

Intravenous Lidocaine Versus Thoracic Epidural Analgesia

A Randomized Controlled Trial in Patients Undergoing Laparoscopic Colorectal Surgery Using an Enhanced Recovery Program

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Background and Objective: Laparoscopy, thoracic epidural analgesia, and enhanced recovery program (ERP) have been shown to be the major elements to facilitate the postoperative recovery strategy in open colorectal surgery. This study compared the effect of intraoperative and postoperative intravenous (IV) lidocaine infusion with thoracic epidural analgesia on postoperative restoration of bowel function in patients undergoing laparoscopic colorectal resection using an ERP.

Methods: Sixty patients scheduled for elective laparoscopic colorectal surgery were prospectively randomized to receive either thoracic epidural analgesia (TEA group) or IV lidocaine infusion (IL group) (1 mg/kg per hour) with patient-controlled analgesia morphine for the first 48 hours after surgery. All patients received a similar ERP. The primary outcome was time to return of bowel function. Postoperative pain intensity, time out of bed, dietary intake, duration of hospital stay, and postoperative complications were also recorded.

Results: Mean times and SD (95% confidence interval) to first flatus (TEA, 24 [SD, 11] [19–29] hrs vs IL, 27 [SD, 12] [22–32] hrs) and to bowel movements (TEA, 44 ±19 [35–52] hrs vs IL, 43 [SD, 20] [34–51] hrs) were similar in both groups ($P = 0.887$). Thoracic epidural analgesia provided better analgesia in patients undergoing rectal surgery. Time out of bed and dietary intake were similar. Patients in the TEA and IL groups were discharged on median day 3 (interquartile range, 3–4 days), $P = 0.744$. Sixty percent of patients in both groups left the hospital on day 3.

Conclusions: Intraoperative and postoperative IV infusion of lidocaine in patients undergoing laparoscopic colorectal resection using an ERP had a similar impact on bowel function compared with thoracic epidural analgesia.

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Laparoscopic approach to colorectal surgery has been shown to accelerate dietary intake and return of bowel function,¹ to facilitate postoperative mobilization,² to reduce the length of

stay in hospital,^{1,3} and to impact positively on postoperative mortality.^{1,3–5} In addition, it has been shown to be safe even for malignant lesions in a number of meta-analyses and systematic reviews.^{1,6,7}

Despite all the major benefits of laparoscopy, elective colorectal resection is still associated with a complication rate varying between 20% and 30% and a postoperative hospital stay of 7 to 10 days.⁸

The enhanced recovery program (ERP), or enhanced rehabilitation, also called fast-track program, was initially proposed over a decade ago to minimize the impact of surgical stress on postoperative morbidity and to accelerate the recovery process.^{8,9} This multidisciplinary approach was initially applied in patients undergoing colonic surgery and found to be feasible and safe. In several uncontrolled trials and subsequently in randomized studies, the ERP had demonstrated significant reduction in hospital stay, with low readmission rate and low morbidity.^{8–10}

Thoracic epidural analgesia (TEA) with local anesthetic agents has been shown to have a positive impact on bowel function after colorectal surgery either as a result of direct effect of neural blockade or for the anti-inflammatory properties of the local anesthetics. This beneficial effect of TEA has been consistently shown in either open^{11,12} or laparoscopic colectomy,¹³ and therefore, this technique, together with minimally invasive approach and ERP, has been considered an essential element to facilitate the recovery process.^{11,14}

More recently, there has been some interest in the use of intravenous (IV) lidocaine in abdominal surgery as a result of its analgesic, antihyperalgesic, and anti-inflammatory effects.^{15–17} Perioperative IV lidocaine has been shown to decrease postoperative pain,¹⁶ to minimize the use of opioids, to facilitate the earlier restoration of bowel function,^{15,17} and to shorten the length of stay after colorectal surgery.¹⁵

Both TEA and IV lidocaine infusion have independently shown to be superior to systemic opioid analgesia with regard to various outcomes after open colorectal resection^{18,19}; however, there is a need to establish whether these 2 techniques are comparable when applied to laparoscopic colorectal surgery in the context of a standardized ERP.

The present randomized trial was designed to compare the effect of TEA and IV lidocaine infusion on the return of bowel function. It is hypothesized that intraoperative and postoperative lidocaine would result in postoperative restoration of bowel function similar to TEA in patients undergoing laparoscopic colorectal resection when an ERP was implemented.

METHODS

Patient Selection

After approval by the Research Ethics Boards of the McGill University Health Centre (GEN06-023) and ClinicalTrials.gov (NCT01155440), a prospective randomized study in patients scheduled to undergo elective laparoscopic colorectal resection

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at the Montreal General Hospital was undertaken between July 2009 and June 2010. Patients, American Society of Anesthesiologists physical status I–III and older than 18 years, were approached in the preoperative clinic, and informed written consent was obtained from each of them. Exclusion criteria were allergy to lidocaine, contraindication to have TEA, chronic treatment with opioid, inability to communicate in either French or English or to understand the purpose of the study, severe physical disability, or metastatic carcinoma.

