Epidural *versus* Continuous Preperitoneal Analgesia during Fast-track Open Colorectal Surgery

A Randomized Controlled Trial

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ABSTRACT

Background: Effective postoperative analgesia is essential for early rehabilitation after surgery. Continuous wound infiltration (CWI) of local anesthetics has been proposed as an alternative to epidural analgesia (EA) during colorectal surgery. This prospective, double-blind trial compared CWI and EA in patients undergoing elective open colorectal surgery.

Methods: Fifty consecutive patients were randomized to receive EA or CWI for 48 h. In both groups, patients were managed according to Enhanced Recovery After Surgery recommendations. The primary outcome was the dynamic pain score measured during mobilization 24 h after surgery (H24) using a 100-mm verbal numerical scale. Secondary outcomes were time to functional recovery, analgesic technique-related side effects, and length of hospital stay.

Results: Median postoperative dynamic pain score was lower in the EA than in the CWI group (10 [interquartile range: 1.6–20] *vs.* 37 [interquartile range: 30–49], $P < 0.001$) and remained lower until hospital discharge. The median times to return of gut function and tolerance of a normal, complete diet were shorter in the EA than in the CWI group ($P < 0.01$ each). Sleep quality was also better in the EA group, but there was no difference in urinary retention rate ($P = 0.57$). The median length of stay was lower in the EA than in the CWI group (4 [interquartile range: 3.4–5.3] days *vs.* 5.5 [interquartile range: 4.5–7] days; $P = 0.006$).

Conclusion: Within an Enhanced Recovery After Surgery program, EA provided quicker functional recovery than CWI and reduced length of hospital stay after open colorectal surgery.

What We Already Know about This Topic

- Guidelines for enhanced recovery after surgery, involving pre, intra, and postoperative care, have been released
- Epidural analgesia and continuous wound infiltration have not been compared in patients undergoing colorectal resection using Enhanced Recovery After Surgery protocols

What This Article Tells Us That Is New

- In 50 patients undergoing colorectal distension and enhanced recovery after surgery care, epidural analgesia, compared with continuous wound infiltration, reduced dynamic pain on the first postoperative day, and sleep quality, and time to return to normal gut function and to hospital discharge

OPEN colorectal surgery induces severe and prolonged postoperative pain, especially during mobilization.[1] Postoperative pain has been found to prolong immobilization, postoperative ileus, sleep disorders, and fatigue, all of which may delay hospital discharge,[2] and is a frequent cause of patient dissatisfaction.[3] Effective postoperative analgesia allowing early mobilization is therefore recognized as a prerequisite for Enhanced Recovery After Surgery programs.[4,5]

Thoracic epidural analgesia (EA) has been shown to improve postoperative analgesia after open intra-abdominal surgery than parenteral opioids.[6,7] EA was also found to reduce postoperative surgical stress,[8] attenuate postoperative ileus,[7] and improve both perioperative quality of life[9] and clinical outcomes[10] after colorectal surgery. Thus, EA is considered an important component of the multimodal Enhanced Recovery After Surgery approach for patients

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undergoing open abdominal surgery.[11–13] Nevertheless, the use of EA is frequently seen as labor intensive, and organizational constraints may explain its infrequent use after colorectal surgery.[14]

Continuous wound infiltration (CWI) of local anesthetics, using a multi-holed catheter placed in the preperitoneal space, has been found to improve pain relief and to accelerate patient recovery, compared with systemic opioids, after open colorectal surgery.[15] CWI may also be more cost-effective than EA.[16] Because of its intuitive simplicity, CWI has been proposed as an attractive alternative to EA after colorectal surgery, although CWI alone may be not sufficient to avoid the need for postoperative opioid.[17] To our knowledge, however, CWI and EA have never been compared within a multimodal enhanced recovery program. We therefore examined the effects of EA and CWI of local anesthetics, within a multimodal enhanced recovery program, in patients who underwent open colorectal surgery. We hypothesized that EA may be more efficient than CWI in providing greater postoperative pain relief and may allow earlier mobilization after surgery.

