REVIEW ARTICLE

Epidural Anesthesia and Gastrointestinal Motility

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Postoperative ileus, a temporary inhibition of gastrointestinal function, is a universal complication after major abdominal surgery. Treatment for ileus is supportive and has changed little since Wangensteen's 1932 report (1) that nasogastric suction could delay or replace operative management of bowel obstruction, thereby reducing mortality. Gastric decompression, together with IV hydration and electrolyte replacement, remains the only proven therapy for ileus (2,3).

Liu et al. (4) suggest that epidural analgesia may significantly shorten the duration of postoperative ileus. The benefits of a reduction in ileus include decreased patient morbidity and potentially substantial cost-savings, as prolongation of hospitalization in the United States due to ileus has been estimated to cost $1,500 per patient or $750,000,000 annually (3). Nevertheless, clinical guidelines currently promulgated by some consulting firms continue to state that "while epidural analgesia is effective for thoracic surgery and certain major musculoskeletal procedures, it has often been associated with prolonged ileus, delayed oral nutrition, and discharge in patients with gastrointestinal surgery" (Milliman and Robertson, Inc, Actuaries and Consultants, Seattle, WA, written communication, 1996).

In this article, the pathophysiology of postoperative ileus is reviewed, and a framework for appreciating the theoretical basis for an effect of epidural anesthesia, especially thoracic epidural anesthesia, on ileus is provided. Potential risks and benefits of epidural anesthesia for bowel surgery are considered, including an examination of relevant animal studies. The major focus of this article is to review recent clinical studies comparing epidural analgesia with systemic analgesia, as well as to review studies comparing epidural narcotics with epidural local anesthetics with regard to postoperative ileus. Catheter location is discussed as a particularly important factor in determining the effects of epidural blockade on gastrointestinal motility. Finally, suggestions for future research are offered.

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Pathophysiology

"On no subject in physiology do we meet with so many discrepancies of fact and opinion as in the physiology of the intestinal movements" (5). Although intestinal motor activity may be normal after physical or chemical blockade of all neural input (6), contractile activity of the bowel is modulated by a variety of neural and humoral factors. Nearly 100 yr ago, Cannon and Murphy (7) demonstrated that opening the peritoneal cavity and manipulating the intestines resulted in a striking inhibition of contractile activity in the gastrointestinal tracts of dogs. The same authors also reported ileus associated with an extraabdominal procedure (crushing the testicles) in cats (8), whereas Meltzer and Auer (9) noted that ileus may follow various less noxious stimuli in rabbits.

Parasympathetic stimulation increases gastrointestinal motility, but tonic inhibitory sympathetic control normally predominates. Thus, blockade of splanchnic nerves or spinal anesthesia results in increased motility or inhibits the development of ileus, whereas vagotomy has little apparent effect. Although the autonomic nervous system has a major role in regulating gastrointestinal transit, other factors must also be involved. Factors that alter gastrointestinal motility in humans or animals are listed in Table 1.

Typically, uncomplicated postoperative ileus is associated with restoration of motility in the stomach and small bowel within 24 h, whereas the colon recovers over 48–72 h (10,11). Neely (12) suggested that the duration of postoperative ileus was related to the severity of the surgical procedure, but other authors' findings do not confirm this (13,14). Other authors (3,15) use the terms paralytic or adynamic ileus to refer to more severe, prolonged inhibition of bowel function, as differentiated from the usual type of uncomplicated postoperative ileus that lasts no more than 3 days.

The duration of postoperative ileus is increased by opioids (16). The dose-dependent inhibitory effects of morphine and other opiates on motility (17) suggest a possible contributory role for endogenous opioids in the pathogenesis of postoperative ileus; however, the lack of effect of naloxone on postoperative bowel function in rats does not support this notion (18).

