




Preoperative opioid, sedative, and antidepressant use is associated with increased postoperative hospital costs in colorectal surgery

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Abstract

Background Opioid (OPD), sedative (SDT), and antidepressant (ADM) prescribing has increased dramatically over the last 20 years. This study evaluated preoperative OPD, SDT, and ADM use on hospital costs in patients undergoing colorectal resection at a single institution.

Methods This study was a retrospective record review. The local ACS-NSQIP database was queried for adult patients (age ≥ 18 years) undergoing open/laparoscopic, partial/total colectomy, or proctectomy from January 1, 2013 to December 31, 2016. Individual patient medical records were reviewed to determine preoperative OPD, SDT, and ADM use. Hospital cost data from index admission were captured by the hospital cost accounting system and matched to NSQIP query-identified cases. All ACS-NSQIP categorical patient characteristic, operative risk, and outcome variables were compared in medication groups using chi-square tests or Fisher's exact tests, and continuous variables were compared using Mann–Whitney U tests.

Results A total of 1185 colorectal procedures were performed by 30 different surgeons. Of these, 27.6% patients took OPD, 18.5% SDT, and 27.8% ADM preoperatively. Patients taking OPD, SDT, and ADM were found to have increased mean total hospital costs (MTHC) compared to non-users (30.8 vs 23.6 for OPD, 31.6 vs 24.4 for SDT, and 30.7 vs 23.8 for ADM). OPD and SDT use were identified as independent risk factors for increased MTHC on multivariable analysis.

Conclusion Preoperative OPD and SDT use can be used to predict increased MTHC in patients undergoing colorectal resections.

Keywords Opioids · Prescription drug use · Colorectal surgery · Healthcare costs · ACS-NSQIP

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Opioid, sedative, and antidepressant prescribing has increased dramatically over the last 20 years, and their use is now considered at the category of an epidemic. The use of opioids alone has seen an increase of 500% over that time-frame, and sedative medications have seen a nearly 50% increase, particularly in older patients [1]. Roughly one in eight Americans takes an antidepressant and antidepressant prescribing has seen an increase of over 65% [2]. The Centers for Disease Control and Prevention now considers prescription drug use as one of the top five health challenges in the United States [3–5].

Healthcare costs have seen a similar increase. High-risk opioid users have increased overall healthcare costs by placing a nearly \$29 billion additional burden on healthcare [6–8]. Preoperative opioid use is prevalent in 25% of patients presenting for non-cardiac surgery and has recently been shown to increase hospital costs, as well as postoperative

costs, in patients undergoing elective general surgery procedures [9, 10].

The cost of surgery and postoperative admission is taking on a larger focus. Numerous methods have been proposed and protocols developed in attempts to reduce healthcare costs. Statistical-based systems, including the Revised Cardiac Risk Index and American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) Surgical Risk Calculator, have been used for predicting risk [11–13]. However, the effect of preoperative use of opioids, sedatives, and antidepressants has not been examined in colorectal surgery. We hypothesize the use of these medications is an important predictor in increased surgical admission costs. The objective of this study is to evaluate the impact of preoperative opioid, sedative, and antidepressant use on hospital costs in patients undergoing colorectal resection at a single institution.

Methods

Study population

This study was a single-institution retrospective record review. The study received approval from the University of Kentucky, Office of Research Integrity Institutional Review Board, with exemption from patient consent and met the guidelines of the responsible government agency. The local University of Kentucky ACS-NSQIP database was queried for adult patients (age ≥ 18 years) undergoing open or laparoscopic, partial or total, colectomy or proctectomy at the University of Kentucky from January 1, 2013 to December 31, 2016. Patients admitted after trauma, who were under 18 years of age, and who had a major surgical procedure within 30 days prior to the index surgery were excluded. The NSQIP database has been used extensively in literature, is peer regulated by surgeons, and allows for a common interpretation of risk factors and 30-day outcome measurements across studies [14].