Materials and Methods

This prospective, randomized, double-blind, single-center study was approved by the Institutional Review Board (Comité de Protection des Personnes Sud-Est VI, Clermont-Ferrand, France, No. 2009-012229-13), and written informed consent was obtained from all patients (Trial registration: EudraCT number: 2009-012229-13; ClinicalTrials.gov Identifier: NCT00915265).

Study Population

Consecutive adult patients undergoing elective open colorectal resection through a periumbilical midline incision, but not involving a stoma, between October 2009 and April 2012, and with American Society of Anesthesiologists physiological status I to III were enrolled. Exclusion criteria were consent refusal, severe obesity (body mass index $\geq 35\ kg/m^2$), pregnancy, and any contraindication to the use of epidural catheter or nonsteroidal anti-inflammatory drugs. We also excluded patients with chronic pain, preoperative opioid consumption, impaired cognitive function, or psychiatric disorder and patients with inflammatory bowel diseases.

Perioperative Care

All patients were managed according to Enhanced Recovery After Surgery recommendations.[13] Patients undergoing left-sided and rectal resections underwent bowel preparation using polyethylene glycol the night before surgery, whereas patients undergoing right-sided resections did not undergo bowel preparation. All surgical procedures were performed by senior surgeons. Patients did not fast preoperatively, and the use of a nasogastric tube and drains was avoided, in accordance with fast-track recommendations.[13] Patients received short-acting premedication with oral hydroxyzine (1 mg/kg) 1 h before anesthesia induction. Standard monitoring included continuous electrocardiography and continuous recording of heart rate, blood pressure, pulse oximetry, end-tidal carbon dioxide concentration, and body temperature. All patients had urinary catheters. Anesthesia was induced with propofol (2 mg/kg), sufentanil (0.2–0.3 μg/kg), and cisatracurium (0.15 mg/kg) and was maintained with desflurane to target a bispectral index (BIS Technology, Aspect Medical Systems, Meern, The Netherlands) between 40 and 50. After the trachea was intubated, the lungs were mechanically ventilated using a positive end-expiratory pressure of 5 cm H_2O and an inspired oxygen fraction of 80%.[18] Muscle paralysis was maintained with subsequent bolus doses of cisatracurium as indicated by orbicular nerve stimulation (train-of-four). Normothermia was maintained using a convective air system (WarmTouch; Tyco Healthcare, Pleasanton, CA). Prophylactic antibiotics were given as recommended.[19]

In all patients, intraoperative intravenous fluid was minimized with individualized goal-directed fluid replacement using esophageal Doppler monitoring (Waki™, Atys Medical, Soucieu-en-Jarrest, France).

Study Protocol

Before admission to the operating room, patients were randomly assigned in a 1:1 ratio for parallel arms and using a concealed allocation approach (computer-generated codes; SEM software, version 2.0)[20] with sealed envelopes to (1) the CWI group with a sham epidural or (2) the EA group with a sham CWI. There was no stratification and blocking on randomization. Study investigators, but not anesthesiologists, were blinded to treatment assignments. Patients in the CWI group underwent a sham epidural puncture before induction of anesthesia, and the catheter was attached to the skin. At the end of surgery, a multi-holed catheter was positioned between the closed parietal peritoneum and the transversalis fascia,[15] and 10 ml 0.2% ropivacaine was administered, followed by a continuous infusion at a constant rate of 10 ml/h. Intraoperative analgesia was maintained using a continuous infusion of sufentanil ($0.1–0.2\ \mu g\ kg^{-1}\ h^{-1}$). Before induction of anesthesia in the EA group, patients underwent insertion of an epidural catheter, between T9 and T11 in patients undergoing left-sided and rectal resections and between T8 and T10 in patients undergoing right-sided resections. Patients received a bolus of 5 ml 0.375% ropivacaine, followed by continuous infusion at 5 ml/h throughout the surgical procedure; patients in this group did not receive sufentanil during surgery. At the end of the operation, a multi-holed catheter was positioned in the same space, and patients were administered a bolus of 10 ml 0.9% saline followed by continuous infusion at 10 ml/h. Patients in both groups received preemptive analgesia (1 g intravenous acetaminophen, 20 mg nefopam) and antiemetic drugs (8 mg dexamethasone sodium phosphate, 1-mg droperidol) 10 min before the end of the operation.