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Table 1. Factors that Alter Gastrointestinal Motility in Humans or Animals

Increase motility	Decrease motility
Parasympathetic stimulation	Sympathetic stimulation
Splanchnic nerve blockade	Pain
Spinal anesthesia	Opioids
Epidural anesthesia	Nitrous oxide
α-Adrenergic blockade	Inhalation anesthetics
β-Adrenergic blockade	Vasopressin
Cholinergic agonists	Catecholamine administration
Anticholinesterase agents	Increased endogenous catecholamines
Local anesthetics (IV)	

Inhaled anesthetics may decrease gastrointestinal motility, but motility consistently recovered within a matter of minutes after cessation of anesthesia in multiple animal studies (19). Thus, it is unlikely that inhaled anesthetics are responsible for diminished gastrointestinal motility lasting much beyond the immediate postoperative period.

Nitrous oxide may have longer-lasting deleterious effects on motility than do the volatile anesthetics. In a study of 40 patients undergoing elective major large bowel surgery under general anesthesia with isoflurane and fentanyl, Scheinin et al. (20) found significantly earlier return of bowel function, as assessed by the passage of flatus and feces, in the 20 patients randomly allocated to air compared with the 20 patients allocated to intraoperative nitrous oxide. The groups were comparable with respect to demographics and surgical procedures. The duration of postoperative hospitalization was significantly shorter for the air group (mean ± SD; 10.0 ± 1.3 vs 11.7 ± 2.5 days; $P < 0.05$).

IV infusion of lidocaine shortens the duration of postoperative ileus in humans (21). In a double-blind study of patients undergoing cholecystectomy, the passage of radiopaque markers through the colon was significantly faster in the 15 patients who received IV lidocaine (100 mg bolus before anesthesia, continuous infusion at 3 mg/min for 24 h) than in the 15 patients who received IV saline. The authors speculate that systemic lidocaine may reduce postoperative peritoneal irritation, thereby suppressing inhibitory gastrointestinal reflexes; however, patients in the lidocaine group received significantly less postoperative narcotics, providing another explanation for the more rapid resolution of ileus.

Risks and Benefits

Some authors have suggested that epidural anesthesia may be detrimental to the healing of a bowel anastomosis because of the increase in bowel motility. Carlstedt et al. (22) observed a significant increase in motility after the administration of atropine and neostigmine to reverse nondepolarizing muscle relaxants during epidural anesthesia; there was no increase in motility after atropine and neostigmine in the absence of epidural anesthesia. The authors warn that such an increase in intestinal motility "may expose a newly constructed colorectal anastomosis to undue strain in the immediate postoperative period" (22).

Despite the theoretical risk of increased motility secondary to anticholinesterase drugs during epidural anesthesia, disruption of colonic anastomoses during or immediately after epidural anesthesia has been reported in only three cases (23,24); none involved neostigmine. Except for a statistically insignificant trend toward increased rates of anastomotic dehiscence in one study (25), there is substantial clinical and experimental evidence that epidural anesthesia/analgesia is safe for patients undergoing bowel resection with anastomosis. Furthermore, by increasing blood flow to the colon (26), epidural anesthesia with postoperative epidural analgesia may promote anastomotic healing.

A study in animals by Schnitzler et al. (27) provides support for the safety of epidural analgesia after bowel anastomosis. After performing colorectal resection and anastomosis in 21 pigs, the authors administered epidural infusions of either bupivacaine, morphine, or saline for 48–72 h postoperatively. Colonic transit time, measured with radiopaque markers and serial radiographs, was accelerated with epidural bupivacaine (3.9 days) and epidural morphine (4 days) compared with epidural saline (6 days; $P < 0.05$). There were no significant differences in blood flow, intraluminal bursting pressure, or hydroxyproline content (a measure of wound healing), and there were no anastomotic complications.

In another animal study, Udassin et al. (28) demonstrated beneficial effects of epidural anesthesia on ileus. These investigators measured the recovery of gastrointestinal motility in rats after a 30-min period of bowel ischemia. After a black test meal and a subsequent 90-min study period, they observed the fraction of the small bowel filled with the colored meal. Although control animals had 84.4% of the small bowel filled with the black meal, 30 min of ischemia resulted in pronounced adynamic ileus, with only 0.7% of the bowel filled with the marker. Lidocaine epidural anesthesia promoted the rapid resolution of ileus after ischemia, compared with epidural saline injection (lidocaine 60.3% filled, saline 30.9% filled).