Anesthesia and Analgesia

No premedication was administered. All patients underwent general anesthesia. On the day of surgery and before the induction of general anesthesia, patients were randomly assigned, using a computer-generated number sealed in a brown envelope, to 2 groups: epidural (TEA) and IV lidocaine (IL).

In the TEA group, an epidural catheter was inserted before induction of general anesthesia in either the eighth or ninth thoracic intervertebral space, and lidocaine 2% 3 mL followed by bupivacaine 0.25% 5 to 10 mL was injected in the epidural space to produce a bilateral segmental sensory block to ice and pinprick between T4 and L3 dermatomes. The neural blockade was maintained during surgery with additional infusion of 5 to 8 mL/hr of bupivacaine 0.25%. A continuous epidural analgesia with bupivacaine 0.1% and morphine 0.02 mg/mL was started in the postanesthesia care unit (PACU) and continued for 48 hrs on the surgical ward. The segmental sensory block was assessed daily by the acute pain service team using ice and pinprick, and the infusion adjusted to maintain a bilateral sensory block between T7 and L3 (area of surgical incision); pain intensity was assessed by verbal rate scale (VRS), ranging from 0 (no pain) to 10 (worst possible pain) at rest, on walking and on coughing. If the VRS at rest exceeded 4, the rate of epidural infusion was increased by increments of 1 mL to a maximum of 15 mL/hr. No rescue analgesia with systemic morphine was used.

In the IL group, patients received, via a separate IV catheter, a bolus of lidocaine 1.5 mg/kg (maximum, 100 mg) just before the induction of anesthesia, followed by an IV infusion of lidocaine 2 mg/kg per hour for the whole surgical procedure. The infusion was then decreased to 1 mg/kg per hour in the PACU and continued for the first 48 postoperative hours. As a rescue analgesia, patients in the IL group received patient-controlled analgesia (PCA) using IV morphine for 48 hrs. The PCA was set up at 1 to 2 mg every 7 mins with no background infusion and was increased if the VRS at rest exceeded 4 at rest. If the VRS at rest in both groups exceeds 4 at 48 hours after surgery, TEA or IL infusion would continue, and VRS reassessed every 2 hours.

General anesthesia was induced in both groups with fentanyl 1.5 µg/kg and propofol 2 mg/kg, and orotracheal intubation was achieved with rocuronium. Intraoperative muscle relaxation was monitored with a neuromuscular nerve stimulator. Supplemental doses of 50 µg of fentanyl were administered if intraoperative blood pressure and heart rate were 25% greater than those of baseline. Anesthesia was maintained with desflurane in a mixture of air 40% and O₂ 60%, and end-tidal concentration of desflurane was adjusted to maintain Bispectral Index (BIS) within 40 to 60. Systolic arterial blood pressure was maintained within 20% of baseline values, and hypotension was treated with IV phenylephrine. A thermal blanket was positioned over the exposed parts of the body to maintain perioperative normothermia (temperature, >36°C). All patients received an IV infusion of sodium chloride 0.9% at a rate of 6 mL/kg per hour and 500 mL of plasma expander. Thirty

minutes before termination of anesthesia, ketorolac 30 mg was administered IV unless there was a contraindication (history of peptic ulcer or renal disease). Prevention of postoperative nausea and vomiting was achieved with droperidol 0.625 mg and dexamethasone 8 mg.

In both groups, multimodal analgesia included 500 mg of naproxen twice a day and acetaminophen 1 g 4 times a day for up to 5 days. Both epidural and lidocaine with PCA were discontinued 48 hrs after surgery if VRS at rest was less than 4, and oral oxycodone 5 to 10 mg was then provided every 4 hrs as breakthrough medication.

Surgical Care

Three experienced laparoscopic surgeons (B.S., S.L., and P.C.) performed all the procedures. All patients had a same-day admission. Mechanical bowel preparation was used for all sigmoid and rectal procedures. Cefazolin 2 g and metronidazole 500 mg were administered 30 mins before induction of anesthesia. Antiembolic stockings were applied before positioning patients on the operating table, and unfractionated heparin 5000 U was injected subcutaneously 1 hr into the surgery.