Postoperative Care

All patients underwent tracheal extubation according to previously defined criteria before discharge from the operating room. Postoperative analgesia was started after arrival in the postanesthesia care unit (PACU) and was titrated using patient-controlled analgesia pumps (Alaris Medical System, Hampshire, United Kingdom), with an opaque envelope placed around the syringe to ensure that ward nurses and study investigators remained blinded. Patients in the EA group received patient-controlled EA using a mixture of 0.2% ropivacaine and 0.25 μg/ml sufentanil at a constant rate of 5 ml/h, with boluses of 5 ml and a 15-min lockout time. Patients in the CWI group received patient-controlled intravenous analgesia using a mixture of 1 mg/ml morphine and 0.05 mg/ml droperidol with the pump set to deliver doses of 1-mg intravenous morphine with a 7-min lockout time. Patients were considered fit for discharge from the PACU after achieving an Aldrete score more than 8.[21] Epidural and multiholed catheters were removed from all patients 48 h after surgery, and boluses of 1-mg intravenous morphine were allowed in each group as a rescue medication thereafter. All patients were given oral acetaminophen (1 g every 6 h) and ketoprofen (50 mg every 6 h) for 48 h. Nausea and vomiting were treated with intravenous 1-mg droperidol as first-line therapy and with 4 mg intravenous ondansetron as rescue therapy. Oral fluids and feeding were started on the day after surgery. Intravenous fluid, maintained until resumption of normal food intake, consisted of 5% dextrose at 1–1.5 ml kg^{-1} h^{-1}. Urinary catheters were removed on the day after surgery. As part of the routine standard practice in our institution, postoperative hypotension, defined as a mean arterial pressure less than 65 mmHg, was treated using intravenous fluids and/or vasopressor, as appropriate. All patients were subjected to enforced early mobilization. Perioperative management was similar in both groups, except for the route of analgesia.

Postoperative Measurements

Postoperative evaluation was started immediately after extubation (hour 0 [H0]). Postoperative data were recorded by nonresearch staff (physicians not involved in the intraoperative management) three times daily until hospital discharge.

The primary endpoint was the dynamic pain score, defined as pain experienced during mobilization from the supine to the sitting position,[22] recorded using a 100-mm verbal numerical rating scale (VNS) at H24.

Secondary endpoints included static (at rest) and dynamic pain scores, measured hourly in the PACU from admission to discharge and three times daily thereafter; time to return of gut function (repeated passage of flatus and stools); time to full oral diet without discomfort; nausea and vomiting requiring treatment with ondansetron; quality of sleep at night, recorded each morning using a 100-mm visual analog scale;[15] and analgesic technique-related side effects, especially urinary retention requiring replacement of a urinary catheter and sedation scores measured at H1, H2, and H4 and twice daily using a 4-point rating scale.[15] Postoperative morbidity and readmission rate were assessed prospectively using defined criteria.[23,24] Length of hospital stay was assessed twice daily from the start of surgery, as described previously.[15] Criteria for hospital discharge were apyrexia defined as central core temperature between 36.7 and 37.8°C, leukocyte count less than 12 10^9/l, absence of anemia with clinical repercussion (no dyspnea at rest, no orthostatic hypotension), resumption of normal bowel function (bowel movement without diarrhea), lack of nausea and/or vomiting, lack of significant pain (VNS < 2 at movement), and ability to wake up and ambulate without help.[15] All patients were evaluated for residual peri-incisional postoperative pain 3 months after surgery.