Aitkenhead et al. (29) reviewed the records of 68 patients who underwent large bowel anastomoses under spinal plus light general anesthesia, epidural plus light general anesthesia, or general anesthesia alone; postoperative analgesia was achieved with systemic narcotics. Early or late postoperative ileus (before or after the 4th postoperative day, respectively) occurred

Table 2. Mechanisms by Which Thoracic Epidural Anesthesia May Promote Gastrointestinal Motility

Blockade of nociceptive afferent nerves
Blockade of thoracolumbar sympathetic efferent nerves
Unopposed parasympathetic efferent nerves
Reduced need for postoperative opiates
Increased gastrointestinal blood flow
Systemic absorption of local anesthetic

in 11.6% (early) and 11.6% (late) of patients in the spinal group, 12.0% and 4.0% of the epidural group, and 19.2% and 23.1% of the general anesthesia group. Anastomotic dehiscences occurred in 7.0% of patients in the spinal anesthesia group, 8.0% of patients in the epidural anesthesia group, and 23.1% of patients in the general anesthesia group. Although the differences observed in this retrospective study were not statistically significant, these investigators concluded that spinal or epidural anesthesia "may have had a beneficial effect on the anastomoses, since other factors were similar in the three groups."

Consideration of the mechanisms and studies described above suggests a number of potentially desirable effects of epidural anesthesia on gastrointestinal motility (Table 2). By blocking thoracolumbar sympathetic nerves while leaving craniosacral parasympathetic nerves undiminished, epidural anesthesia—especially thoracic epidural anesthesia—would be expected to increase gastrointestinal motility. Furthermore, by substantially reducing or abolishing postoperative pain, epidural analgesia with a local anesthetic and/or narcotic decreases or eliminates the need for postoperative systemic opiates, thereby avoiding a major contributing factor to postoperative ileus. Additionally, to the extent that increased gastrointestinal blood flow (26) and systemic actions of local anesthetics (21) increase gastrointestinal motility, epidural analgesia may further reduce the duration of postoperative ileus.

Epidural Analgesia Compared with Systemic Analgesia

Numerous recent studies have compared epidural analgesia and systemic analgesia with regard to the postoperative recovery of gastrointestinal function. Sixteen such studies published since 1977 are presented in Table 3, arranged in descending order by location of the epidural catheter. In all eight studies with epidural catheter placement above T12, gastrointestinal function recovered significantly more rapidly when epidural analgesia was used than when patients received systemic analgesics. Studies in which the epidural catheter was positioned at or below T12, or in which the location of the epidural catheter was not specified, were equally as likely to show faster recovery of gastrointestinal function with epidural analgesia as with systemic analgesia. In no case was systemic analgesia associated with more rapid recovery of gastrointestinal motility.

One of the first studies to compare the gastrointestinal effects of epidural local anesthetics with systemic narcotics was that of Gelman et al. (30). These authors monitored intestinal motility by external electroenterography (EEnG) in 30 patients after cholecystectomy under general anesthesia. In 21 patients, an epidural catheter was placed at T7-8 and was intermittently dosed with bupivacaine during or after surgery. Electrical activity, as assessed by using EEnG, was decreased for 3–4 days after surgery. Eighty percent of the time, EEnG activity increased after epidural injections of bupivacaine, but EEnG activity almost always decreased after an IV or IM nicomorphine injection.

In a randomized study of 214 patients undergoing major abdominal operations, Seeling et al. (31) compared patients receiving thoracic (T7-11) epidural plus light general anesthesia followed by postoperative thoracic epidural analgesia (bupivacaine 0.25% plus fentanyl 2 mg/mL, 6–10 mL/h for 76 ± 1.45 h) with a control group receiving general anesthesia alone and postoperative IV or IM piritramide. The time to first feces was shorter in the epidural group (79 ± 1.51 vs 93 ± 1.38 h), but time to hospital discharge was the same. Although analgesia and ability to cough were better in the epidural group, the incidence and severity of postoperative complications were the same in both groups.

