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Authors
Halabi, Wissam J
Kang, Celeste Y
Nguyen, Vinh Q
et al.

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Epidural Analgesia in Laparoscopic Colorectal Surgery A Nationwide Analysis of Use and Outcomes

Wissam J. Halabi, MD; Celeste Y. Kang, MD; Vinh Q. Nguyen, PhD; Joseph C. Carmichael, MD; Steven Mills, MD; Michael J. Stamos, MD; Alessio Pigazzi, MD, PhD

IMPORTANCE The use of epidural analgesia in laparoscopic colorectal surgery has demonstrated superiority over conventional analgesia in controlling pain. Controversy exists, however, regarding its cost-effectiveness and its effect on postoperative outcomes.

OBJECTIVES To examine the use of epidural analgesia in laparoscopic colorectal surgery at the national level and to compare its outcomes with those of conventional analgesia.

DESIGN, SETTING, AND PARTICIPANTS This is a retrospective review of laparoscopic colorectal cases performed with or without epidural analgesia for cancer, diverticular disease, and benign polyps. Patient demographic characteristics, disease and procedure types, and hospital settings were listed for patients in the epidural and conventional analgesia groups. A 1 to 4 case-matched analysis was performed, matching for patient demographic characteristics, hospital setting, indications, and procedure type. Data were obtained from the Nationwide Inpatient Sample between January 1, 2002, and December 31, 2010.

MAIN OUTCOMES AND MEASURES Total hospital charge, length of stay, mortality, pneumonia, respiratory failure, urinary tract infection, urinary retention, anastomotic leak, and postoperative ileus.

RESULTS A total of 191 576 laparoscopic colorectal cases were identified during the study period. Epidural analgesia was used in 4102 cases (2.14%). Epidurals were more likely to be used in large teaching hospitals, cancer cases, and rectal operations. On case-matched analysis, epidural analgesia was associated with a longer hospital stay by 0.60 day (P = .003), higher hospital charges by $3732.71 (P = .02), and higher rate of urinary tract infection (odds ratio = 1.81; P = .05). Epidural analgesia did not affect the incidence of respiratory failure, pneumonia, anastomotic leak, ileus, or urinary retention.

CONCLUSIONS AND RELEVANCE The perioperative use of epidural analgesia in laparoscopic colorectal surgery is limited in the United States. While epidural analgesia appears to be safe, it comes with higher hospital charges, longer hospital stay, and a higher incidence of urinary tract infections.

The first published report on the use of epidural analgesia in laparoscopic colorectal surgery dates back to 1995.[1] Since then, several studies have compared the outcomes of epidural analgesia with those of conventional analgesia following laparoscopic colorectal surgery.[2-9] While all reports agree that epidurals are superior to conventional analgesia with respect to pain control,[2-9] data are conflicting regarding other

postoperative outcomes such as ileus, bowel function, length of hospital stay, and complication rates.[3,10-12]

Most of the published series are either limited by small numbers or come from centers that are highly experienced in laparoscopic techniques and have specialized teams for the placement and care of epidural catheters. As such, their results may not be generalizable. Moreover, while the cost associated with epidural placement has been analyzed in open surgery,[10,13,14] there are no such reports in laparoscopic colorectal surgery. This is important because laparoscopic colorectal surgery is gaining widespread acceptance in the United States, as it was used in 43%of colorectal surgical procedures in 2009.[11]

This is a large retrospective review examining the use of epidural analgesia in elective laparoscopic colorectal surgery during a 9-year period in the United States in different hospital settings, patient populations, disease states, and procedure types. The effects of epidural analgesia on selected postoperative outcome measures were compared with those of conventional analgesia using a case-matched analysis.