Laparoscopy was achieved using a 12-mm untipped Hasson cannula inserted under direct vision into the peritoneal cavity through a small vertical infraumbilical incision to establish the pneumoperitoneum, which was maintained with carbon dioxide insufflation to a pressure of 12 mm Hg. This incision was later extended to 4 to 5 cm to deliver the colon or sigmoid for resection and reanastomosis. Three additional 5-mm trocars were inserted under laparoscopic vision. For right and left colectomy, the colon was completely mobilized laparoscopically, and the blood vessels divided intracorporeally. The resection and anastomosis was performed extracorporeally. For rectal resections, the anastomosis was completed extracorporeally through a 10-cm horizontal incision and using the double-shaped end-to-end anastomotic circular stapling technique. Nasogastric tube and abdominal drains were not used.

The ERP started to be implemented in 2008 in this institution, and the major components of this perioperative program are composed of preoperative education; reduction of unnecessary bowel preparation and preoperative fasting; surgical stress reduction; avoidance of excess IV fluid infusion; early removal of nasogastric tube, urinary catheter, and other drains; earlier oral intake; and encouraged mobilization, which have been previously described.⁸

Outcome Measures

All the postoperative data were collected daily by the research assistant unaware of the hypothesis. During the first 3 postoperative days, the research assistant would collect data from the patients' diary and from the patients' medication record. The acute pain service and the ward nurses followed the clinical pathway that has been set up by the ERP.

The primary outcome was time to return of bowel function as measured by time (in hours) from the end of surgery to passage of flatus and bowel movements. The secondary outcome measure was quality of postoperative analgesia, as assessed by VRS at rest, on walking, and on coughing at 24, 48, and 72 hrs after an surgery. Intermediate outcomes included time to first fluid intake and to full diet, time out of bed either sitting or walking, incidence of nausea and vomiting, duration of hospital stay defined as time spent in the hospital from the day of admission to the day of hospital discharge, incidence of medical and surgical complications, and readmission rate.

Complications were defined as follows: ileus as abdominal distension, no flatus or bowel movement, or nausea/vomiting

that prevents oral intake or requires therapeutic use of nasogastric tube. Urinary retention was failure to pass urine requiring insertion of urinary catheter. Surgical complications were categorized as anastomotic leak, intra-abdominal collection diagnosed by clinical or radiology, bowel obstruction, and wound infection.

Statistical Analysis

The 2 interventions, TEA and lidocaine infusion, have previously been shown to be superior to parenteral morphine in the colorectal surgery population, and therefore, it was decided not to include the parenteral morphine group as a control group.

The sample size was calculated base on the results previously published in patients undergoing laparoscopic colorectal resection using ERP setting. The average time to return of bowel movements in the epidural subgroup of the study of Basse et al⁵ was 48 (SD, 20) hrs, whereas in the lidocaine subgroup of the study of Kaba et al,¹⁵ it was 32 (SD, 19) hrs. Twenty-five subjects in each group were sufficient to demonstrate a difference in time to return of the bowel movement with a type I error of 0.05 and a power of 80%. The number was increased to 30 patients to include dropouts.

Data were collected on the standard forms and entered into a private computer database. Categorical variables were analyzed by χ^2 test and Fisher exact test. Continuous variables are presented as mean (SD) (95% confidence interval [CI]) or median and interquartile range and when data were not normally distributed and were compared between groups using either a 2-tailed Student *t* test or the Mann-Whitney *U* test. All statistical tests were 2-tailed at a significant level of 0.05. Statistical analysis was performed using SPSS version 18 for Windows (SPSS Inc, Chicago, Ill).

RESULTS

Patient Selection

A total of 75 eligible patients were enrolled in this study. Seven patients did not meet our study criteria, 5 patients refused to participate, and drug interaction with lidocaine led to exclusion of 1 patient. Thus, 62 patients were randomized and

assigned equally to both groups. Two patients had to be excluded from final analysis: 1 patient in the TEA group for conversion to laparotomy, and 1 patient in the IL group for unknown drug reaction (Fig. 1).

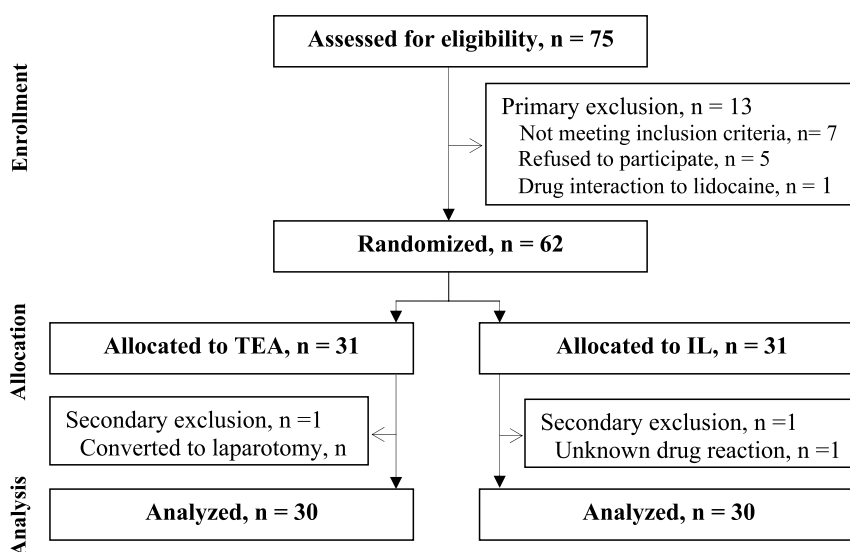
The demographic characteristics and the clinical data of the 2 groups were similar (Table 1). The diagnosis, type of surgery, need for ileostomy, and comorbidities were equally distributed in both groups. There were no differences in intraoperative opioid consumption, BIS, end-tidal desflurane concentration, amount of IV fluid replacement and blood loss, duration of surgery, and number of patients who have episodes of hypotension and vasopressor use (Table 2). Hypotension is defined as decreasing in blood pressure below baseline more than 10 mins. No patients showed signs of lidocaine toxicity in the postoperative period.