Statistical Analysis

The sample size calculation was based on the primary endpoint. On the basis of previous findings[15,25] of mean VNS scores of 27 ± 10 and 40 ± 20 during patient-controlled EA and CWI, respectively, and assuming that a mean VNS difference of at least 15 points was clinically relevant (estimated SD, 20), with a two-sided significance level of 0.05 and a power of 95%, 46 patients would be required in each group. Interim analysis on the dynamic pain scores at H24 (primary endpoint) was conducted by an independent data monitoring board after enrollment of the first 50 patients. Stopping boundaries were designed to allow termination of the study if the use of EA demonstrated lower pain scores at H24 ($P < 0.016$).[26]

Analyses were conducted on an intention-to-treat basis. The Shapiro–Wilk test was used to assess normality. Categorical and quantitative variables are presented as mean ± SD or median (interquartile range), according to the distribution of each. Student *t* test or ANOVA was used for comparisons when variables were normally distributed and variances were equivalent, with the Kruskal-Wallis H test used otherwise. Qualitative variables are presented as absolute values (%) and were compared using the chi-square test. Because VNS scores were not normally distributed (asymmetric distribution), the Kruskal-Wallis H test was used. *Post hoc* analyses were performed with the Bonferroni correction to control for multiple comparisons of VNS scores. *P* values less than 0.05 were considered statistically significant. Data were analyzed using SEM software (version 2.0).[20]

Results

For ethical reasons, the independent monitoring board stopped the trial after interim analysis of the first 50 patients showed lower pain scores at H24 in addition to a significant between-group difference in the duration of hospital stay ($P = 0.006$).

Of the 60 patients initially enrolled, six refused to participate; the remaining 54 matched the study criteria and were randomized. Four patients were excluded from analysis

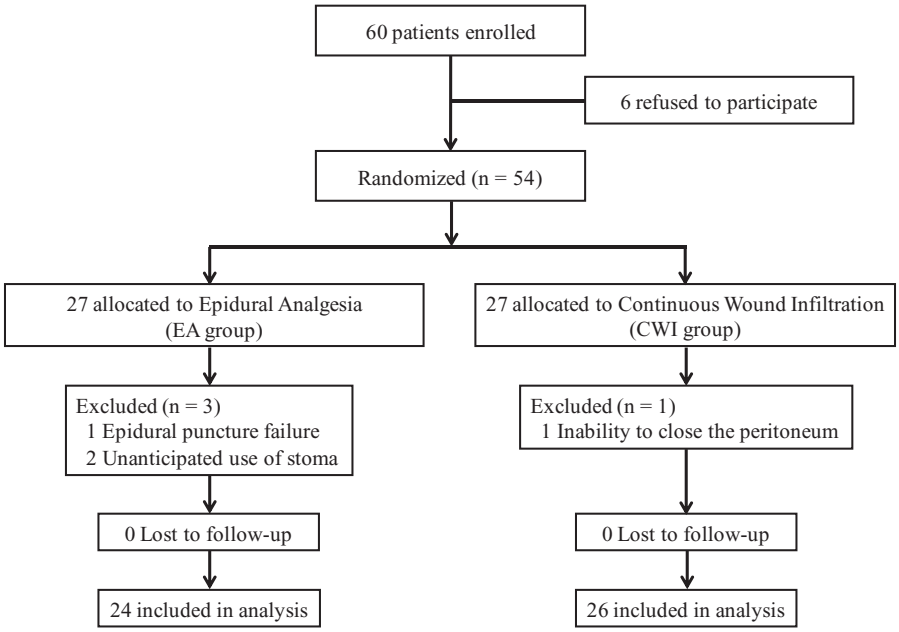

Fig.1. Flow diagram of patients in this study.

because of an intraoperative decision to use a stoma (n = 2), failure of epidural puncture (n = 1), and inability to close the peritoneum (n = 1). Thus, 50 patients successfully completed the study, 24 in the EA and 26 in the CWI group, and were included in the analysis (fig. 1). Complete 3-month follow-up data were available for all except one patient in the CWI group who developed severe postoperative respiratory failure. No relevant clinical or technical problems occurred with either of the two analgesic techniques.