Data obtained from the NSQIP database included patient characteristics (gender, age, race, American Society of Anesthesiology [ASA] classification, body mass index [BMI], functional status, smoking status, and medical comorbidities including congestive heart failure [CHF], chronic obstructive pulmonary disease [COPD], diabetes, renal failure, ascites, and hypertension), preoperative laboratory values (white blood cells, sodium, BUN, creatinine, albumin, hematocrit, platelets, INR, alkaline phosphatase, and bilirubin levels), and surgical variables (emergency status, operative indication, procedure type, wound classification, ostomy creation, and operative duration).

Individual patient medical records were reviewed to determine the preoperative use of specific opioids, sedatives,

and antidepressants based on the medication reconciliation (which was finalized and confirmed by direct communication with the patient's pharmacy as well as a pharmacist to patient interview). Preoperative use was defined as a medication listed on the Medication Reconciliation Document on admission by the patient and discussed with a member of pharmacy staff. Hospital cost data from the index admission were captured by the hospital cost accounting system (Allscripts EPSi Version 7.5 FP2, Chicago, IL; Allscripts Healthcare, LLC, Chesterfield, MO) and matched to the cases identified by the NSQIP query. Total hospital costs included operating room services and supplies to include holding room, operating room, post-anesthesia care, as well as ward accommodations, intensive care, pharmacy, diagnostics, ancillary treatments such as physical therapy, and blood. Total hospital costs included both direct (supplies, nursing, and equipment) and indirect costs (administration, facility, and other overhead), but did not include professional fees.

Outcome measures included costs related to normal accommodations, supplies, operating room, pharmacy, diagnostics, intensive care, and ancillary therapies. These costs were aggregated to give us Total Hospital Cost. All patient characteristics, surgical characteristics, and outcomes recorded were strictly defined by the ACS-NSQIP 2017 Participant Use Data File [15]. There were no patients who had missing outcomes data or were lost to follow-up as only complete 30-day follow-up data was recorded into our local NSQIP database.

Statistical analysis

All ACS-NSQIP categorical patient characteristic, operative risk, and outcome variables were compared in medication groups using chi-square tests or Fisher's exact tests, and continuous variables were compared using Mann–Whitney U tests. A p value of ≤ 0.05 was considered the threshold for statistical significance in the bivariate calculations.

ACS-NSQIP patient and operative risk factors were considered in a backward multivariable logistic regression of total costs (p for entry ≤ 0.05 , for exit ≥ 0.10). Medication use variables were then added into the model in the presence of the independent risk factors.

Results

A total of 1185 colorectal procedures were performed at a single site by 30 different surgeons with volumes ranging from 1 to 497 cases. The mean age was 55.8 ± 15.5 years and median age was 57. Six-hundred two (50.8%) were female, 134 (11.3%) minority race, and 59 (0.5%) were of known

Hispanic ethnicity. Seven-hundred ninety-three (66.9%) were elective procedures, and 22.5% were emergent.

Patient preoperative characteristics predictive of hospital cost

The mean total hospital cost (MTHC) for the cohort, measured in \$1000 s, was 25.7 ± 30.5 . MTHC was 19.8 for elective cases which increased for non-elective, non-emergent (32.0), and emergent (40.4). Transfer status was also significantly associated with MTHC as patients admitted from home had lower cost than those from outside hospitals, emergency departments, and nursing homes. MTHC increased with increasing ASA class. Functional status, pulmonary status, preoperative inflammatory response, and other significant medical comorbidities were associated with increased MTHC as listed in Table 1.

Patient characteristics that did not vary with MTHC included sex, race or ethnicity, current smoking status, ascites, chronic use of steroids, recent weight loss greater than 10%, and BMI.

Preoperative laboratory values associated with MTHC were assessed. Uremia, hyponatremia and hypernatremia, elevated creatinine, hypoalbuminemia, leukocytosis and leukopenia, anemia, and thrombocytopenia were associated with increased MTHC. Thrombocytosis was associated with decreased MTHC. The mean total hospital costs associated with abnormal laboratory values are listed in Table 2.