Methods

Patient Population

The Healthcare Cost and Utilization Project Nationwide Inpatient Sample (NIS) database was retrospectively analyzed for elective laparoscopic colorectal procedures performed with or without the use of epidural analgesia between January 1, 2002, and December 31, 2010. The NIS is the largest all-payer inpatient care database in the United States and contains information from nearly 8million hospital stays each year across the country. The data set approximates a 20% stratified sample of American community, nonmilitary, nonfederal hospitals, resulting in a sampling frame that comprises approximately 95% of all hospital discharges in the country. Data elements within the NIS are drawn from hospital discharge abstracts that allow determination of all procedures performed and postoperative outcomes during a given hospitalization.[12] Approval for the use of the NIS patient-level data in this study was obtained from the institutional review board of the University of California Irvine Medical Center and the NIS. The requirement for informed consent was waived because this is a retrospective study.

Inclusion Criteria

All patients with an International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) diagnosis code of benign colon polyps (211.3,230.3, V12.72), colon cancer (153.0-153.9), rectal benign polyps (211.4, 230.4, 230.5, 569.0), rectal cancer (154.0-154.2, 154.8), and diverticular disease (562.10-562.13) who underwent laparoscopic right or left hemicolectomy, sigmoidectomy, anterior resection, or abdominoperineal resection were included. Patients who underwent epidural placement were identified by ICD-9-CM procedure codes 03.90 and 03.91. Patients who

did not have an epidural catheter inserted were counted in the conventional analgesia group.

Exclusion Criteria

Converted cases as well as urgent or emergent procedures were excluded to minimize bias favoring one form of analgesia over the other. Missing data listed in the tables were excluded as well.

Study Variables

Age, sex, race/ethnicity, payer type, and a list of comorbidities provided by the NIS and based on the Elixhauser comorbidity measures[15] were listed for the epidural and conventional analgesia groups. Hospital type (teaching vs nonteaching), location (urban vs rural), and size (small vs medium vs large)were also examined. The use of epidurals by disease type and procedure types was also included.

End Points

The following end points chosen a priori were compared between epidural and conventional analgesia: length of hospital stay, total hospital charge, postoperative ileus, pneumonia, respiratory failure, urinary tract infection (UTI), urinary retention, and anastomotic leak. The choice of these endpoints is based on previously published data that showed controversial results due to small sample sizes. Mortality was initially included as an end point for the case-match analysis. It was later excluded as the numbers were small, precluding a meaningful analysis.

Statistical Analysis

All statistical analyses were conducted using SAS version 9.3 (SAS Institute, Inc) and R Statistical Environment (R Foundation) statistical software. Groups were compared using $\chi 2$ test with Yates correction and t test. For the prespecified end points of interest, we compared outcomes between epidural and conventional analgesia using linear regression and logistic regression. From our NIS sample, we matched each epidural case to 4conventional analgesia controls based on age (within 2 years), sex, race/ethnicity, payer type, comorbidities, disease type, procedure type, and the use of stoma. This ensures controlling for the matching factors. Odds ratios were obtained with 95% confidence intervals. Robust standard errors were used for inference. The Holm method was used to account for multiple comparisons. An adjusted mean difference (or odds ratio) was declared statistically different from 0 (or 1) if the adjusted P value is less than .05. The Horvitz-Thompson estimator was used to compute the total number of cases based on sampling weights.

Results

From 2002 to 2010, a total of 191 576 patients underwent laparoscopic colorectal procedures in the United States for the indications considered in our analysis. Epidurals were used in only 4102 cases (2.14%). Table 1 lists the use of epidural analgesia in different hospital settings, disease states, and procedure types.