The demographic and surgical characteristics of the two groups were similar, except for the intraoperative consumption of sufentanil (table 1). All patients were successfully extubated before discharge from the operating room. The mean length of stay in the operating room was similar in the EA and CWI groups (185 ± 63 min *vs.* 207 ± 74 min, $P = 0.19$).

The mean total dose of intravenous morphine in the PACU was 8 ± 7 mg for patients in the CWI group. Pain intensity and sedation levels in the PACU are shown in table 2. There was no difference in postoperative nausea and vomiting between groups, with only one patient in the EA group requiring ondansetron ($P = 0.79$). Time to reach PACU discharge criteria was significantly lower in the EA than in the CWI group (104 ± 41 min *vs.* 144 ± 56 min, $P = 0.008$).

Postoperative pain scores at rest were significantly lower in the EA than in the CWI group throughout the first 3 days after surgery, but did not differ thereafter, including on the day of hospital discharge (table 3). The median VNS of pain intensity on mobilization at H24 was lower in the EA than in the CWI group (10 [2–20] *vs.* 37 [30–49], $P < 0.001$). Dynamic pain scores during mobilization decreased steadily in the CWI group over the first three postoperative days, whereas dynamic pain scores remained fairly constant and consistently lower in the EA group. Moreover, lower dynamic VNS for the EA group was obtained at hospital discharge compared with the CWI group ($P = 0.02$, fig. 2). Total morphine consumption during the first 2 days after surgery is shown in table 3. From postoperative day 3 (after ablation of catheters) until hospital discharge, 17 patients (mean dose: 3 ± 4 mg) in the CWI group and 10 (mean dose: 1.5 ± 2 mg) in the EA group required intravenous morphine as rescue medication ($P = 0.09$).

Recovery parameters are presented in table 4. The median times to return of gut function and time to tolerate a normal full diet were both shorter in the EA than in the CWI group ($P < 0.01$ each, table 4). The groups did not differ in median dose of ondansetron ($P = 0.30$) or need for a nasogastric tube ($P = 0.81$). No patient developed postoperative sedation. The mean postoperative sleep quality score was higher in the EA than in the CWI group (70 ± 15 mm *vs.* 56 ± 10 mm, $P < 0.001$). The overall urinary retention rate requiring replacement of a urinary catheter was low (1%) and did not differ ($P = 0.57$) in the two groups. Postoperative complications are shown in table 4. The overall 30-day mortality rate was 2%, in that one patient in the CWI group died after severe postoperative respiratory failure. The median postoperative length of hospital stay was significantly shorter in the EA than in the CWI group (fig. 3). The overall readmission rate was 4%, but did not differ in the two groups ($P = 0.66$). No patient had residual peri-incisional postoperative pain 3 months after surgery.

Discussion

This double-blinded study showed that, during elective colorectal surgery within an enhanced rehabilitation program, EA resulted in lower postoperative pain scores

Table 1. Demographic and Surgical Characteristics of the Patients

	EA Group (n = 24)	CWI Group (n = 26)	*P* Value
Age, yr	63 ± 12	68 ± 9	0.07
Sex, M/F	13/11	13/13	0.77
Height, m	169 ± 10	166 ± 10	0.35
Weight, kg	73 ± 17	68 ± 12	0.22
ASA score, I/II/III	5/15/4	2/18/6	0.33
Type of surgery, n (%)			0.85
Left-sided colectomy	9 (38)	8 (31)	
Right-sided colectomy	13 (54)	15 (58)	
Rectum resection	2 (8)	3 (11)	
Type of incision, n (%)			0.59
Supraumbilical	1 (4)	1 (4)	
Subumbilical	0	2 (8)	
Both	23 (96)	23 (88)	
Size of incision, cm	19 ± 6	20 ± 6	0.59
Duration of surgical procedure, min	129 ± 62	154 ± 68	0.07
Volume of fluids, ml			0.23
Crystalloid	900 [675–1388]	1000 [1000–1500]	0.10
Colloid	125 [0–500]	0 [0–500]	0.78
Intraoperative sufentanil, µg	21 ± 14	53 ± 23	<0.001

Values are presented as mean ± SD, median [interquartile range] or absolute value (%).
ASA = American Society of Anesthesiologists physiological status; CWI = continuous wound infiltration; EA = epidural analgesia.

than CWI. EA also shortened the time to return to normal gastrointestinal function and length of hospital stay.