In a study designed to compare postoperative pulmonary complications in patients after major abdominal surgery, Jayr et al. (32) randomly allocated 153 patients to receive either general anesthesia with postoperative subcutaneous morphine or combined thoracic (T7-11) epidural-general anesthesia with postoperative thoracic epidural analgesia (bupivacaine 0.125%, 10 mL/h with morphine 0.25 mg/h) for 4 days. Recovery of intestinal gas transit was significantly earlier in the epidural group, but the duration of hospitalization was not different.

In a randomized, double-blind study of 30 morbidly obese patients undergoing gastroplasty, Rawal et al. (33) compared the effects of thoracic (T8) epidural morphine 4 mg with morphine 0.1 mg/kg IM given on demand. Postoperative analgesia was better with epidural morphine, at significantly smaller total doses of morphine. Bowel function, as assessed by first flatus or feces, recovered sooner with epidural morphine. Duration of hospitalization was significantly shorter with epidural morphine (7.1 ± 0.3 days) than with IM morphine (9.0 ± 0.6 days; $P < 0.05$).

In a study by Bredtmann et al. (25), 116 patients undergoing colonic resection and/or anastomosis were randomly allocated to receive thoracic (T8-9 or

Table 3. Studies Comparing Postoperative Epidural Analgesia with Systemic Analgesia

Author, year	Epidural catheter location	Surgical procedure	Study design	*n*	Epidural analgesia (duration)	Systemic analgesia	Gastrointestinal recovery
Gelman et al., 1977 (30)	T7–8	Cholecystectomy	NRCT	30	Bupiv 0.25% (~3–5 days)	Nicomorphine IV/IM	Increased EEnG activity with epidural
Seeling et al., 1990 (31)	T7–11	Major abdominal	RCT	214	Bupiv 0.25% w/ fentanyl (~76 h)	Piritramide IV/IM	Earlier feces with epidural
Jayr et al., 1993 (32)	T7–11	Major abdominal	RCT	153	Bupiv 0.125% w/ morphine (4 days)	Morphine SC, paracetamol IV	Earlier flatus with epidural
Rawal et al., 1984 (33)	T8	Gastroplasty	RCT	30	Morphine (36–48 h)	Morphine IM	Earlier flatus and feces, shorter LOS with epidural
Bredtmann et al., 1990 (25)	T8–10	Colectomy	RCT	116	Bupiv 0.25% (72 h)	Piritramide IM, tramadol IM	Earlier feces with epidural
Liu et al., 1995 (34)	T8–10	Colectomy	RCT	54	Bupiv, morphine, or both (60–100 h)	Morphine IV	Earlier flatus with epidural
de Leon-Casasola et al., 1996 (35)	T10–12	Abdominal hysterectomy	COS	68	Bupiv 0.05% with morphine (~4 days)	Morphine IV	Shorter NG suction, earlier flatus and solid food, shorter LOS with epidural
Wallin et al., 1986 (36)	T12–L1	Cholecystectomy	RCT	30	Bupiv 0.25% (24 h)	Pentazocine IM	No difference in transit of radiopaque markers
Wattwil, 1989 (37)	T12–L1	Abdominal hysterectomy	RCT	40	Bupiv 0.25% (26–30 h)	Ketobemidone IM	Earlier flatus and feces, quicker transit of radiopaque markers with epidural
Hjortso et al., 1985 (38)	L1–2	Major abdominal	RCT	100	Bupiv 0.5% (24 h), morphine (72 h)	Morphine IM	No difference in times to first flatus, feces, or food
Ahn et al., 1988 (39)	L2–3	Colon or rectum	RCT	30	Bupiv 0.25% (48 h)	Pentazocine IV	Shorter barium transit time, earlier flatus and feces with epidural
Scheinin et al., 1987 (40)	"Middle of planned incision"	Colonic	RCT	60	Bupiv 0.25% (48 h)	Oxycodone IM	Earlier feces with epidural
Lehman and Wiseman, 1995 (41)	Not specified	Colon or rectum	COS	102	Narcotic and/or local anesthesia (~4 days)	Narcotics IV or IM	No difference in time to first flatus or feces
Morimoto et al., 1995 (42)	Not specified	Colectomy, IAPT	COS	85	Fentanyl (72 h)	Morphine	Earlier feces and oral intake, shorter LOS with epidural
Kanazi et al., 1996 (43)	Not specified	Colectomy, IAPT	COS	50	Local anesthetic and narcotic (24 h), then fentanyl or morphine	Not specified ("usually PCA")	No difference in duration of NG suction or time to liquid or solid food
Scott et al., 1996 (44)	T6–10 or L2–4	Colectomy, IAPT	COS	179	Narcotic and/or local anes (up to 6 days)	Morphine IV	Earlier bowel sounds and greater stool output with thoracic epidural