After backwards multiple regression, independent patient predictors of cost in order of predictive strength were ASA class, preoperative inflammatory response, functional status, existing open wound, hypoalbuminemia, disseminated cancer, leukocytosis, leukopenia, bleeding disorders, and dyspnea.

Operative characteristics predictive of hospital cost

Open colectomy procedures (CPT code beginning with 4414- and 4415-) had increased MTHC, while laparoscopic colectomy procedures (CPT code beginning with 4420- and 4421-) had decreased MTHC. A full listing of operative procedures and costs are listed in Table 3. Increasing operative duration was also predictive of increased MTHC. Clean/contaminated wounds had lower MTHC (20.9) than contaminated (26.2) and dirty/infected wounds (30.0) as did wound closure techniques. Fully closed wounds had MTHC of 23.4, while MTHC increased with closure of only deep layers (42.5) and no closure (75.9). Preoperative transfusion within 72 h was predictive of increased MTHC.

With independent preoperative risk factors fixed in the model, independent operative predictors of cost were procedure group (first four digits of CPT code), duration of operation, wound closure technique, and transfusion requirement.

Hospital costs by drug class

Three-hundred twenty-seven (27.6%) patients took opioids (OPD), 219 (18.5%) took sedatives (SDT), and 329 (27.8%) took antidepressants (ADM) preoperatively. All classes of medications studied were associated with increased MTHC (30.8 vs 23.6 for OPD, 31.6 vs 24.4 for SDT, and 30.7 vs 23.8 for ADM).

Patients taking OPD were found to have increased costs compared to non-users for all sub-costs in the analysis. Mean accommodation costs and supply costs were each \$970 more than non-users. ICU costs were \$2,130 more for OPD users. OPD users had a mean increase of \$1,310 in pharmacy costs compared to non-users. A complete listing of cost differences per category can be seen in Table 4. When adjusted for independent preoperative and operative risks for increased cost on multivariate analysis, patients taking OPD had a cost increase of \$1,173 (regression coefficient 1.07, 95% confidence interval (CI) 1.01–1.14, $p=0.030$).

Similar to OPD users, patients taking SDT were associated with increased mean cost of various subcategories. SDT users saw a mean increase of \$2,740 in ICU costs and \$1,380 in pharmacy costs. Complete listing of cost differences per category can be seen in Table 4. When controlled for significant variables on multivariate analysis, patients taking SDT had a mean cost increase of \$1,843 (regression coefficient 1.11, 95% CI 1.03–1.19, $p=0.004$).

Antidepressant use followed a comparable trend as OPD and SDT use. Mean bed cost was \$1,010 higher than non-users. ICU costs were \$2,030 higher on average and pharmacy costs were increased by \$1,630. Complete listing of cost differences by category can be found in Table 4. On multivariate analysis, ADM users had a mean increase of \$838 (regression coefficient 1.05, 95% CI 0.99–1.12, $p=0.102$).

An interaction term between the drug use classes in the multivariable regression was not a significant predictor of MTHC.

Discussion

Preoperative use of OPD, SDT, and ADM has been increasing. Nearly a third of our patients undergoing colorectal surgery used OPD and ADM preoperatively, and over one in five took SDT. Optimizing patients preoperatively is a key surgical principle and has classically focused on modifiable risk factors, such as tobacco use, obesity, and functional status, as well as cardiopulmonary status and nutrition. Only recently has preoperative usage of specific medications been studied as it relates to post-operative outcomes [16, 17]. OPD and SDT have been identified as risk factors for poor surgical outcomes [18,

