscopic cohorts for the inpatient episode. The opioids included in the analysis included all formulations of alfentanil hydrochloride, dilaudid fentanyl, fentanyl citrate, hydrocodone bitartrate, hydromorphone, levorphanol, meperidine, methadone, morphine, oxycodone, oxymorphone, propoxyphene, remifentanil, sufentanil, tapentadol, and tramadol. Total opioid consumption was defined in morphine equivalent dose (MME), based on the Centers for Disease Control MME published conversion factors [31, 32]. Costs were defined as the total direct costs (fixed and variable) to the healthcare system. Total fixed cost included those that did not relate directly to or vary with the activity (volume) of the department, such as depreciation, management, repair and maintenance and overhead. Total variable costs include those that related directly to or varied with the activity (volume) of the department such as supplies and hands on patient care.

Univariate analysis was performed to compare the demographic, outcome variables, and costs, using Chi-square tests, Mann–Whitney, or Kruskal–Wallis tests, as appropriate for categorical and continuous variables across the laparoscopic and open approaches. The adjusted inpatient cost difference was estimated by using a generalized estimating equation (GEE) multivariable model with gamma distribution. The adjusted length of hospital stay difference was estimated by using a generalized estimating equation (GEE) multivariable model with Poisson distribution. Medicare and age > 65 were covariate, and both payor and age were included in the GEE multivariable model. The adjusted odds ratios for complications and readmission were estimated by using multivariate logistic regression models. The factors controlled for in the analysis included age at surgery, gender, race, comorbidity measures, operation type (emergency or elective), cancer diagnosis, preexisting chronic pain syndrome (with the assumption that these patients had preexisting opioid use—identified by diagnostic codes 338.29 chronic pain; 338.21 chronic pain due to trauma; 338.28 chronic pain postoperative; 338.4 chronic pain syndrome), and hospital characteristics including bed size, teaching status, urban versus rural, and geographic region. All statistical analyses were performed using SAS version 9.4 (SAS Institute Inc., Cary NC).

The study did not involve human subjects, and the data analyzed were de-identified and compliant with the Health Insurance Portability and Accountability Act (HIPAA); thus, this study was exempt from Institutional Review Board (IRB) approval (45 CFR § 46.001(b) (4)).

Results

During the study period, 50,098 cases were included in the analysis—40.4% were laparoscopic ($n=20{,}264$) and 59.6% open ($n=29{,}834$) cases. In the laparoscopic cohort, 93.4% received opioids, while 6.6% were opioid free. In the open cohort, 94.7% received opioids, while 5.3% were opioid free. Our surrogate for preexisting opioid use, chronic pain, revealed 2.3% of laparoscopic and 4.8% of open patients reported preexisting chronic pain. Patient and hospital demographics are detailed in Table 1. There were significant differences for certain variables in the opioid and opioid-free groups for both the laparoscopic and open cohorts. The oldest patients (> 65 years) were most likely to be opioid free in both approaches ($p<0.0001$). Patients with the comorbidities of obesity ($p=0.0247$ laparoscopic, $p=0.0468$ open) and cancer ($p=0.0287$ laparoscopic, $p=0.0259$ open) were more likely to use opioids. In addition, across both surgical procedures, medicare patients ($p<0.0001$), patients in the smallest (bed size < 200) and largest (bed size > = 500) hospitals ($p<0.0001$), and those in the Midwest region were more likely "opioid free" ($p<0.0001$). Compared to non-teaching hospitals, patients who received treatment in teaching hospitals were more likely "opioid free" in laparoscopic group (8.7% teaching vs. 5.2%) non-teaching ($p<0.0001$), but there were no significant differences in the open group. There were no significant differences by gender for opioid use in either surgical approach.

The postoperative outcomes are seen in Table 2. In both the laparoscopic and open approaches, opioid-free patients had significantly shorter LOS than opioid patients (mean 4.78 days vs. 5.56 days laparoscopic and 8.56 days vs. 9.70 days open; both $p<0.0001$). Opioid-free patients were significantly more likely to be discharged home without post-discharge nursing needs for both approaches ($p=0.0002$ laparoscopic, $p=0.0001$ open). The total costs for the hospital episode were significantly lower in the opioid-free cohort in both laparoscopic and open cases ($p<0.0001$). There were no significant differences in complications or readmission rates for opioid and opioid-free cohorts in either surgical approach. In the patients receiving opioids during the hospital stay, laparoscopic patients had a significantly lower MME/day and total MME for the episode of care, as well as significantly fewer days on opioids than open patients (all $p<0.0001$) (Table 3).