NRCT = nonrandomized controlled trial, RCT = randomized controlled trial, COS = controlled observational study, Bupiv = bupivacaine, SC = subcutaneous, EEnG = electroenterogram, LOS = length of stay, NG = nasogastric, IAPT = ileo-anal pull-through, PCA = patient-controlled analgesia.

T9-10) epidural plus general anesthesia or to receive general anesthesia alone. The groups were comparable with respect to preoperative morbidity, as well as to surgical procedures. Patients in the epidural group received bupivacaine 0.75% during surgery and 0.25% continuously for 3 days to maintain blockade of T5-L2; control patients received systemic narcotics and other analgesics. Epidural patients had significantly lower pain scores and earlier bowel movements. Nevertheless, the authors of this study noted several disadvantages of epidural analgesia, including significantly more fevers, as well as statistically insignificant trends toward higher rates of rectal anastomotic breakdown, blood replacement, intensive care therapy, and longer hospitalization.

Liu and colleagues (34) randomized 54 patients undergoing partial colectomy into four groups. All patients had a standardized general anesthetic, as well as standardized postoperative care. One group received IV morphine analgesia; the other groups received thoracic (T8-10) epidural morphine, bupivacaine, or both. Groups were similar with respect to patient demographics, type and duration of surgery, and blood loss and fluid replacement. Time to first flatus and time to fulfillment of predetermined discharge criteria were significantly shorter for patients in the bupivacaine (flatus 40 ± 2 h, discharge 62 ± 5 h) and bupivacaine plus morphine (43 ± 4 h, 67 ± 8 h) epidural groups than for those in the epidural morphine (71 ± 4 h, 102 ± 13 h) and the IV morphine (81 ± 3 h, 96 ± 7 h) groups. Analgesia with activity was also significantly better in the two epidural bupivacaine groups.

In a retrospective review of 68 women who underwent radical hysterectomies, de Leon-Casasola et al. (35) compared bowel function recovery with postoperative continuous thoracic (T10-12) epidural analgesia (bupivacaine 0.05% with morphine 0.01% for approximately 4 days) with IV morphine via patient-controlled analgesia (PCA). The epidural group required fewer days of nasogastric therapy (4 ± 3 vs 8 ± 2), had shorter times to first flatus (4 ± 3 vs 8 ± 2 days), tolerated solid foods sooner (6 ± 2 vs 11 ± 3 days), and had a shorter duration of hospitalization (10 ± 3 vs 14 ± 4 days) than the PCA group. Total hospital room costs were significantly less for epidural patients ($4175 vs $5845).

Wallin et al. (36) studied 30 patients undergoing elective cholecystectomy under general anesthesia; in 15 patients, an epidural catheter was inserted preoperatively at T12-L1 and dosed with 0.5% plain bupivacaine (18–20 mL, level from T2-4 to S3-5); postoperative sensory blockade was maintained with intermittent injections of 0.25% bupivacaine (10–14 mL every 3 h) for 24 h in the epidural group, and by IM pentazocine in the general anesthesia alone group. Colonic motility was evaluated by the transit of radiopaque markers on serial abdominal radiographs, by time to first flatus, and by time to first feces. Despite effective epidural blockade in 11 patients (as evidenced by lower blood glucose concentrations for 24 h after skin incision), there were no significant differences in the passage of radiopaque markers or in times to first flatus or feces. However, it is possible that the lack of benefit in the epidural group was due to the relatively low insertion site (T12-L1), as well as the short duration of epidural analgesia (24 h), compared with the much longer mean transit times for radiopaque markers (>60 h).