Postoperative Gastrointestinal Function

Postoperative return of bowel function, flatus and bowel movements, showed similar results in the both TEA and IL groups (Table 3). Time to return of flatus was significantly faster in the subgroup who had primary rectal anastomosis compared with those who had primary colonic anastomosis (20 [SD, 9] [24–32] hrs vs 28 [SD, 11] [14–26] hrs; *P* = 0.032). There was no difference in return of bowel movements between these 2 subgroups.

Postoperative Pain Relief and Analgesic Medication

Data on postoperative VRS pain at rest, on walking, and on coughing are presented in Table 4 for the colonic and the rectal resections. Although the 2 subgroups undergoing colonic resection were similar, there was significantly less pain in the TEA group at rest and on walking. Epidural catheter and PCA morphine were used for the first 2 postoperative days and stopped on the morning of postoperative day 2. Epidural failure occurred in 1 patient within the first 24 hrs, and the epidural catheter was reinserted in the PACU, and an adequate quality of analgesia was achieved. The consumption of morphine was recorded for each postoperative day during the first 2 days after surgery. In the TEA group, the median consumption of epidural morphine



TEA = thoracic epidural analgesia; IL = intravenous lidocaine.

FIGURE 1. Study design according to the CONSORT diagram showing the flow of participants through each stage of a randomized trial.

TABLE 1. Demographic Characteristics and Clinical Data of 2 Studied Groups

	TEA (n = 30)	IL (n = 30)
Age, mean (SD), y	61 (15)	58 (16)
Sex (male/female), n	19/11	19/11
Weight, mean (SD), kg	74 (15)	80 (20)
BMI, mean (SD), kg/m ²	26 (4)	28 (7)
ASA (I/II/III), n	12/14/4	9/20/1
Diagnosis, n (%)		
Cancer	21 (70)	17 (57)
Polyps	6 (20)	5 (16)
Diverticular disease	1 (3)	2 (7)
Inflammatory bowel disease	2 (7)	6 (20)
Type of surgery, n (%)		
Right hemicolectomy	10 (33)	9 (30)
Left hemicolectomy	3 (10)	4 (13)
Sigmoid resection	2 (7)	4 (13)
Anterior resection	7 (23)	3 (10)
Low anterior resection	6 (20)	6 (20)
Proctocolectomy	2 (7)	4 (14)
With ileostomy	8 (27)	9 (30)
Comorbidity, n (%)		
Hypertension	9 (30)	10 (33)
Diabetes	4 (13)	0 (0)
Coronary artery disease	3 (10)	1 (3)
Dyslipidemia	2 (7)	3 (10)
Asthma	2 (7)	1 (3)
Atrial fibrillation	2 (7)	0 (0)
Anemia	1 (3)	1 (3)
Obstructive sleep apnea	1 (3)	1 (3)
Chronic obstructive pulmonary disease	1 (3)	0 (0)

BMI indicates body mass index; ASA, American Society of Anesthesiologists.

for the first and second 24 hrs was 3.8 (3.3–4.9) mg and 2.9 (2.0–3.5) mg, respectively. In the IL group, IV morphine for the same period was 25.5 (17–41) and 8.5 (0–31) mg respectively. On postoperative day 3, the median value of oral oxycodone was 27.5 (20–35) mg for the TEA group and 20.0 (20–32) mg for the IL group ($P = 0.434$).

TABLE 2. Intraoperative Data

	TEA (n = 30)	IL (n = 30)	P
Fentanyl consumption, mean (SD), μ g	208 (60)	235 (40)	0.104
BIS, mean (SD)	44 (7)	44 (6)	0.992
End tidal desflurane, mean (SD), %	4.7 (0.8)	5 (0.9)	0.343
Fluid resuscitation, mean (SD), L	1.7 (0.6)	1.9 (0.7)	0.223
Estimated blood loss, mean (SD), mL	308 (108)	285 (119)	0.662
Duration of surgery, mean (SD), min	213 (90)	220 (78)	0.739
No. (%) patients with hypotension	4 (13)	4 (13)	1.000
No. (%) patients using vasopressor	5 (17)	6 (20)	0.739

Data are presented as mean (SD) or absolute number (%).