Table 1. Use of Epidural Analgesia in the United States According to Hospital Setting, Disease Types, and Procedure Types

Characteristic	Total Laparoscopic Cases, No. (N = 191 576)	Cases With Epidural Analgesia, No. (%) (n = 4102)	*P* Value
Hospital type			
Teaching	97 958	2496 (2.55)	<.001
Nonteaching	92 362	1606 (1.74)	
Missing	1256	NA	
Hospital location			
Urban	177 349	3748 (2.11)	<.001
Rural	12 971	354 (2.73)	
Missing	1256	NA	
Hospital bed size			
Small	19 004	294 (1.55)	<.001
Medium	41 738	719 (1.72)	
Large	110 369	2871 (2.67)	
Missing	20 465	NA	
Disease type			
Colon benign polyps	42 566	572 (1.34)	<.001
Rectum benign polyps	170	0	
Diverticular disease	73 228	1332 (1.82)	
Colon cancer	62 991	1575 (2.50)	
Rectal cancer	12 621	623 (4.94)	
Procedure type			
Right colectomy	81 842	1403 (1.71)	<.001
Left colectomy	16 293	395 (2.42)	
Sigmoidectomy	76 917	1646 (2.14)	
Anterior resection	11 961	506 (4.23)	
Abdominoperineal resection	4164	152 (3.78)	

Abbreviation: NA, not applicable

The use of epidural analgesia was more common in teaching hospitals than in nonteaching ones and was more common in large hospitals than in medium and small hospitals ($P < .001$). Epidural analgesia was most commonly used in rectal cancer cases, followed by colon cancer, and was least commonly used in cases involving benign polyps ($P < .001$). Comparing patient demographic characteristics in the epidural and conventional analgesia groups, we observed no differences in mean patient age or sex distribution. Examining race/ethnicity, epidural analgesia was more likely to be used

in white patients and less likely to be used in African American and Hispanic patients. Differences were also seen with respect to payer type as epidural analgesia was more likely to be used in patients with private insurance (P < .001). Comorbidities also differed between the 2 groups as epidurals were more likely to be used in patients with metastatic cancer and anemia and less likely to be used in obese patients, patients with congestive heart failure, or patients with chronic pulmonary disease (Table 2).

Table 2. Patient Characteristics in the Conventional and Epidural Analgesia Groups

Characteristic	Analgesia		*P* Value
	Conventional (n = 187 474)	Epidural (n = 4102)	
Age, mean (IQR), y	63 (53-73)	62 (52-72)	.32
Sex, No. (%)			
Male	89 209 (47.58)	1985 (48.40)	.35
Female	97 562 (52.04)	2107 (51.36)	
Missing	703 (0.38)	10 (0.24)	
Race, No. (%)			
White	127 632 (68.08)	3353 (81.74)	<.001
African American	11 755 (6.27)	112 (2.73)	<.001
Hispanic	10 480 (5.59)	86 (2.10)	<.001
Other	6543 (3.49)	178 (4.34)	.01
Missing	31 064 (16.57)	363 (8.85)	
Payer, No. (%)			
Private	85 432 (45.57)	2137 (52.10)	<.001
Medicare	72 984 (38.93)	1570 (38.27)	<.001
Medicaid	4218 (2.25)	101 (2.46)	.74
Other	5661 (3.02)	76 (1.85)	<.001
Missing	19 179 (10.23)	218 (5.32)	
Comorbidities, No. (%)			
Metastatic cancer	17 154 (9.15)	739 (18.02)	<.001
Hypertension	90 962 (48.52)	1864 (45.44)	<.001
Anemia	24 259 (12.94)	603 (14.70)	<.001
Congestive heart failure	5699 (3.04)	91 (2.22)	.003
Chronic pulmonary disease	24 165 (12.89)	471 (11.48)	.008
Obesity	16 085 (8.58)	309 (7.53)	.02
Diabetes mellitus	28 290 (15.09)	572 (13.94)	.04
Chronic liver disease	2662 (1.42)	46 (1.12)	.12
Valvular heart disease	7386 (3.94)	147 (3.58)	.26
Chronic kidney disease	5118 (2.73)	121 (2.95)	.42

Abbreviation: IQR, interquartile range.

Total hospital charge, length of stay, mortality, and postoperative complications for the 2 groups are presented in Table 3.