EA has been shown to provide greater pain relief than systemic opioids after abdominal surgery.[7] EA use avoids the administration of systemic morphine, thus enhancing rehabilitation after colorectal surgery.[5] Recently, however, the benefits of EA in patients undergoing open colorectal surgery have been challenged by the use of CWI of local anesthetics.[15,27,28] Compared with intravenous patient-controlled morphine analgesia, Beaussier *et al.*[15] nicely demonstrated that CWI using 0.2% ropivacaine for 48 h after open colonic surgery significantly reduced pain scores, both at rest and during coughing, and duration of hospitalization. In contrast to earlier studies, in which the catheter was placed in the subcutaneous space, and with CWI showing no clinical advantage,[29,30] the authors used preperitoneal placement, based on a hypothesis that the parietal peritoneum contributes to postoperative pain and ileus.[15] In the current study, using the same dose–volume procedure, we found that the dynamic pain scores with CWI were similar to those reported in the study by Beaussier *et al.*, despite the lower daily consumption of systemic morphine

Table 2. Postoperative Pain Scores (VNS) in the PACU and Sedation Levels in the Two Groups

	EA Group (n = 24)	CWI Group (n = 26)	*P* Value
Pain score (VNS) at rest, mm			
H0.5	0 [0–35]	30 [10–50]	0.021
H1	0 [0–20]	30 [20–50]	0.0026
H2	10 [0–20]	25 [12.5–37.5]	0.016
Pain score (VNS) during mobilization, mm			
H0.5	0 [0–42.5]	60 [30–70]	0.009
H1	20 [0–30]	50 [30–70]	0.003
H2	20 [0–30]	40 [32.5–70]	<0.001
Sedation level			
H1	0 [0–1]	1 [0–1]	0.46
H2	0 [0–1]	0 [0–1]	0.77
H4	0.5 [0–0.75]	0 [0–0]	0.46

Data are presented as median [interquartile range], with Bonferroni correction applied for comparisons within each scale. The threshold of statistical significance is 0.017 for VNS scores.
CWI = continuous wound infiltration; EA = epidural analgesia; PACU = postanesthesia care unit; VNS = visual numerical rating scale.

Table 3. Pain Scores (VNS) at Rest and Daily Morphine Consumption

	EA Group (n = 24)	CWI Group (n = 26)	*P* Value
VNS, Day 1			
Morning	0 [0–0]	30 [10–30]	<0.001
Afternoon	0 [0–5]	20 [10–30]	0.001
Evening	0 [0–0]	20 [10–30]	<0.001
VNS, Day 2			
Morning	0 [0–12.5]	20 [2.5–20]	0.015
Afternoon	0 [0–0]	15 [0–30]	0.018
Evening	0 [0–0]	10 [2.5–30]	<0.001
VNS, Day 3			
Morning	0 [0–10]	0 [0–20]	0.60
Afternoon	0 [0–20]	0 [0–10]	0.95
Evening	10 [0–10]	10 [0–10]	0.98
VNS, day of discharge	0 [0–10]	8 [0–20]	0.23
Daily morphine consumption, mg			
Day 1	—	18 ± 10	NR
Day 2	—	17 ± 18	NR
Day 3	2.0 ± 3.5	5.5 ± 6.4	0.034
Day 4	2.2 ± 3.4	2.1 ± 3.9	0.87

Data are presented as median [interquartile range] or mean ± SD, as appropriate, with Bonferroni correction applied for comparisons within each scale. The threshold of statistical significance is 0.017 for VNS scores.