Table 1 Patient preoperative characteristics predictive of hospital costs

Variable	<i>n</i>	Mean total hospital costs \$000's (SD)	<i>p</i> value
All patients	1185	25.7 (30.5)	
Presentation			< .001
Same-day elective	793	19.8	
Not elective & not emergent	125	32.0	
Emergency	267	40.4	
Transfer status			< .001
Not transferred (admitted from home)	912	21.6	
Outside emergency department	164	34.6	
From acute care hospital inpatient	80	46.3	
Nursing home—chronic care—intermediate care	15	50.2	
Other/Unknown	14	48.4	
Age quartile, year			< .001
≤ 47	317	30.2	
48–57	292	35.7	
58–67	307	28.7	
68+	269	25.9	
ASA physical status classification			< .001
I–II	373	17.5	
III	695	24.8	
IV–V	117	57.4	
Diabetes			< .001
Non-insulin	133	27.2	
Insulin	90	34.3	
Preoperative functional status			< .001
Partially dependent	65	47.6	
Totally dependent	17	70.3	
Preoperative inflammatory response			< .001
None	1002	20.5	
SIRS	26	29.7	
Sepsis	98	42.3	
Septic shock	59	74.4	
Dyspnea			< .001
No	984	26.2	
Moderate exertion	175	26.6	
At rest	26	99.7	
Severe COPD	119	35.9	< .001
Preoperative ventilator	25	89.3	< .001
CHF	28	58.3	< .001
Medically treated HTN	628	29.8	< .001
Renal failure	7	114.8	< .001
Dialysis	19	54.9	< .001
Disseminated cancer	162	27.7	.009
Preoperative open wound	63	41.0	< .001
Bleeding disorder	109	45.8	< .001
Preoperative transfusion	18	65.8	< .001

SIRS systemic inflammatory response syndrome, *COPD* chronic obstructive pulmonary disease, *CHF* congestive heart failure, *HTN* hypertension

Table 2 Patient preoperative lab values predictive of hospital costs

Variable	<i>n</i>	Mean total hospital costs \$000's (SD)	<i>p</i> value
All patients	1185	25.7 (30.5)	
BUN > 40 mg/dL	53	62.2	< .001
Sodium < 135 mmol/L	70	35.3	< .001
Sodium > 145 mmol/L	18	37.3	< .001
Creatinine > 1.2 mg/dL	160	43.1	< .001
Albumin < 3.5 g/dL	461	35.1	< .001
WBC ≤ 4500/mm ³	78	35.1	< .001
WBC > 11,000/mm ³	241	38.5	< .001
HCT < 38%	519	30.9	< .001
Platelets < 150,000/mm ³	94	45.7	< .001
Platelets > 400,000/mm ³	92	21.3	< .001

BUN blood, urea, nitrogen, *WBC* white blood cell, *HCT* hematocrit

19]. When adjusted for all significant independent preoperative and perioperative risk factors, OPD and SDT significantly increased MTHC. ADM use also showed a trend toward increased MTHC though it did not reach statistical significance. These findings identify preoperative use of OPD and SDT as independent risk factors for increased hospital costs relating to colorectal surgery.

The OPD epidemic has seen a significant increase in prescription and illicit OPD use in Kentucky and surrounding states to levels higher than national averages [20, 21]. OPD has been associated with increased postoperative complications and length of stay in orthopedic and abdominal surgery literature [10, 22, 23]. Patients using OPD have been shown to be at higher risk for pneumonia and respiratory failure. This is due to respiratory depression and is worsened in patients with COPD. OPD has also been associated with factors prolonging length of stay, including postoperative nausea and vomiting, prolonged ileus, and urinary retention. These have also led to increased morbidity and mortality [10, 24, 25]. Our results demonstrate increased cost in effectively all aspects of hospitalization, including costs relating to operating room, supplies, intensive care, pharmacy, diagnostics, and ancillary treatments. After adjusting for known risk factors, preoperative OPD use increased MTHC by nearly \$1,200.