Table 3. Unadjusted Outcomes of Conventional and Epidural Analgesia in Laparoscopic Colorectal Surgery

Outcome	Analgesia		*P* Value
	Conventional (n = 187 474)	Epidural (n = 4102)	
Total charge, mean (IQR), $	43 883 (24 143-50 494)	47 300 (29 936-52 360)	<.001
Length of stay, mean (IQR), d	5 (3-6)	6 (4-7)	.09
In-hospital mortality, No. (%)	937 (0.50)	5 (0.12)	<.001
Postoperative complications, No. (%)			
CVA	75 (0.04)	5 (0.12)	.03
Cardiac complications	2737 (1.46)	76 (1.85)	.04
Respiratory failure	3224 (1.72)	61 (1.49)	.28
Pneumonia	2662 (1.42)	60 (1.48)	.87
Ileus or bowel obstruction	26 752 (14.27)	456 (11.12)	<.001
Anastomotic leak	18 222 (9.72)	293 (7.14)	<.001
Acute renal failure	7124 (3.80)	152 (3.70)	.78
UTI	4218 (2.25)	121 (2.95)	.003
Urinary retention	3693 (1.97)	81 (1.97)	>.99
Wound complications	5212 (2.78)	132 (3.22)	.10
Postoperative bleeding	3843 (2.05)	30 (0.73)	<.001
DVT	394 (0.21)	10 (0.24)	.77

Abbreviations: CVA, cerebrovascular accident; DVT, deep venous thrombosis; IQR, interquartile range; UTI, urinary tract infection.

The mean length of stay was 5 days in the conventional group and 6 days in the epidural group. On univariate analysis, epidural analgesia was associated with a lower mortality compared with conventional analgesia (0.12% vs 0.50%, respectively; P < .001). The incidences of ileus, anastomotic leak, and postoperative bleeding were significantly lower in the epidural analgesia group (all P < .001). On case-control matched analysis, after matching for patient age, sex, race/ethnicity, payer type, comorbidities, disease type, procedure type, and the use of stoma, we found that patients in the epidural group stayed in the hospital about0.60 day longer than patients in the conventional group (95% CI, 0.27-0.93; P = .003). Also, epidural analgesia increased hospital charges by $3732.71 (P = .02). Patients receiving epidurals had a 1.81-fold risk of having aUTI (95%CI, 1.01-3.29; P = .05). The use of epidurals did not affect the rate of respiratory failure, pneumonia, or urinary retention. Also, no differences were detected in the incidence of ileus or anastomotic leak (Table 4). Mortality was not evaluated on case-matched analysis as the numbers were small.

Table 4. Risk-Adjusted Outcomes of Epidural Analgesia in Laparoscopic Colorectal Surgery[a]

Outcome	Mean Difference or OR (95% CI)	*P* Value
Mean difference		
Length of hospital stay, d	0.60 (0.27-0.93)	.003
Total charge, $	3732.71 (723.68-6741.73)	.02
OR		
UTI	1.81 (1.01-3.29)	.05
Urinary retention	0.73 (0.36-1.45)	>.99
Respiratory failure	1.28 (0.57-2.92)	>.99
Pneumonia	2.15 (0.83-5.58)	.57
Ileus	0.83 (0.60-1.14)	.98
Anastomotic leakage	0.87 (0.60-1.27)	>.99

Abbreviations: OR, odds ratio; UTI, urinary tract infection.
[a] Linear and logistic regression analysis based on 1 to 4 case-control matching comparing epidural analgesia with conventional analgesia. Conventional analgesia is used as the reference group.

Discussion

The perioperative use of epidural analgesia in laparoscopic colorectal surgery is limited in the United States. This limited use may be explained by the higher charges associated with the use of epidurals. Our results are in line with previous findings.[10,13,14] The high charges associated with epidural analgesia can be explained by the longer hospital stay observed in this group as well as the additional cost of the epidural equipment itself. While charge and cost are different, charge is a good reflection of cost and is readily available in the NIS database, whereas cost must be calculated using a charge to cost conversion. We did not perform this calculation as the results would remain essentially unchanged.