Using the regression model, opioid use was independently associated with operative approach. Open surgery cases were 18% more likely to use opioids than laparoscopic cases (OR 1.18, 95% CI 1.083–1.287). In the adjusted regression analysis (Table 4), total hospital inpatient costs were 16% greater with opioids (95% CI 1.13–1.18, $p<0.0001$) and 24% more expensive open than laparoscopic surgery (95% CI 1.23–1.25, $p<0.0001$). The length of hospital stay was 11% longer with opioids (95% CI 1.09–1.12, $p<0.0001$) and 27% longer with open than laparoscopic surgery (95% CI 1.26–1.28, $p<0.0001$). Overall complications were not significantly different with opioids, but were 89% more likely with open surgery (95% CI 1.88–1.95, $p<0.0001$). Readmissions were increased by 14% with both opioid use (95% CI 1.00–1.31, $p=0.05$) and open surgery (95% CI 1.30–1.49, $p<0.0001$).

Discussion

With the escalating opioid epidemic, all methods to reduce opioid use and their associated costs are necessary [15–18, 22]. We sought to evaluate the impact of opioid utilization across quality measures and costs after open and laparoscopic colorectal surgery. We found there are currently a small percentage of colorectal surgical admissions that are opioid free, more laparoscopic than open cases. Opioid-free procedures had shorter LOS, lower rates of postoperative complications and post-discharge nursing utilization, and lower costs. When opioids were used, laparoscopic procedures used lower doses and had a shorter duration of use. Open cases were independently associated with opioid use, and the combination of opioid use with an open procedure was associated with a greater risk of complications, readmissions, and costs.

More than 50 million Americans undergo inpatient surgery annually, and opioids remain the primary modality for inpatient acute pain management [33, 34]. Our work is the first to survey the current state of opioid use in inpatient colorectal surgery, finding 93.44% of laparoscopic cases and 94.7% of open cases. In a previous national review of

Table 1 Patient and hospital demographics

Surgical approach	Laparoscopic					Open				
Opioid use	Yes		No		*p* value	Yes		No		*p* value
n (%)	18,935	93.44%	1329	6.56%	–	28,265	94.74%	1569	5.26%	–
Mean age (years, SD)	60.88	14.93	62.97	15.12	< 0.0001	63.24	15.85	65.84	16.2	< 0.0001
Age group (*n*, %)										
18–34	1083	86	73	14	< 0.0001	1488	88	71	12	< 0.0001
35–44	1460	96.05	60	3.95		1904	96.45	70	3.55	
45–54	3307	94.14	206	5.86		4114	95.3	203	4.7	
55–64	4623	93.36	329	6.64		6363	95.3	314	4.7	
≥ 65	8462	92.75	661	7.25		14,396	94.05	911	5.95	
Gender (*n*, %)										
Female	10,153	93.28	731	6.72	0.03282	15,196	94.55	876	5.45	0.1095
Male	8782	93.62	598	6.38		13,069	94.96	693	5.04	
Comorbidities (*n*, %)[a]										
CHF	746	3.94	65	4.89	0.0873	2363	8.36	141	8.99	0.3837
CVD	276	1.46	29	2.18	0.036	793	2.81	50	3.19	0.3752
PVD	450	2.38	29	2.18	0.6519	1246	4.41	73	4.65	0.6467
Hypertension	9659	51.01	719	54.1	0.0294	16,562	58.6	952	60.68	0.1033
Diabetes mellitus	3432	18.13	253	19.04	0.4049	5925	20.96	350	22.31	0.2033
Obesity	2938	15.52	237	17.83	0.0247	4819	17.05	298	18.99	0.0468
COPD	2696	14.24	206	15.5	0.2042	5326	18.84	324	20.65	0.0754
Cancer	6355	33.56	465	34.99	0.0287	8246	29.17	499	31.8	0.0259
Payers (*n*, %)										
Medicare	8363	92.73	656	7.27	< 0.0001	14,740	94.1	925	5.9	< 0.0001
Medicaid	1189	94.37	71	5.63		2438	96.1	99	3.9	
Commercial	8524	94.57	489	5.43		9152	95.91	430	4.49	
Others	859	88.37	113	11.63		1935	94.39	115	5.61	
Hospital beds (*n*, %)										
000–099	1060	93.47	74	6.53	< 0.0001	1391	90.27	150	9.73	< 0.0001
100–199	2456	89.41	291	10.59		4031	91.84	358	8.16	
200–299	2905	96.99	90	3.01		5495	96.44	203	3.56	
300–399	3503	95.84	152	4.16		5335	95.15	272	4.85	
400–499	2643	96.88	85	3.12		4220	97.24	120	2.76	
≥ 500	6368	90.91	637	9.09		7793	94.36	466	5.64	
Teaching hospital (*n*, %)	7283	91.31	693	8.69	< 0.0001	10,692	94.54	618	5.46	0.215
Urban versus Rural (*n*, %)										
Rural	2062	94.07	130	5.93	0.2087	4273	95.68	193	4.32	0.2087
Urban	16,873	93.37	1199	6.63		23,992	94.58	1376	5.42	
Regions (*n*, %)										
Midwest	3042	83.8	588	16.2	< 0.0001	4849	87.23	710	12.77	< 0.0001
Northeast	3368	93.19	246	6.81		4207	95.9	180	4.1	
South	9732	95.85	421	4.15		15,237	96.22	598	3.78	
West	2793	97.42	74	2.58		3972	98	81	2	