CWI = continuous wound infiltration; EA = epidural analgesia; NR = not related; VNS = visual numerical rating scale.

by our patients. This may be due to a difference in the postoperative use of nonsteroidal anti-inflammatory drugs, which have been shown to have opioid-sparing effects.[13] It is noteworthy that the difference in the dynamic component of pain persisted on the day of hospital discharge, although effective analgesia (*i.e.*, VNS pain score ≤ 30/100 mm) was achieved in both groups.

We also found that, compared with CWI, EA improved functional recovery, which is regarded as playing a pivotal role for early rehabilitation after surgery.[13] Indeed, the recovery of normal gastrointestinal function, as assessed by times to first defecation and tolerance of full oral intake, and postoperative sleep quality were both improved with EA. These findings are consistent with those of previous studies of EA

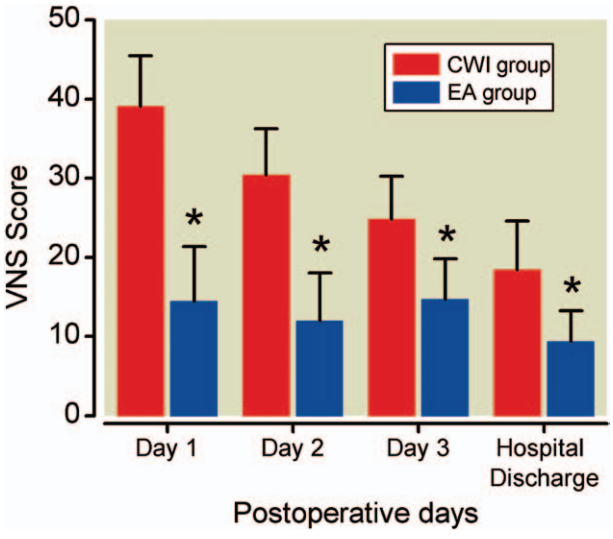

Fig.2. Postoperative pain intensity during mobilization in the EA and CWI groups assessed using a verbal numerical rating scale (VNS). VNS scores were significantly lower in the EA than in the CWI group until postoperative day 3 and remained lower at hospital discharge. Data are mean ± 95% CI. CWI = continuous wound infiltration; EA = epidural analgesia. *$P < 0.05$.

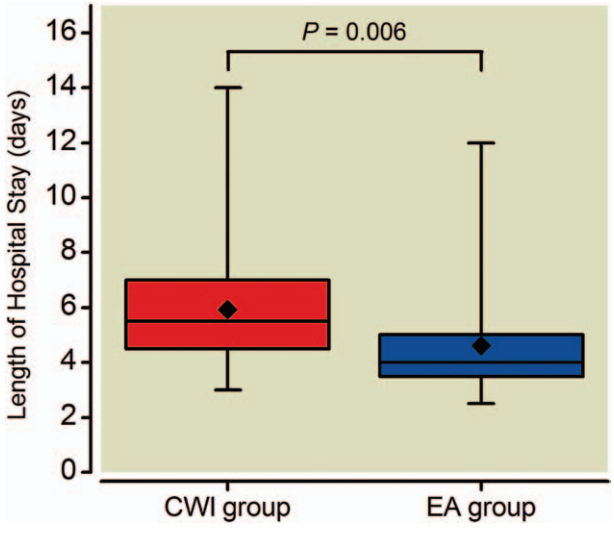

Fig.3. Length of hospital stay in the EA and CWI groups. Data are presented as median (*horizontal line within the box*), interquartile range (*upper and lower edges of the boxes*), maximum and minimum (*upper and lower bars*), and means (*black diamonds within the boxes*). CWI = continuous wound infiltration; EA = epidural analgesia.