TABLE 3. Time to Return of Bowel Function

Primary Anastomosis	TEA (n = 22)	IL (n = 21)	P
Time to first flatus, hr	24 (11) (19–29)	27 (12) (22–32)	0.380
Time to first bowel movement, hr	44 (19) (35–52)	43 (20) (34–52)	0.887
Primary Ileostomy	TEA (n = 8)	IL (n = 9)	P
Time to first flatus, hr	25 (14) (13–36)	28 (17) (15–42)	0.614
Time to first bowel movement, hr	39 (23) (19–58)	36 (17) (23–49)	0.794

Data are presented as mean (SD) (95% confidence interval).

Postoperative Clinical Data, Incidence of Complications, and Readmission

There was no difference between the 2 groups in the time to the first fluid and full dietary intake and time out of bed either sitting or walking over the first 3 postoperative days

TABLE 4. VRS Pain at Rest, on Walking, and on Coughing in the 2 Subgroups, Colon and Rectum

Colon	TEA (n = 15)	IL (n = 17)	P
VRS at rest			
At 24 hrs	2 (0–3)	2 (0–2)	0.556
At 48 hrs	0 (0–2)	0 (0–2.5)	0.789
At 72 hrs	1 (0–2)	1 (0–1.5)	0.426
VRS on walking			
At 24 hrs	2 (1–3)	3 (2–4)	0.210
At 48 hrs	2 (0–2)	3 (0.5–4)	0.104
At 72 hrs	1 (0–3)	1 (0–3)	0.798
VRS on coughing			
At 24 hrs	4 (2–5)	4 (3–5)	0.969
At 48 hrs	3 (1–4)	4 (1–5)	0.219
At 72 hrs	2 (0–3)	2 (0–4)	0.344
Rectal	TEA (n = 15)	IL (n = 13)	P
VRS at rest			
At 24 hrs	0 (0–2)	3 (1.5–3)	0.023
At 48 hrs	0 (0–2)	3 (1–3)	0.008
At 72 hrs	2 (0–2)	2 (1–2.5)	0.248
VRS on walking			
At 24 hrs	2 (0–4)	4 (2.5–5)	0.207
At 48 hrs	2 (0–2)	4 (2.5–5.5)	0.032
At 72 hrs	1 (0–3)	3 (1.5–4.5)	0.028
VRS on coughing, cm			
At 24 hrs	5 (0–6)	4 (1.5–6)	0.944
At 48 hrs	4 (0–4)	4 (2.5–6)	0.227
At 72 hrs	2 (1–5)	4 (2.5–5)	0.149
Morphine consumption, mg	Via Epidural (n = 30)	Via PCA (n = 30)	P
At 24 hrs	3.8 (3.3–4.9)	25.5 (17–41)	—
At 48 hrs	2.9 (2.0–3.5)	8.5 (0–31)	—
Oral oxycodone, mg			
At 72 hrs	27.5 (20–35)	20.0 (20–32)	0.434

Data are presented as median (interquartile range). Verbal rate scale = 0–10.

TABLE 5. Clinical Data of Postoperative Period

	TEA (n = 30)	IL (n = 30)	P
Time to first drink, hr	4.25 (3–6)	3.75 (2–6)	0.252
Time to first full diet, hr	35 (22–51)	38 (22–46)	0.894
Time sitting out of bed, min			
Day 1	90 (28–135)	120 (27–240)	0.603
Day 2	83 (28–300)	120 (30–360)	0.528
Day 3	125 (30–338)	120 (30–375)	0.801
Time walking out of bed, min			
Day 1	10 (2–15)	9 (3–15)	0.788
Day 2	25 (10–40)	15 (10–46)	0.870
Day 3	30 (12–60)	30 (14–60)	0.817
Readiness to discharge, d	3 (3–4)	3 (3–4)	0.534
Hospital stay, d	3 (3–4)	3 (3–4)	0.744
Nausea	17 (57%)	11 (37%)	0.438
Vomiting	18 (60%)	12 (40%)	0.791
Postoperative complications in hospital			
Urinary retention	3 (10%)	0 (0%)	0.076
Ileus	2 (7%)	6 (20%)	0.129
Bleeding per rectum	1 (3%)	0 (0%)	0.313
Exudate from stoma	0 (0%)	1 (3%)	0.313
Other medical complications	2 (7%)	1 (3%)	0.554

Data are presented as median (interquartile range) or absolute number (%).