Costs related to operating room, intensive care, pharmacy, diagnostics, and ancillary treatments were increased in patients taking SDT preoperatively. As previously stated, SDT has been found to be an independent risk factor for adverse outcomes in non-cardiac surgery [18]. Patients taking these medications also have been found to have increased operative times, increased length of stay, and

Table 3 Operative characteristics predictive of hospital costs

Variable	<i>n</i>	Mean total hospital costs \$000's (SD)	<i>p</i> value
All patients	1185	25.7 (30.5)	
Procedure group			< .001
Open partial colectomy	405	33.6	
Total abdominal colectomy	58	50.3	
Proctectomy	47	22.9	
Lap partial colectomy	425	17.7	
Lap total abdominal colectomy	75	18.3	
Lap proctectomy	76	20.6	
Ostomy	650	29.3	< .001
Duration of operation, incision to close, mins.			< .001
≤ 120	322	22.5	
121–180	409	25.3	
181–240	248	27.2	
241+	206	30.1	
Wound class			< .001
Clean/Contaminated	706	20.9	
Contaminated	276	26.2	
Dirty/Infected	203	41.9	
Wound closure			< .001
All layers of incision (deep and superficial) fully closed	1111	23.4	
Only deep layers closed; superficial left open	33	42.5	
No layers of incision are surgically closed	41	75.9	
Transfused w/in 72 h of incision	146	56.3	< .001

Table 4 Costs in drug use and non-use cohorts; by cost center (\$000's)

Cost center	All pts.	Opioid			Sedative			Antidepressant		
		No	Yes	<i>p</i> -value	No	Yes	<i>p</i> -value	No	Yes	<i>p</i> -value
No. pts.	1185	828	327		966	219		856	329	
Mean total costs (SD)	25.7 (30.5)	23.6	30.8	<.001	24.4	31.6	.002	23.8	30.7	.001
Bed costs	6.43 (6.01)	6.14	7.11	.011	6.28	7.11	.065	6.15	7.16	.010
Med-Surg supply costs	5.20 (5.39)	4.91	5.88	.005	5.10	5.66	.165	5.05	5.61	.109
OR costs	4.82 (2.63)	4.70	5.09	.022	4.74	5.18	.023	4.79	4.91	.486
ICU costs	3.59 (10.4)	2.95	5.08	.001	3.08	5.82	<.001	3.03	5.06	.003
Pharmacy costs	2.66 (6.43)	2.27	3.58	.001	2.41	3.79	.004	2.21	3.84	<.001
Diagnostics costs	2.06 (3.82)	1.82	2.62	.001	1.95	2.57	.028	1.79	2.78	<.001
Ancill. Trx. costs	0.74 (2.30)	0.59	1.08	.001	0.64	1.17	.002	0.62	1.06	.003
Blood costs	0.23 (0.97)	0.20	0.32	.043	0.23	0.27	.546	0.21	0.29	.235

increased readmissions [26]. This could be attributed to the effects of SDT on respiratory and cognitive functions which have been demonstrated to contribute to poor surgical outcomes [27–29]. Chronic use of SDT has also been shown to increase postoperative delirium, and decrease adequate pain control and overall prolonged surgical recovery [30–33]. Adverse events, such as surgical site infection, lead to a need for further procedures, longer hospital stays, and amplified care requirements. After adjusting for significant independent risk factors, SDT use increased MTHC by over \$1,800.

ADM use has been shown to be associated with increased adverse events, prolonged LOS, and higher morbidity and mortality [34, 35]. Our study showed significantly increased costs relating to bed costs, intensive care, pharmacy, diagnostics, and ancillary therapies. Nonetheless, our multivariate analysis did not demonstrate that preoperative ADM use independently increases MTHC. Also, any combined use of multiple medication classes did not have a synergistic effect on MTHC greater than the risk of each medication class alone.

Prior to this study, the association between preoperative medication use and postoperative hospital costs had not been studied in colorectal surgery literature. It has been reported that preoperative OPD use has increased overall healthcare costs [7]. Reports from spine surgery literature have shown increased costs following cervical and lumbar fusions [36, 37]. Elective abdominal general surgery procedures have also shown increased hospital costs as well as overall postoperative costs [10]. However, no study to date has investigated the relationship between preoperative OPD and SDT use to all-comers in colorectal surgery resections.