In a randomized study of 40 patients undergoing abdominal hysterectomy, Wattwil (37) compared epidural analgesia with bupivacaine with IM ketobemidone (i.e., a synthetic opioid). All patients received general anesthesia, but those in the epidural group (T12-L1 catheter, 0.5% bupivacaine to achieve at least a T6 level before induction of general anesthesia) received no intraoperative opioids. Postoperative analgesia was maintained with 0.25% bupivacaine at 8 mL/h for 26–30 h in the epidural group, and with ketobemidone in the general anesthesia alone group. Pain relief was significantly better in the epidural group. Despite the low catheter position and short duration of epidural infusion, gastrointestinal motility, as assessed by times to first flatus and feces and by radiopaque markers and serial radiographs, was significantly enhanced in the epidural group.

Hjortso et al. (38) randomized 100 patients scheduled for elective abdominal surgery to either general anesthesia with postoperative IM morphine (4–8 mg every 4–6 h), or combined lumbar (L1-2) epidural-general anesthesia with postoperative epidural analgesia. Epidural catheters were dosed preoperatively with sufficient 1.5% etidocaine to block T4-S5; postoperative epidural analgesia was achieved with 0.5% bupivacaine, 5 mL/4 h for 24 h, with morphine 4 mg/12 h for 72 h. Postoperative pain relief, assessed retrospectively on the 5th postoperative day, was better in the epidural group; nonetheless, there were no significant differences in a variety of postoperative complications. There also were no significant differences in recovery of bowel function as assessed by flatus, feces, and food intake. This is the only large, randomized, prospective study that has not found any advantage for epidural analgesia with regard to recovery of bowel function; however, the epidural insertion site was low (L1-2) and the dose of bupivacaine was small (total 30 mL over 24 h).

Ahn et al. (39) randomly allocated 30 patients undergoing surgery of the left colon and/or rectum to postoperative lumbar (L2-3) epidural analgesia (0.25% bupivacaine, 8- to 15-mL boluses for 48 h) or to a control group receiving IV pentazocine. One hour after surgery, barium was injected into a duodenal tube; transit time was measured using serial radiographs. Compared with the control group, the epidural group

had significantly shorter barium transit times through the small (12 vs 24 h for epidural versus control) and large intestines (35 vs 150 h), as well as significantly shorter times to first flatus and feces.

Scheinin et al. (40) randomly allocated 60 patients undergoing colonic surgery to one of four groups with regard to postoperative pain control: 1) a control group receiving IM oxycodone on request; 2) an epidural group receiving an epidural bupivacaine infusion (0.25%, 4–6 mL/h for 48 h); 3) an epidural group receiving epidural morphine boluses (2–6 mg/d for 48 h); or 4) an epidural group receiving an epidural morphine infusion (2–6 mg/d for 48 h). Bowel movements occurred on the 2nd postoperative day in the epidural bupivacaine group, significantly earlier than all other groups (4th postoperative day).

Lehman and Wiseman (41) reviewed the hospital courses of 102 patients who underwent elective colonic surgery. All patients received general anesthesia; 41 patients received postoperative epidural analgesia with narcotics alone or together with local anesthetic for an average of 3.4 ± 1.4 days (range 1–7 days), whereas 61 patients received postoperative parenteral narcotics or ketorolac. There were no significant differences in duration of ileus or length of hospital stay in this retrospective study. The site of epidural catheterization was not identified.