CVD cardiovascular disease, *CHF* congestive heart failure, *COPD* chronic obstructive pulmonary disease, *PVD* peripheral vascular disease

[a]Comorbidites were calculated as row totals and are not expected to total 100%, as not all patients had comorbidities, and some patients had more than one of the comorbidities

common inpatient procedures from 2009 to 2010, Kessler et al. reported 98.6% of surgical patients received opioids during the hospitalization [15]. The authors did not stratify opioid use or postoperative outcomes by surgical approach. However, the small reduction in opioid use despite the attention and use of ERAS highlights the need for alternative methods to reduce use.

Table 2 Postoperative outcomes

Surgical approach	Laparoscopic				*p* value	Open				*p* value
Opioid use	Yes		No			Yes		No		
	Mean	SD	Mean	SD		Mean	SD	Mean	SD	
Length of stay (mean, SD)	5.56	4.53	4.78	3.74	< 0.0001	9.70	7.66	8.56	7.44	< 0.0001
Total cost (mean, SD)	$16,514	$17,476	$14,383	$9756	< 0.0001	24,534	21,949	20,792	21,047	< 0.0001
	n	%	n	%	p value	n	%	n	%	*p* value
Complications (*n*, %)	7920	41.83	587	44.17	0.0946	20,348	71.99	1,106	70.49	0.1984
Discharge status (*n*, %)										
Home	15,850	93.25	1,147	6.75	0.0002	15,746	94.53	911	5.47	0.0001
Home with home care	1887	95.74	84	4.26		6122	95.73	273	4.27	
Skilled nursing facility	817	91.49	76	8.51		3802	94.48	222	5.52	
Long-term care/other	293	188	18	12		1831	191	88	9	
Mortality (*n*, %)	88	95.65	4	4.35		764	91.06	75	8.94	
Readmission (*n*, %)	1407	7.43	87	6.55	0.233	3247	11.49	170	10.83	0.4294

Table 3 Opioid utilization in milligram morphine equivalent (MME) and days of use

Approach	Laparoscopic				Open				p value
	Mean	SD	IQR	Median	Mean	SD	IQR	Median	
MME/day	52.27	268.35	15.63–53.75	20.05	55.98	194.21	14.67–60.40	28.50	< 0.0001
Total MME	194.18	616.41	37.50–194	88.00	306.81	1129.06	56.00–290	131.50	< 0.0001
Days on opioids	3.61	3.38	2.00–4.00	3.00	6.10	5.79	3.00–8.00	5.00	< 0.0001

IQR Interquartile range, 25–75 percentiles

Table 4 Multivariate model for opioid use and approach on quality metrics

Opioid use versus opioid free	OR	95% LCL	95% UCL	*p* value
Total cost	1.16	1.13	1.18	< 0.0001
Length of hospital stay	1.11	1.09	1.12	< 0.0001
Readmission	1.144	0.996	1.314	0.0569
Complications	0.951	0.866	1.044	0.2878
Open versus laparoscopic				
Total cost	1.24	1.23	1.25	< 0.0001
Length of hospital stay	1.27	1.26	1.28	< 0.0001
Readmission	1.394	1.301	1.493	< 0.0001
Complications	1.893	1.883	1.976	< 0.0001