Table 4. Postoperative Recovery Parameters and Complications

	EA Group (n = 24)	CWI Group (n = 26)	*P* Value
Time until full diet tolerated, days	1 [1–1]	2 [2–3]	<0.001
Time until return of gut function, days			
Time until flatus	1 [1–1.5]	2 [1.5–2.4]	<0.001
Time until stools	3 [2–4]	4.5 [4–7]	0.005
Sleep quality score, mm			
First postoperative night	56 ± 28	49 ± 20	0.35
Second postoperative night	70 ± 21	50 ± 20	0.004
Third postoperative night	72 ± 20	59 ± 14	0.003
Postoperative complications, No. (%)			
Anastomotic leakage	1 (4)	2 (8)	0.59
Wound abscess	0	1 (4)	0.33
Intra-abdominal abscess	0	1 (4)	0.33
Urinary tract infection	1 (4)	0	0.29
Venous thromboembolism	0	0	NR

Data are presented as median [interquartile range] or mean ± SD, as appropriate.
CWI = continuous wound infiltration; EA = epidural analgesia.

during fast-track open colorectal surgery,[31] although we did not allow the use of laxatives. Postoperative ileus has been identified as one of the most important causes of patient discomfort, prolonging convalescence and length of hospital stay.[32] Interestingly, the quality of night sleep, which has been regarded as reflecting patient well-being, was better with EA, except on the first postoperative night. It is likely that prolonged morphine consumption, which was not abolished by CWI despite a multimodal analgesia regimen, may have contributed to the delayed return of bowel function.

In contrast to previous studies,[7] we found that EA shortened the duration of hospital stay after colorectal surgery.[7] This discrepancy may be due to the absence, in previous studies, of an enhanced recovery and multimodal program, in addition to EA.[7] The use of an inappropriate volume of fluid during surgery might also explain this difference. Indeed, there is extensive evidence that excessive fluid loading during surgery can predispose to the development of intestinal edema, an increased duration of postoperative ileus, and an increased length of hospital stay.[33] As part of our routine care program, patients were individually managed using goal-directed fluid administration. Although the latter has not yet been clearly demonstrated to be beneficial during colorectal surgery given recent advances in perioperative care,[34] it has been found to improve patient outcomes after major abdominal surgery.[35] Thus, goal-directed fluid administration may have contributed to the reduced length of hospital stay in our two patient groups.

Another striking finding was the lack of difference in urinary retention between our EA and CWI groups. By blocking the innervation of the detrusor muscle, EA has been found to increase the risk of postoperative urinary retention,[7,36] which can delay hospital discharge. In contrast to previous studies, we planned urinary catheter removal on the day after surgery. Our results are in good agreement with those of a recently published study, which found that early removal of a urinary catheter during EA did not increase recatheterization rates.[37] Administration of excess fluid volumes intraoperatively, which predisposes to bladder overdistension, is another important cause of postoperative urinary retention, but this may have been offset by our rational administration of intraoperative fluid.

Our study had several limitations. First, although interim analysis was planned using stopping boundaries, which were less stringent with respect to ineffectiveness than to efficacy, in that a *P* value less than 0.016 was required to stop the study for efficacy, a formal rule is insufficient to prevent bias resulting from stopping early, resulting in a likelihood of overestimating the effects of EA in our study.[38] Furthermore, although length of hospital stay was a secondary endpoint, the independent monitoring board stopped the study because of ethical concerns. Second, our results should be interpreted in view of our experimental conditions. It is uncertain whether the use of a more conventional fluid administration protocol, rather than a goal-directed protocol, would have led to similar results. Third, the use of postoperative EA alone (rather than intraoperative and postoperative) could have ensured better comparability of both groups. Nevertheless, previous data suggested that the timing of EA is important in providing effective preemptive analgesia[39] and that EA should be preferably commenced intraoperatively.[13] Fourth, the use of patient-controlled intravenous morphine in addition to the continuous wound infusion of ropivacaine in the CWI group could have influenced the between-groups difference in functional recovery. However, the use of CWI alone has been shown not to prevent the opioid need postoperatively, and there was therefore an ethical responsibility to provide adequate analgesia.

In conclusion, our findings show that, compared with CWI, EA improves postoperative pain relief and functional recovery and reduces length of hospital stay after open colorectal surgery within an enhanced rehabilitation program.

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