Morimoto et al. (42) reviewed the records of 85 patients who underwent proctocolectomy with ileal pouch-anal canal anastomosis at the Mayo Medical Center. Postoperative pain was treated with systemic morphine in 41 patients and with epidural fentanyl (bolus 1 $\mu g/kg$, infusion 1 $\mu g \cdot kg^{-1} \cdot h^{-1}$ for 3.1 ± 1.2 days) in 44 patients. Patients in the epidural group had shorter times to first feces (3.5 ± 1.2 vs 4.3 ± 1.3 days) and to first oral intake (4.5 ± 0.9 vs 6.2 ± 3.2 days) and had shorter total hospital stays (9.6 ± 2.8 vs 12.1 ± 4.4 days). Epidural patients also experienced significantly less need for nasogastric suction (61% vs 90% of patients, duration 1.9 ± 1.7 vs 4.1 ± 2.3 days) and IV fluids (6.6 ± 2.0 vs 9.9 ± 4.6 days), although the criteria used to determine need were not reported.

Kanazi et al. (43) came to a different conclusion from reviewing the records of 50 patients who underwent colectomy with ileal pouch-anal anastomosis at the University of Nebraska Medical Center. All patients received general anesthesia; postoperative pain was managed with epidural medications (local anesthetic and narcotic for 24 h, then fentanyl or morphine) in 23 patients; 27 patients received parenteral analgesics only. Although the pain scores were significantly lower in the epidural group, there were no significant differences in duration of nasogastric suction (4.1 ± 1.8 vs 4.6 ± 4.1 days, epidural versus parenteral), number of patients requiring tube reinsertion, or time to tolerating liquid (4.8 ± 1.9 vs 5.1 ± 4.4 days) or regular (7.0 ± 2.5 vs 7.7 ± 5.3 days) diet. The mean hospital stay was 10.5 ± 3.6 days for the epidural group, similar to the 12.6 ± 6.9 days for the parenteral group.

In a retrospective comparison of thoracic epidural analgesia, lumbar epidural analgesia, and IV morphine via PCA, Scott et al. (44) observed the best pain control and fastest resolution of ileus in the thoracic epidural group. Patients undergoing restorative proctocolectomy under general anesthesia received intra- and postoperative analgesia with narcotics or local anesthetic-narcotic mixtures via either a thoracic (T6-10, $n = 53$) or lumbar (L2-4, $n = 51$) epidural catheter; a third group did not receive epidurals and had postoperative pain control with IV morphine via PCA ($n = 75$). Thoracic epidural catheters were infused for a longer period of time (3.7 ± 1.8 days) than were lumbar catheters (2.0 ± 1.2 days; $P < 0.05$), and smaller doses of morphine were used with thoracic catheters (0.25 mg/h) than with lumbar catheters (0.35 mg/h). Nevertheless, the pain scores (daily visual analog scale) were lowest in the thoracic epidural group. Bowel sounds returned 2.45 ± 1.19 days postoperatively in the thoracic group, significantly earlier than in the lumbar (3.17 ± 1.18 days) or PCA (2.96 ± 1.14 days) groups ($P < 0.05$). Similarly, patients with thoracic catheters had stool outputs greater than 50 mL/8 h 3.4 ± 1.7 days postoperatively versus 4.0 ± 1.5 days postoperatively for patients with lumbar catheters and 4.3 ± 1.3 days postoperatively for patients with PCA ($P < 0.05$). There were no significant differences in postoperative length of stay. This study provides direct evidence for the importance of catheter location in determining the effects of epidural analgesia on postoperative gastrointestinal motility.

Epidural Local Anesthetics Compared with Epidural Narcotics

Studies evaluating postoperative gastrointestinal function comparing epidural local anesthetics with epidural narcotics are presented in Table 4. In all studies with epidural catheter placement above T12, gastrointestinal motility was greater with the use of epidural local anesthetics compared with epidural narcotics.