Given our results, the preoperative use of OPD and SDT should be considered in the preoperative risk stratification and optimization of colorectal surgery patients. Enhanced Recovery after Surgery (ERAS) is a surgical optimization program that systematically works to decrease surgical complications, LOS, and costs [38–40]. While ERAS has

previously primarily focused on perioperative OPD use, our findings indicate that SDT use may also be considered in the prediction of increased perioperative costs. Provider's knowledge of preoperative use of these medications may allow for expectant management of postoperative complications and reduce costs.

The ACS-NSQIP database allows for comparison with other studies performed through its database, given the precise definition of each outcome variable and homogeneity of the data series within a fixed timeframe. However, there are limitations to this study. We cannot prove causality within a retrospective study despite demonstrating a strong association between SDT and increased MTHC. Also, with the study performed at a single institution, the results may not apply to all centers. There lies the possibility of unmeasured confounders as well, including high-risk comorbid conditions or clinical risk factors among medication users which could influence morbidity and mortality more than the medication itself. Multivariate analysis will adjust for known confounders, but it is impossible to capture all risk factors associated with outcomes and cost. In the same light, preoperative medication users could be higher risk than captured in our bivariate analysis. Under these circumstances, recognition of preoperative medication use can aide in identifying patients with higher risk of increased cost. Two sources of potential bias were identified. First, not all preoperative and operative risk factors were captured in our study. Examples could be patient compliance and socioeconomic status. However, the NSQIP database is one of the most robust clinical datasets available, including blood tests and other granular clinical variables. Additionally, there is unknown treatment bias related to this retrospective review that could alter the outcomes resulting from unknown surgical decision making as it relates to technique, approach, and indications. Our study did include multiple surgeons from different services which partially mitigates selection bias.

Further limitations include the lack of both specific dosage and length of use for each medication preoperatively in our data analysis. This would allow us to stratify users based on these factors and improve generalizability. Unfortunately, we were limited by the capabilities of the medication record, which is currently being improved to allow linkage to a state-wide electronic reporting system. Lastly, preoperative illicit use of these medications was not captured in our database. With the current state of the OPD epidemic and illicit use of SDT, we may be significantly underestimating the true amount of preoperative SDT use as well as OPD use. These could skew the data analysis and give falsely low results. Certainly, future randomized prospective studies are warranted to further this project and also to identify the impact of medication dose or chronicity on healthcare costs.

Conclusion

OPD, SDT, and ADM use is increasingly prevalent and can be used to predict increased total hospital costs in patients undergoing colorectal resections. These increased costs, in combination with previous findings of risk for adverse outcomes, underscore the importance of preoperative evaluation of drug usage for both risk prediction and optimization.

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Compliance with ethical standards