The other potential explanation to the limited use of epidural analgesia in laparoscopic colorectal surgery comes from the fact that laparoscopic surgery is already associated with less postoperative pain compared with open surgery.[16] Therefore, surgeons and anesthesiologists may not view epidurals to be necessary in these cases. Hospital factors may further explain the limited use of epidural analgesia as our data show that epidurals were more likely to be used in large and teaching hospitals where dedicated anesthesia teams are available at all times to monitor postoperative care.

The effect of epidural analgesia on length of stay has been examined before with mixed results.[3,5-8] Only 1 study showed a shorter hospital stay associated with the use of epidurals, [6] while others were unable to demonstrate any association. In our results, the use of epidural analgesia was associated with an increase in length of stay by more than half a day. This finding may be explained by the additional time required to transition patients to other forms of conventional analgesia as well as removing the bladder catheter, which typically occurs a few hours after the epidural catheter is removed.

The higher risk of UTI in patients receiving epidural analgesia is in line with previously published data.[4,5,14,17] Epidurals cause transient detrusor muscle dysfunction,18 necessitating the use of indwelling bladder catheters for the entire duration of epidural placement, which typically ranges from 1 to 5 days.[3,4,6] In dwelling bladder catheters are known to increase the risk of UTI; the longer they are left in place, the higher the risk of UTI is.[19] This finding is important in view of the newly implemented National Patient Safety Goals to reduce the incidence of catheter-based UTI by limiting their use.[20] Therefore, the risk of UTI should be balanced against the benefits benefits of epidurals in terms of pain control, especially in colorectal cases, which are known to carry a higher risk of urinary complications.[21]

Interestingly, the risk of urinary retention was not affected. This is in contrast to previously published data showing a higher incidence of urinary retention with epidural analgesia.[4,5,14,17] Of note is that prior studies examined the incidence of urinary retention on univariate analysis and therefore did not adjust for any potential confounders such as patient factors and procedure types. This lack of association in our results may be explained by the fact that epidurals are usually removed at least 4 hours prior to the discontinuation of bladder catheters to avoid this complication.[3] Because the effect of epidural drugs is short lived, the incidence of urinary retention should technically be low.

The effect of epidural analgesia on pulmonary function and the incidence of pulmonary complications has been the subject of debate. High thoracic epidural anesthesia bears the adverse effects of both sympathetic and respiratory motor blockades, which may increase the risk of respiratory failure.[22] We were unable to demonstrate an association between epidural analgesia and respiratory failure or pneumonia. This lack of association may be due to the fact that epidurals in laparoscopic colorectal surgery are inserted at the T7 to T12 level, where the risk of high thoracic blockade is low.[1,3-7,9] This finding is in contrast to a recent meta-analysis by Pöpping et al[23] that showed a lower incidence of pneumonia and pulmonary complications associated with epidural analgesia. The meta analysis, however, also included open thoracic and abdominal cases during a 30-year period. The reason our results were different may be related to the facts that laparoscopy already preserves lung function better than open surgery and that colorectal surgery does not affect lung function as much as thoracic and upper abdominal surgery.[24] This explains the low incidence of pneumonia and respiratory failure in our study. Pöpping and colleagues provided another potential explanation: They hypothesized that the lower rates of pulmonary complications observed in older studies were due to a lack of safety profile of older systemic analgesia rather than a beneficial effect of epidurals.

Prolonged ileus occurring more than 6 days postoperatively is relatively common following colorectal surgery and is multifactorial.[25,26] While epidural analgesia has been shown to decrease the time needed for return of bowel function in open colorectal procedures,[27] the results in laparoscopic colorectal surgery have been conflicting, with some studies showing a faster return[7,9] but others showing no difference at all.[3,4,8] Our results showed a lower incidence of ileus in the epidural group on univariate analysis; however, this association was not observed on case-match analysis. This may be due to the fact that laparoscopy is already associated with less surgical trauma

And inflammation[28] and a faster return of bowel function.[29] The other explanation of our finding is that ileus in the NIS database refers to prolonged ileus, which, because of its multifactorial nature, is unlikely to be affected by the use of epidurals alone.