More focus is being placed on the role of the acute inpatient surgical event to address the opioid crisis, which can be a gateway to continued use, abuse, and diversion of prescription opioids [19–21]. The overall prevalence of prolonged (more than 90 day) opioid usage has been reported in 6–10% of opioid-naïve postsurgical patients, with a rate of over 14.4% in gastrointestinal surgery specifically [35]. Thus, the inpatient period provides an opportunity to reduce opioid use and its associated costs [19–22]. Laparoscopic colorectal surgery has been shown to improve postoperative outcomes, especially in conjunction with an ERAS protocol [22, 26–29]. The value proposition from expanding laparoscopic colorectal surgery has been demonstrated to improve quality measures—significantly lowering readmissions, complications, mortality, and total costs compared to open surgery [36]. Here, we found the combination of a laparoscopic and opioid-sparing approach in colorectal surgery further improved quality measures, with significantly lower costs, length of stay, complications, and readmission rates than open cases with opioid use. Given these findings, the laparoscopic approach could add further benefit in fighting the opioid epidemic and improving surgical quality.

Our works agree with the existing literature supporting the adverse impact of prescription opioid use on healthcare utilization after surgery [37–39]. However, studies to date have focused on patients that were on opioids *before* surgery. An evaluation of 200,005 elective abdominal surgeries between 2009 and 2012 from the Truven database found 8.8% of patients used opioids preoperatively. Preoperative opioid use significantly increased postoperative healthcare utilization though longer lengths of stay, greater post-discharge nursing needs, higher readmission rates, and overall greater expenditures at 90, 180, and 365 days following surgery compared to opioid-naïve patients [40]. Cron et al. analyzed elective abdominopelvic surgeries from 2008 to 2014 from a single center within the Michigan Surgical Quality Collaborative database, finding 21% of surgical patients used opioids preoperatively. Compared with opioid-naïve patients, these had 9.2% higher costs, 12.4% longer length of stay, and were more likely to have complications and readmissions. Given these outcomes, further study could focus on the impact of the laparoscopic approach on outcomes for patients on preoperative opioids.

Our study adds to the current literature, as the impact of the surgical approach on opioid utilization during the anchor episode has not been previously described. We found the open approach was independently associated with opioid use during the hospital stay, with open cases 20% more likely than laparoscopic cases to use opioids. In addition, when opioids were used, laparoscopic patients had significantly lower daily and total doses, and fewer days on opioids than open cases. This is important, as patients with higher opioid consumption during the inpatient stay are more likely to report higher use of opioids after discharge [8]. Other work looking at the impact of the surgical approach on opioid use concentrated on utilization after discharge. In a single institution retrospective review, Stafford et al. found 91% of patients were discharged on opioids; 4% patients remained on opioids beyond 30 days, and 25% of those remained on opioids at 90 days [41]. A minimally invasive approach attenuated the risk of prolonged opioid use (more than 30 days after surgery) (OR 0.6; CI 0.4–0.9). Pairing these finding with our results, the benefit of a minimally invasive approach is effective for reducing opioids during the inpatient stay, and the effects appear durable through the postoperative period from the published work.

We recognize limitations in the work. First, the data source used was a national administrative database, which offers a large sample size for power, but little detail on the specific data fields evaluated. In particular, we used chronic pain as a surrogate for preexisting opioid use, which is limited as it is self-reported in addition to possible coding and capture errors, which may underestimate the scope of the preexisting opioid use. However, the strategy may be the best solution with the data source, and the variable was controlled in the multivariate model. We also had no data on the use, specific components, and compliance with ERAS pathways, which could influence outcomes, including complications and costs. With this data source, there was the unexpected finding that overall complications were not significantly lower when opioid free. We attribute this to limitations from confounding and limited data elements in clinical and prescribing patterns in the Premier database. Confounding by complexity of cases could also impact the results and conclusions. We attempted to control for this with the multivariate analysis. Alternate study designs, such as matching, restricting variables, or stratification would be alternate methods. There is also the potential for coding and capture errors, errors in outcomes based on self-reported information, such as codes for chronic pain and preexisting opioid use. While opioid use was found associated with costs, complications, and readmissions, it is important to note the data to date show the relationship, and not the causality; opioids are associated with these quality markers, but are not necessarily responsible for the outcomes and be a marker for other problems leading to these outcomes. Further work will examine these associations. Regardless of the limitation, this work offers value in showing the current state of opioid use, the feasibility of opioid-free surgery in both open and laparoscopic approaches, and the potential to reduce opioid utilization and improve quality outcomes by expanding laparoscopic colorectal surgery.