(Table 5). Readiness for discharge and length of hospital stay were also similar. Postoperative nausea and vomiting occurred in both groups with the same incidence. There was a higher incidence of urinary retention in the TEA group, but similar number of medical and surgical complications.

The distribution of duration of hospital stay is presented in Figure 2. Sixty percent of patients in each group were discharged home on postoperative day 3 and 80% on day 4, with the maximum duration of hospital stay of 9 days in both groups. The reasons for hospital discharge beyond postoperative day 3 are presented in Table 6.

Readmission occurred in 7 patients (23.3%) in both TEA and lidocaine groups (Table 7). The highest incidence of com-

plication was anastomotic leak, which occurred in 6 patients: 3 patients had computed tomography-guided drainage for releasing intra-abdominal collection, 2 patients were reoperated on, and the other patient received conservative treatment because of the small amount of intra-abdominal collection. Four patients having small-bowel obstruction were treated by conservative treatment. Two patients revisited the hospital with abdominal pain and were treated conservatively, and no evidence of anastomotic leak was found. The rate of readmission in the 2 groups was similar in the 2 groups; however, the duration of hospital stay during the readmission period was longer in the IL group. ($P = 0.053$).

DISCUSSION

The results of this prospective randomized study demonstrated that, when the ERP was implemented, the average return of bowel movement after laparoscopic surgery was within the first 48 hrs, with no difference between IV lidocaine and TEA. In addition, duration of hospital stay and rate of readmission were similar with these 2 techniques.

During the past 2 decades, laparoscopic approach to colorectal surgery has gained more popularity because of better short- and long-term outcomes. A meta-analysis published in 2006,² and subsequently confirmed more recently by a systematic review and meta-analysis,^{1,7} showed that laparoscopy for colorectal cancer resulted in a faster return of bowel movement by 0.6 to 1.3 days and less postoperative pain, thus facilitating a shorter hospital stay by approximately 2 days when compared with open surgery.² In addition, there was no increase in the rate of surgical complications and oncology outcome.⁶ However, at close scrutiny, return of bowel movement was still longer than 72 hrs,^{2,4,7} with an average postoperative hospital stay of at least 7 days.^{2,4,8}

Thoracic epidural analgesia has been shown in open colorectal surgery not only to have superior analgesic effect over systemic morphine, but also to accelerate significantly the recovery of bowel function by 1 to 2 days.^{12,14,20} It has also been the case when the laparoscopic approach was used; however, the benefits of TEA on accelerating the return of bowel function have not been consistent. In some studies, the use of TEA was shown to be beneficial as it provided excellent analgesia and shortened the return of bowel function,^{13,21} but this was not the case in an earlier study that did not report a significant difference

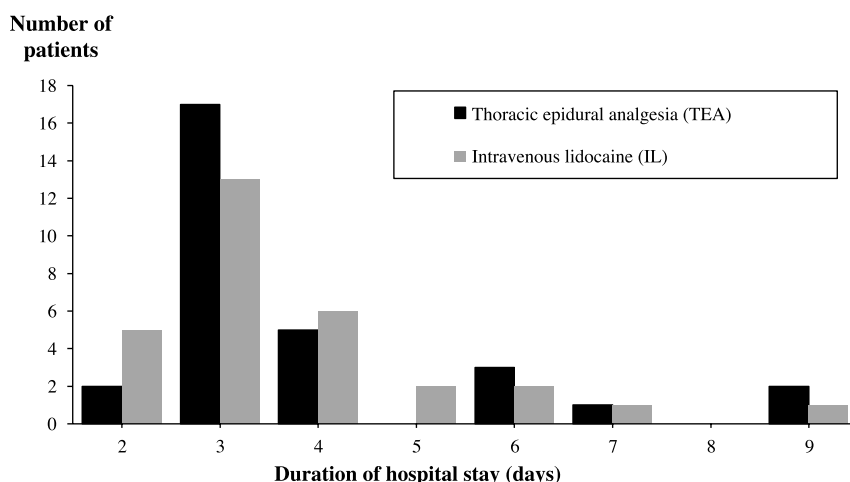
**FIGURE 2.** Distribution of duration of hospital stay.