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References

1. Maust DT, Lin LA, Blow FC (2019) Benzodiazepine use and misuse among adults in the United States. *Psychiatr Serv* 70:97–106
2. Pratt LB, Brody DJ, Gu Q (2017) Antidepressant use among persons aged 12 and over: United States, 2011–2014. *NCHS Data Brief* 283:1–8
3. 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:e41–47
4. Paulozzi LJ, Mack KA, Hockenberry JM (2014) Variation among states in prescribing of opioid pain relievers and benzodiazepines—United States, 2012. *J Saf Res* 51:125–129
5. Kolodny A, Courtwright DT, Hwang CS, Kreiner P, Eadie JL, Clark TW, Alexander GC (2015) The prescription opioid and heroin crisis: a public health approach to an epidemic of addiction. *Annu Rev Public Health* 36:559–574
6. Vietri J, Masters ET, Barsdorf AI, Mardekian J (2018) Cost of opioid medication abuse with and without tampering in the USA. *Clinicoecon Outcomes Res* 10:433–442
7. Chang HY, Kharrazi H, Bodycombe D, Weiner JP, Alexander GC (2018) Healthcare costs and utilization associated with high-risk prescription opioid use: a retrospective cohort study. *BMC Med* 16:69
8. 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
9. Hilliard PE, Waljee J, Moser S, Metz L, Mathis M, Goesling J, Cron D, Clauw DJ, Englesbe M, Abecases G, Brummett CM (2018) Prevalence of preoperative opioid use and characteristics associated with opioid use among patients presenting for Surgery. *JAMA Surg* 153:929–937
10. 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
11. Liu Y, Cohen ME, Hall BL, Ko CY, Bilimoria KY (2016) Evaluation and enhancement of calibration in the American College of Surgeons NSQIP surgical risk calculator. *J Am Coll Surg* 223:231–239
12. Lee TH, Marcantonio ER, Mangione CM, Thomas EJ, Polanczyk CA, Cook EF, Sugarbaker DJ, Donaldson MC, Poss R, Ho KK, Ludwig LE, Pedan A, Goldman L (1999) Derivation and prospective validation of a simple index for prediction of cardiac risk of major noncardiac surgery. *Circulation* 100:1043–1049
13. Bilimoria KY, Liu Y, Paruch JL, Zhou L, Kmiecik TE, Ko CY, Cohen ME (2013) Development and evaluation of the universal ACS NSQIP surgical risk calculator: a decision aid and informed consent tool for patients and surgeons. *J Am Coll Surg* 217:833–842
14. Maggard-Gibbons M (2014) The use of report cards and outcome measurements to improve the safety of surgical care: the American College of Surgeons National Surgical Quality Improvement Program. *BMJ Qual Saf* 23:589–599
15. User Guide for the 2017 ACS NSQIP Participant Use Data File (PUF). 2018. https://www.facs.org/~media/files/quality%2520programs/nsqip/nsqip_puf_userguide_2017.ashx. Accessed June 22, 2020
16. Garcia-Miguel FJ, Serrano-Aguilar PG, Lopez-Bastida J (2003) Preoperative assessment. *Lancet* 362:1749–1757
17. Gan T, Jackson NA, Castle JT, Davenport DL, Oyler DR, Ebbitt LM, Evers BM, Bhakta AS (2020) A retrospective review: patient-reported preoperative prescription opioid, sedative, or antidepressant use is associated with worse outcomes in colorectal surgery. *Dis Colon Rectum* 63:965–973
18. Ward N, Roth JS, Lester CC, Mutiso L, Lommel KM, Davenport DL (2015) Anxiolytic medication is an independent risk factor for 30-day morbidity or mortality after surgery. *Surgery* 158:420–427
19. Cron DC, Englesbe MJ, Bolton CJ, Joseph MT, Carrier KL, Moser SE, Waljee JF, Hilliard PE, Khetarpal S, Brummett CM (2017) Preoperative opioid use is independently associated with increased costs and worse outcomes after major abdominal surgery. *Ann Surg* 265:695–701
20. Nelson LS, Juurlink DN, Perrone J (2015) Addressing the opioid epidemic. *JAMA* 314:1453–1454
21. Manchikanti L, Helm S 2nd, Fellows B, Janata JW, Pampati V, Grider JS, Boswell MV (2012) Opioid epidemic in the United States. *Pain Phys* 15(3 Suppl):ES9–ES38
22. Li Y, Stocchi L, Cherala D, Liu X, Remzi FH (2016) Association of preoperative narcotic use with postoperative complications and prolonged length of hospital stay in patients with Crohn disease. *JAMA Surg* 151:726–734