In conclusion, opioid-free colectomy can be a reality and would result in improvements in healthcare utilization and postoperative outcomes in both laparoscopic and open colorectal surgery. Laparoscopy would further improve outcomes over open surgery, with improved quality measures, and lower overall costs for the surgical episode. These results highlight the benefit of continued efforts to reduce opioid utilization, improve patient outcomes, and expand utilization of laparoscopy. The initiative to increase laparoscopic colorectal surgery, which adds value and lowers costs, could be an effective tool during the transition to a value-based payment system.

Compliance with ethical standards

Disclosures Ms. Zhang is employed by Medtronic, who provided access to the data source for the analysis. No products or services from Medtronic were relevant to this work, and there was no payment for the work. Deborah S. Keller and Manish Chand have no conflicts of interest or financial ties to disclose.

Appendix 1: case selection and exclusions codes for colorectal surgery

Inclusion	
DRG codes	329, 330, 331
ICD-9 procedure codes	
Open	45.71, 45.72, 45.73, 45.74, 45.75, 45.76, 45.79, 45.82, 45.83
Laparoscopic	17.31, 17.32, 17.33, 17.34, 17.35, 17.36, 17.39, 45.81
CPT/HCPCS codes for colectomy	

Inclusion	
Open	44140, 44141, 44143, 44144, 44,145, 44146, 44150, 44151, 44155, 44156, 44157, 44158, 44160, 45113, 45121
Laparoscopic	44204, 44205, 44206, 44207, 44208, 44210, 44211, 44212
Exclusion	
Robotic assistance	
ICD-9 (add-on procedure code)	17.41, 17.42, 17.43, 17.44, 17.45, 17.49
CPT/HCPCS	S2900

CPT/HCPCS current procedural terminology/healthcare common procedure coding system

ICD-9 International Classification of Disease, Ninth edition

DRG diagnostic-related group

Appendix 2: complications

General category	ICD-9-CM code
Ileus/small bowel obstruction (including constipation and PONV)	560.1, 560.2, 560.81, 560.89, 560.9, 997.4, 787.01, 564.3, 564.09, E937.9
Anastomotic leak. Organ space SSI	569.5, 567.22, 566, 567.21, 567.23, 567.29, 567.89, 567.9, 599.0, 996.64, 567.38
Superficial SSI and wound complications (hematoma/ seroma, wound infection, dehiscence)	682.2, 682.8, 682.9, 686.8, 686.9, 998.59, 958.3, 998.30, 998.31, 998.32, 998.33, 998.13, 998.51, 998.59, 998.6, 729.91, 998.12
Clostridium difficile colitis	008.45
Pulmonary infection	481, 482.0, 482.1, 482.2, 482.30, 482.31, 482.32, 482.39, 482.40, 482.41, 482.42, 482.49, 482.81, 482.82, 482.83, 482.89, 482.9, 483.0 485, 486, 507.0, 997.31, 997.32, 997.3, 518.5
Deep venous thrombosis	453.40, 453.41, 453.42, 453.82, 453.83
Urinary tract infection	599.0, 996.64, 788.2
Dehydration/acute renal failure	584.9, 276.51
Bleeding	998.11, 578.9, 285.1, 459.0, 285.1, 998.12, 569.3, 568.81, 569.3
Bleeding requiring transfusion	99.00, 99.01, 99.02, 99.03, 99.04, 99.05, 99.06, 99.07, 99.09
Peritonitis	567.38, 567.39, 567.2, 567.21, 567.22, 567.39, 567.8, 567.89, 567.9, 568.81
GI complications (Fistula)	997.4, 569.81, 593.82, 599.1, 596.1
Delirium/confusion/accidental fall	780.09, 293.9, 780.97, E884.4