TABLE 6. Reasons for Hospital Discharge Beyond Postoperative Day 3

	Age, y	Sex	BMI, kg/m ²	ASA	Diagnosis	LOS, d	Reason for Delayed Discharge
TEA							
Right hemicolectomy	24	M	25	1	Polyp	4	Social reason
Sigmoid resection	60	F	14	1	Cancer	4	Urinary retention
Anterior resection	71	M	33	3	Cancer	4	Urinary retention
Low anterior resection	73	M	24	2	Cancer	4	Social reason
Anterior resection	48	M	28	1	Cancer	4	Social reason
Right hemicolectomy	64	M	33	1	Cancer	6	Urinary retention
Right hemicolectomy	78	F	23	2	Polyp	6	Bleeding per rectum
Sigmoid resection	60	F	28	2	Cancer	6	Chest pain
Low anterior resection	83	M	27	3	Polyp	7	Asthmatic attack
Low anterior resection	71	M	28	2	Cancer	9	Ileus
Proctocolectomy	63	F	21	2	IBD	9	Ileus
IL							
Left hemicolectomy	52	M	31	1	Polyp	4	Ileus
Sigmoid resection	45	M	52	2	Cancer	4	Social reason
Anterior resection	46	F	20	1	Diverticulitis	4	Ileus
Low anterior resection	78	M	26	2	Cancer	4	Social reason
Low anterior resection + ileostomy	73	M	40	2	Cancer	4	Exudate from stoma
Low anterior resection + ileostomy	86	F	24	2	Cancer	4	Social reason
Left hemicolectomy	57	M	24	1	Diverticulitis	5	Ileus
Low anterior resection	56	F	28	1	Cancer	5	Social reason
Right hemicolectomy	68	M	29	2	Cancer	6	Ileus
Left hemicolectomy	76	M	27	2	Cancer	6	Hypertension
Proctocolectomy + ileostomy	51	M	28	2	IBD	7	Ileus
Proctocolectomy	68	F	28	2	IBD	9	Ileus

BMI indicates body mass index; ASA, American Society of Anesthesiologists; LOS, length of hospital stay after the surgery; M, male; F, female; IBD, inflammatory bowel disease.

with parenteral morphine.²² It has to be said that the 2 former studies did not incorporate in their practice an ERP, and this might explain their results. It appears therefore that when the ERP is part of the surgical care, the effects of TEA on dietary intake and bowel function are less evident. This is the case with the findings reported in 4 studies,^{5,8,22,23} where laparoscopy, TEA, and ERP influenced positively the length of hospital stay, the return of bowel function, and the quality of analgesia. Similarly, pain scores were significant lower,^{21,22} and return of bowel movements occurred within 2 days after surgery in the ERP setting.^{21,23}

In the present study, the median time to return of bowel movements and duration of hospital stay in both TEA and lidocaine groups were 44 hrs and 3 days, respectively, and similar to those reported by others.^{21–23} These findings would imply that, although TEA appears to be an important component facilitating the recovery process after bowel surgery, the analgesic technique of IV lidocaine could provide similar benefits and an equivalent return in bowel function.

Intravenous lidocaine has been shown to have analgesic, antihyperalgesic, and anti-inflammatory properties, which can attenuate the excessive inflammatory response associated with visceral surgery.^{15–17} Although the exact mechanism is not known, it seems that lidocaine targets different steps within the inflammatory cascade, such as intracellular G protein-coupled receptors and complement and proinflammatory cytokines,^{17,24} thus blocking neural transmission at the site of tissue injury. Perioperative and postoperative IV lidocaine has been shown to provide adequate postoperative pain relief with a significant

decrease in opioid consumption following major abdominal surgery.¹⁶ In the present study, the overall quality of analgesia was similar in those patients undergoing colonic resection; however, it was not the case in patients with rectal resection. This might be explained by the use of an 8-cm subumbilical incision with greater nociception, perhaps, than produced by the 4- to 5-cm incision in the group without rectal anastomosis.

The beneficial effect of IV lidocaine on bowel function in patients undergoing elective open colorectal surgery has been reported in several studies in non-ERP and ERP settings.^{15,17} In both instances, the use of lidocaine was associated with faster return of bowel function and shorter hospital stay.¹⁷ More recent data in colon surgery using a laparoscopic approach and an ERP have shown that IV lidocaine improved postoperative analgesia and bowel function compared with placebo. The benefits were associated with a significant reduction in hospital stay (2 [2–3] vs 3 [3–4] days; $P = 0.001$).¹⁵ These findings, to some extent, are confirmed in the present study with similar length of hospital stay, even though our population was composed of more than 70% of cancers and 50% of all resections were rectal.

Enhanced recovery program, also called accelerated recovery strategy or fast-track, was introduced in the mid-1990s as a coordinated multidisciplinary perioperative care plan aimed to reduce postoperative complications and to allow a faster recovery of daily activities.¹⁷ This approach included the following: revision of the traditional perioperative care, optimization of anesthetic and analgesic techniques, improved knowledge of perioperative organ dysfunction, and minimally invasive surgery.^{8,9} All the major components of the ERP, such as surgical