In a study in healthy volunteers, Thoren and Wattwil (45) compared acetaminophen absorption, a measure of the rate of gastric emptying, after thoracic (T4) epidural injection of either 4 mg of morphine or 0.5% bupivacaine (sufficient to block at least T6-10). Compared with control acetaminophen absorption studies without epidural injection, epidural analgesia with morphine significantly delayed gastric emptying (lower mean and maximal serum acetaminophen concentrations, longer time to peak concentration, smaller

Table 4. Studies Comparing Epidural Local Anesthetics with Epidural Narcotics

Author, year	Epidural catheter location	Surgical procedure	Study design	*n*	Local anesthetic	Narcotic	Duration (h)	Gastrointestinal recovery
Thoren and Wattwil, 1988 (45)	T4	None (volunteers)	COS	10	Bupiv 0.5%	Morphine	Single dose	Greater acetaminophen absorption with local
Thorn et al., 1996 (46)	T5–6	Cholecystectomy	RCT	14	Bupiv 0.25%	Morphine	24	Greater EMG and acetaminophen absorption with local
Liu et al., 1995 (34)	T8–10	Colonic	RCT	54	Bupiv	Morphine	60–100	Earlier flatus with local
Thoren et al., 1989 (47)	T12–L1	Abdominal hysterectomy	RCT	22	Bupiv 0.25%	Morphine	42	Earlier flatus, feces, oral fluids with local
Schnitzler et al., 1992 (27)	T12–L1	Colorectal (pigs)	RCT	21	Bupiv 0.125%	Morphine	72	No difference in transit of radiopaque markers
Bisgaard et al., 1990 (48)	L2–4	Major abdominal	RCT	29	Bupiv and morphine	Morphine	48	No difference in time to first flatus or feces or in transit of radiopaque markers
Scheinin et al., 1987 (40)	"Middle of planned incision"	Colon or rectum	RCT	60	Bupiv 0.25%	Morphine	48	Earlier feces with local

COS = controlled observational study, RCT = randomized controlled trial, Bupiv = bupivacaine, EMG = electromyogram.

area under concentration-time curve), whereas acetaminophen absorption after epidural bupivacaine was the same as that after control.

In a small, randomized study in 14 patients after open cholecystectomy, Thorn et al. (46) compared gastroduodenal myoelectric activity and acetaminophen absorption during thoracic epidural analgesia with bupivacaine (0.25% at 8.0 ± 0.9 mL/h) or morphine (4 mg plus 2 mg as needed). Pain relief (visual analog scale) at rest was the same in both groups. Acetaminophen absorption was significantly delayed in the epidural morphine group. Furthermore, epidural morphine was associated with significant changes in gastroduodenal myoelectric activity compared with epidural bupivacaine.

Thoren et al. (47) compared low thoracic (T12-L1) epidural bupivacaine (0.5% intraoperatively, 0.25% postoperatively for 42 h) with epidural morphine (4 mg, then 2 mg bolus as needed up to 42 h) in 22 patients undergoing abdominal hysterectomies under general anesthesia. The epidural bupivacaine patients had significantly better pain relief, earlier flatus (22 ± 16 vs 56 ± 22 h, $P < 0.001$), earlier feces (57 ± 44 vs 92 ± 22 h, $P < 0.05$), and earlier and greater intake of oral fluids.

In a randomized study of 29 patients undergoing elective major abdominal surgery, Bisgaard et al. (48) compared lumbar (L2-4) epidural analgesia with bupivacaine plus morphine as a continuous infusion for 3–6 days with epidural morphine boluses for 48 h. Although pain relief was better with the combination of bupivacaine plus morphine, there were no differences in colonic motility, as assessed by first flatus, first feces, and radiopaque markers.

Conclusions

Thoracic epidural anesthesia with postoperative thoracic epidural analgesia has been shown to have beneficial effects on postoperative pain and recovery of bowel function after major abdominal surgery; lumbar epidural blockade is not as consistently effective. Local anesthetics and local anesthetic-narcotic mixtures seem to be more effective with fewer undesirable side effects than epidural narcotics alone; however, published studies are limited by relatively small numbers of subjects, as well as by lack of documentation of the level of epidural blockade or degree of analgesia or sympathectomy.

Future studies should include documentation of the level of epidural blockade, and might include measurements of intestinal blood flow and motility. Additional studies are required to determine the ideal drugs for epidural infusion, optimal timing of administration (i.e., when to start, as well as how long to continue), and differences, if any, in outcome measures such as patient satisfaction and time to return to work.

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