SSI superficial site infection

References

1. Kenan K, Mack K, Paulozzi L (2012) Trends in prescriptions for oxycodone and other commonly used opioids in the United States, 2000–2010. Open Med 6:e41–e47
2. Centers for Disease Control and Prevention CDC (2017) Wide-ranging online data for epidemiologic research (WONDER). CDC, National Center for Health Statistics, Atlanta. http://wonder.cdc.gov
3. Hedegaard H, Warner M, Miniño AM. Drug Overdose Deaths in the United States, 1999–2016. NCHS Data Brief. 20171-8
4. Kochanek KDMSL, Xu JQ, Arias E (2017) Mortality in the United States, 2016. NCHS Data Brief, No. 293. National Center for Health Statistics, Hyattsville
5. Center for Behavioral Health Statistics and Quality (2017) 2016 National Survey on Drug Use and Health: detailed tables. Substance Abuse and Mental Health Services Administration, Rockville
6. Paulozzi LJ, Jones CM, Mack KA et al (2011) Vital signs: overdoses of prescription opioid pain relievers—United States, 1999–2008. MMWR Morb Mortal Wkly Rep 60:1487–1492
7. Carlson RG, Nahhas RW, Martins SS, Daniulaityte R (2016) Predictors of transition to heroin use among initially non-opioid dependent illicit pharmaceutical opioid users: a natural history study. Drug Alcohol Depend 160:127–134
8. Bartels K, Mayes LM, Dingmann C, Bullard KJ, Hopfer CJ, Binswanger IA (2016) Opioid use and storage patterns by patients after hospital discharge following surgery. PLoS ONE 11:e0147972
9. Florence CS, Zhou C, Luo F, Xu L (2016) The economic burden of prescription opioid overdose, abuse, and dependence in the United States, 2013. Med Care 54:901–906
10. The White House Council of Economic Advisers. Council of Economic Advisers Report: the Underestimated Cost of the Opioid Crisis. Issued November 20, 2017. https://www.whitehouse.gov/briefings-statements/cea-report-underestimated-cost-opioid-crisis/?utm_source=link
11. Fox CD, Berger D. Fine PG et al (2000) Pain assessment and treatment in the managed care environment. A position statement from the American Pain Society. American Pain Society, Glenview
12. Baker DW (2017) History of The Joint Commission's Pain Standards: lessons for today's prescription opioid epidemic. JAMA 317:1117–1118
13. Gupta A, Lee LK, Mojica JJ, Nairizi A, George SJ (2014) Patient perception of pain care in the United States: a 5-year comparative analysis of hospital consumer assessment of health care providers and systems. Pain Phys 17:369–377
14. US Department of Health and Human Services. About the U.S. Opioid Epidemic. https://www.hhs.gov/opioids/about-the-epidemic/index.html. 2018
15. Kessler ER, Shah M, Gruschkus SK, Raju A (2013) Cost and quality implications of opioid-based postsurgical pain control using administrative claims data from a large health system: opioid-related adverse events and their impact on clinical and economic outcomes. Pharmacotherapy 33:383–391
16. Minkowitz HS, Gruschkus SK, Shah M, Raju A (2014)Adverse drug events among patients receiving postsurgical opioids in a large health system: risk factors and outcomes. Am J Health Syst Pharm 71(18):1556–1565