TABLE 7. Clinical Data of Readmission to Hospital

	Age, y	Sex	BMI, kg/m ²	ASA	Diagnosis	LOS,* d	Readmission		
							Reason for Readmission	POD	LOS,† d
TEA									
Right hemicolectomy + ileostomy	64	M	33	1	Cancer	6	Anastomotic leak	9	12
Right hemicolectomy	77	M	29	2	Polyp	3	Urinary retention	3	2
Right hemicolectomy	64	M	30	1	Cancer	3	Anastomotic leak	17	2
Anterior resection	65	M	29	3	Cancer	3	Bleeding per wound	5	0
Low anterior resection	83	M	27	3	Polyp	7	Anastomotic leak	6	2
Proctocolectomy + ileostomy	22	M	22	1	Polyp	4	Small-bowel obstruction	5	4
Proctocolectomy + ileostomy	63	F	21	2	IBD	9	Anastomotic leak	4	0
Median	64		28			3		13	2
Interquartile range	63–73		22–30			3–7		8–17	0–4
IL									
Right hemicolectomy	21	F	18	2	IBD	3	Anastomotic leak	5	2
Left hemicolectomy	57	M	24	1	Diverticulitis	5	Anastomotic leak	4	19
Sigmoid resection	59	M	24	2	Cancer	4	Anastomotic leak	2	29
Anterior resection + ileostomy	76	M	26	3	Cancer	4	Small-bowel obstruction	2	11
Low anterior resection + ileostomy	53	M	34	2	Cancer	3	Anastomotic leak	4	12
Proctocolectomy + ileostomy	41	M	34	1	IBD	3	Small-bowel obstruction	17	3
Proctocolectomy + ileostomy	51	M	28	2	IBD	7	Small-bowel obstruction	3	5
Median	53		26			3		8	11
Interquartile range	41–59		23–34			3–5		6–10	3–19
<i>P</i>	0.073		0.902			0.535		0.259	0.053

Data are presented as absolute number or median (interquartile range).

*Length of hospital stay after the surgery.

†Length of hospital stay after readmission.

BMI indicates body mass index; ASA, American Society of Anesthesiologists; POD, postoperative day (the interval between first discharge from hospital and readmission); IBD, inflammatory bowel disease.

stress reduction, avoidance of excess IV fluid infusion, earlier oral intake, and encouraged mobilization, have independently been shown to impact positively on patient outcome,^{8–10} and when combined, they have led to a significant reduction in length of hospital stay, down to 3 to 5 days after open colorectal surgery²⁵ and to 2 to 4 days after laparoscopic surgery.^{5,8} Also, return to normal activities was shown to be accelerated.⁵

Although the average readiness for discharge in the present study was 3 days, only 60% of all patients left the hospital on day 3, and this was independent of the analgesia group. As reported in Table 5, 11 patients (18%) left on day 4 for reasons not strictly related to the surgical technique, such as social reason and ileus, thus potentially amenable to modifications. The in-hospital complication rate was similar in both groups, averaging 26%.

Readmission rate was 23%, with no difference between the 2 groups. Fifty-seven percent of the readmissions occurred in patients who has rectal surgery, and this is in agreement with the literature indicating a higher number of readmissions in this subgroup.^{5,8} Nine (64 %) of 14 patients were readmitted within the first 5 days after discharge, and 43% stayed for less than 3 days. Except for one, all reasons for readmission were surgically related, and only 2 patients were reoperated on. These findings would indicate that perhaps some of the readmissions could have been avoided if patients were kept in hospital longer.²⁶

Previous authors have commented on the difficulty to achieve sufficient adherence to the principles of the ERP, particularly in the postoperative period.²⁷ In the present study, al-

though return to oral dietary intake was achieved within a time frame in more than 70% of patients, few were able to mobilize out of bed effectively and for a long period. Yet, ability to ambulate independently is part of the discharge criteria. Preliminary attempts to introduce validated walking tests to assess functional capacity in surgical populations have indicated that these tests can be used to determine the impact of analgesia and can predict long-term outcomes.^{28,29} Therefore, there is a need to identify if these measures of functional outcome in the colorectal surgery population besides hospital length of stay and return of bowel function are clinically meaningful when assessing the safety of a clinical pathway.

There are some limitations associated with this study. Presence of a control group receiving PCA morphine would have facilitated the comparison of the 2 interventions versus what is considered standard practice in laparoscopic surgery. However, there is published evidence demonstrating the superiority of the 2 interventions versus systemic morphine. Because of different design and patient population studied, it was difficult to hypothesize which of these 2 techniques, epidural or IV lidocaine, would have had a greater impact on return of bowel function.

The definition and management of ileus were not standardized in the present study, and this might imply that the incidence of ileus was greater than 12% reported. Recently, a classification of ileus has been proposed, and efforts should be made to report this important complication in a more systematic fashion.³⁰

In conclusion, the findings of this study demonstrate that, in the context of an ERP, perioperative IV infusion of lidocaine has the same impact on postoperative restoration of bowel function as TEA, with equal incidence of complications and duration of hospital stay.

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