Anastomotic leakage is a rare but devastating complication in colorectal surgery.[30] Again, there has been much debate on whether epidurals have any effect on colorectal anastomosis. Some investigators believe that the sympathetic blockade offered by epidural analgesia may protect against leakage because of an increased splanchnic blood flow to the anastomosis.[31] Others have refuted those findings by showing that epidurals produce a significant decrease in the oxygenation-perfusion state of colorectal anastomoses due to a steal effect[32] or by showing that early recovery of colonic motility induced by epidural analgesia could increase the anastomotic disruption rate.[33] Published data examining the effect of epidurals on anastomosis were limited by small sample sizes. In act, Holte and Kehlet[34] estimated that more than 1000 patients should be included in each group to demonstrate a significant association between epidurals and anastomotic leak. Our relatively large sample sizes enabled us to control for multiple confounders that may affect leak rates. The lack of association in our case-matched analysis adds more evidence that epidurals may have no effect on anastomotic leak.[35,36]

The main limitation in our study lies in its retrospective nature and its inherent biases. The NIS does not provide specific information such as pain levels and patient satisfaction, which are the major benefits of epidural analgesia based on previously published data. The use of ICD-9-CM codes in discharge data may be prone to coding errors. The NIS does not include whether epidural catheters were inserted intraoperatively or postoperatively. It is possible in some cases that an epidural was placed postoperatively when systemic analgesia failed; however, this number is likely to be very small and as such would not affect outcomes. Also, the duration for which the epidural or the indwelling bladder catheters were left in place or cases in which the bladder catheter was reinserted are not provided in the NIS database. Procedural complications specific to epidurals such as lower extremity motor or sensory deficit, epidural abscess, or epidural hematoma are not provided. However, these complications are rare.[37] The NIS only provides information related to single hospital stays; as such, long-term data, readmission rates, and 30-day mortality rates are unknown. These limitations, however, are likely to affect both groups. While the incidence of postoperative bleeding was lower in the epidural group, we did not perform a risk-adjusted analysis on this complication owing to small sample sizes and the inability to account for the use of deep venous thrombosis prophylaxis. The same reason prevented us from examining mortality on case-matched analysis. Nevertheless, to our knowledge, our study is the largest to date investigating the use and outcomes of perioperative epidural analgesia in laparoscopic colorectal surgery in different settings.

Conclusions

The use of epidural analgesia in laparoscopic colorectal surgery in the United States is limited and demonstrates some selectivity with regard to patients' demographic characteristics, hospital settings, and disease types. While previous studies have already demonstrated its superiority in terms of pain control,[2-9] our results demonstrate that the use of epidural analgesia is safe, as it was not associated with any major complications.

However, it comes with higher hospital charges, longer hospital stay, and higher risk of UTI. Therefore, the use of epidural analgesia should be made on a case by case basis after careful consideration of its risks and benefits. Large randomized clinical trials are needed to validate these findings.

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Analysis and interpretation of data: All authors.
Drafting of the manuscript: Halabi, Kang, Nguyen, Carmichael, Pigazzi.
Critical revision of the manuscript for important intellectual content: Halabi, Nguyen, Carmichael, Mills, Stamos, Pigazzi.
Statistical analysis: Kang, Nguyen.
Administrative, technical, or material support: Stamos.
Study supervision: Carmichael,Mills, Stamos, Pigazzi.

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Author Affiliations: Department of Surgery, Irvine School of Medicine, University of California, Irvine (Halabi, Kang, Carmichael,Mills, Stamos, Pigazzi); Department of Statistics, University of California, Irvine (Nguyen).
Corresponding Author: Alessio Pigazzi,MD, PhD, Department of Surgery, University of California, Irvine, 333 City BlvdW, Ste 850, Orange, CA 92868 (apigazzi@uci.edu).