17. Tan M, Law LS, Gan TJ (2015) Optimizing pain management to facilitate enhanced recovery after surgery pathways. Can J Anaesth 62:203–218
18. Sun EC, Darnall BD, Baker LC, Mackey S (2016) Incidence of and risk factors for chronic opioid use among opioid-naive patients in the postoperative period. JAMA Intern Med 176:1286–1293
19. Lee JS, Hu HM, Edelman AL et al (2017) New persistent opioid use among patients with cancer after curative-intent surgery. J Clin Oncol 35:4042–4049
20. Brummett CM, Waljee JF, Goesling J et al (2017) New persistent opioid use after minor and major surgical procedures in US Adults. JAMA Surg 152:e170504
21. Carroll I, Barelka P, Wang CK et al (2012) A pilot cohort study of the determinants of longitudinal opioid use after surgery. Anesth Analg 115:694–702
22. Brandal D, Keller MS, Lee C et al (2017) Impact of enhanced recovery after surgery and opioid-free anesthesia on opioid prescriptions at discharge from the hospital: a historical-prospective study. Anesth Analg 125:1784–1792
23. Wick EC, Grant MC, Wu CL (2017) Postoperative multimodal analgesia pain management with nonopioid analgesics and techniques: a review. JAMA Surg 152:691–697
24. Joshi GP (2005) Multimodal analgesia techniques and postoperative rehabilitation. Anesthesiol Clin North America 23:185–202
25. Carmichael JC, Keller DS, Baldini G et al (2017) Clinical Practice Guidelines for Enhanced Recovery After Colon and Rectal Surgery From the American Society of Colon and Rectal Surgeons and Society of American Gastrointestinal and Endoscopic Surgeons. Dis Colon Rectum 60:761–784
26. Pache B, Hübner M, Jurt J, Demartines N, Grass F (2017) Minimally invasive surgery and enhanced recovery after surgery: the ideal combination. J Surg Oncol 116:613–616
27. Vlug MS, Wind J, Hollmann MW et al (2011) Laparoscopy in combination with fast track multimodal management is the best perioperative strategy in patients undergoing colonic surgery: a randomized clinical trial (LAFA-study). Ann Surg 254:868–875
28. Spanjersberg WR, van Sambeeck JD, Bremers A, Rosman C, van Laarhoven CJ (2015) Systematic review and meta-analysis for laparoscopic versus open colon surgery with or without an ERAS programme. Surg Endosc 29:3443–3453
29. Thiele RH, Rea KM, Turrentine FE et al (2015) Standardization of care: impact of an enhanced recovery protocol on length of stay, complications, and direct costs after colorectal surgery. J Am Coll Surg 220:430–443
30. Premier Research Services. https://www.premierinc.com/transforming-healthcare/healthcare-performance-improvement/premier-research-services/. Accessed Sept 2017.
31. Control NCFIPA (2016) CDC compilation of benzodiazepines, muscle relaxants, stimulants, zolpidem, and opioid analgesics with oral morphine milligram equivalent conversion factors, 2016 version. Centers for Disease Control and Prevention, Atlanta. https://www.cdc.gov/drugoverdose/media/
32. Medicaid CFMA. (2015) Opioid morphine equivalent conversion factors. https://www.cms.gov/Medicare/Prescription-Drug-Coverage/PrescriptionDrugCovContra/Downloads/Opioid-Morphine-EQ-Conversion-Factors-March-2015.pdf
33. Rudd RA, Aleshire N, Zibbell JE, Gladden RM (2016) Increases in drug and opioid overdose deaths—United States, 2000–2014. MMWR Morb Mortal Wkly Rep 64:1378–1382
34. Wunsch H, Wijeysundera DN, Passarella MA, Neuman MD (2016) Opioids prescribed after low-risk surgical procedures in the United States, 2004–2012. JAMA 315:1654–1657
35. Jiang X, Orton M, Feng R et al (2017) Chronic opioid usage in surgical patients in a Large Academic Center. Ann Surg 265:722–727
36. Keller DS, Delaney CP, Hashemi L, Haas EM (2016) A national evaluation of clinical and economic outcomes in open versus laparoscopic colorectal surgery. Surg Endosc 30:4220–4228
37. Strassels SA (2009) Economic burden of prescription opioid misuse and abuse. J Manag Care Pharm 15:556–562
38. Waljee JF, Li L, Brummett CM, Englesbe MJ (2017) Iatrogenic opioid dependence in the United States: are Surgeons the Gatekeepers. Ann Surg 265:728–730
39. Jones CM, Logan J, Gladden RM, Bohm MK (2015) Vital signs: demographic and substance use trends among heroin users—United States, 2002–2013. MMWR Morb Mortal Wkly Rep 64:719–725
40. Waljee JF, Cron DC, Steiger RM, Zhong L, Englesbe MJ, Brummett CM (2017) Effect of preoperative opioid exposure on healthcare utilization and expenditures following elective abdominal surgery. Ann Surg 265:715–721
41. Stafford C, Francone T, Roberts PL, Ricciardi R (2018) What factors are associated with increased risk for prolonged postoperative opioid usage after colorectal surgery. Surg Endosc 32:3557–3561

Affiliations

Deborah S. Keller[1] · Jianying Zhang[2] · Manish Chand[3]

Jianying Zhang
jianying.zhang@medtronic.com

Manish Chand
m.chand@ucl.ac.uk

[1] Division of Colon and Rectal Surgery, Department of Surgery, NewYork-Presbyterian, Columbia University Medical Center, Herbert Irving Pavilion, 161 Fort Washington Avenue, 8th Floor, New York, NY 10032, USA

[2] Minimally Invasive Therapies Group, Medtronic, Inc, Boulder, CO, USA

[3] GENIE Centre, University College London, London, UK