23. Cozowicz C, Olson A, Poeran J, Morwald EE, Zubizarreta N, Girardi FP, Hughes AP, Mazumdar M, Memtsoudis SG (2017) Opioid prescription levels and postoperative outcomes in orthopedic surgery. *Pain* 158:2422–2430
24. Sayal P, Bateman BT, Menendez M, Eikermann M, Ladha KS (2018) Opioid use disorders and the risk of postoperative pulmonary complications. *Anesth Analg* 127:767–774
25. Chung W-S, Lai C-Y, Lin C-L, Kao C-H (2015) Adverse respiratory events associated with hypnotics use in patients of chronic obstructive pulmonary disease: a population-based case–control study. *Medicine* 94:e1110–e1110
26. Neff C, Totten C, Plymale M, Oyler DR, Davenport D, Roth JS (2018) Associations between anxiolytic medications and ventral hernia repair. *Hernia* 22:753–757
27. Raats JW, van Eijnsden WA, Crolla RMPH, Steyerberg EW, van der Laan L (2015) Risk factors and outcomes for postoperative delirium after major surgery in elderly patients. *PLoS ONE* 10:e0136071–e0136071
28. American Geriatrics Society Expert Panel on Postoperative Delirium in Older Adults (2015) Postoperative delirium in older adults: best practice statement from the American Geriatrics Society. *J Am Coll Surg* 220:136–148.e1
29. Brown 4th C, Deiner S (2016) Perioperative cognitive protection. *Br J Anaesth* 117(suppl_3):iii52–iii61
30. Sutherland AM, Katznelson R, Clarke HA, Tait G, Beattie WS (2014) Use of preoperative antidepressants is not associated with postoperative hospital length of stay. *Can J Anaesth* 61:27–31
31. Orri M, Boleslawski E, Regimbeau J-M, Barry C, Hassler C, Gregoire E, Bachellier P, Scatton O, Mabrut JY, Adham M, Vibert E, Revah-Levy A, Farges O (2015) Influence of depression on recovery after major noncardiac surgery. *Ann Surg* 62:882–899; discussion 889–890
32. Kudoh A, Takase H, Takahira Y, Takazawa T (2004) Postoperative confusion increases in elderly long-term benzodiazepine users. *Anesth Analg* 99:1674–1678
33. Brown CH, LaFlam A, Max L, Wyrobek J, Neufeld KJ, Kebaish KM, Cohen DB, Walston JD, Hogue CW, Riley LH (2016) Delirium after spine surgery in older adults: incidence, risk factors, and outcomes. *J Am Geriatr Soc* 64:2101–2108
34. Vashishta R, Kendale SM (2019) Relationship between preoperative antidepressant and anti-anxiety medications and postoperative hospital length of stay. *Anesth Analg* 128:248–255
35. Auerbach AD, Vittinghoff E, Maselli J, Pekow PS, Young JQ, Lindenauer PK (2013) Perioperative use of selective serotonin reuptake inhibitors and risks for adverse outcomes of surgery. *JAMA Intern Med* 173:1075–1081
36. Jain N, Brock JL, Phillips FM, Weaver T, Khan SN (2018) Chronic preoperative opioid use is a risk factor for increased complications, resource use, and costs after cervical fusion. *Spine J* 18:1989–1998
37. Jain N, Phillips FM, Weaver T, Khan SN (2018) Preoperative chronic opioid therapy: a risk factor for complications, readmission, continued opioid use and increased cost after one- and two-level posterior lumbar fusion. *Spine* 43:1331–1338
38. Greco M, Capretti G, Beretta L, Gemma M, Pecorelli N, Braga M (2014) Enhanced recovery program in colorectal surgery: a meta-analysis of randomized controlled trials. *World J Surg* 38:1531–1541
39. Muller S, Zalunardo MP, Hubner M, Clavien PA, Demartines N, Zurich Fast Track Study Group (2009) A fast-track program reduces complications and length of hospital stay after open colonic surgery. *Gastroenterology* 136:842–847
40. Roulin D, Donadini A, Gander S, Griesser A-C, Blanc C, Hubner M, Schafer M, Demartines N (2013) Cost-effectiveness of the implementation of an enhanced recovery protocol for colorectal surgery. *Br J Surg* 100:1108–1114

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