Characterizing Postoperative Paralytic Ileus as Evidence for Future Research and Clinical Practice

Annette Bisanz, MPH, RN, CNS
J. Lynn Palmer, PhD
Suresh Reddy, MD, SFARCS
Lynn Cloutier, MSN, RN, ACNP
Teresa Dixon, MS, RD, CNSD
Marlene Z. Cohen, PhD, RN, FAAN
Eduardo Bruera, MD

Postoperative ileus, a delay of gastrointestinal (GI) motility beyond 3 days, is common in patients after GI surgery. This disorder increases length of hospital stay and costs millions of dollars annually. This study was done to determine clinical factors associated with paralytic ileus. An interdisciplinary team developed a data collection tool based on eight hypotheses derived from a review of literature on factors that contribute to ileus. In a retrospective medical record review of 101 patients who had abdominal surgery, 44 developed postoperative ileus and 57 did not. Data analysis found that three factors were statistically significant in reducing ileus: (1) early postoperative introduction of fluids and food, (2) avoidance of positive fluid balance exceeding 1,000 ml, and (3) avoiding potassium elevations over a 3-day period. A trend identified that the use of nonsteroidal anti-inflammatory drugs could reduce the incidence of ileus. Clinical implications include the importance of encouraging early oral intake, monitoring fluid intake and output in postoperative patients, and identifying positive fluid balance early to prevent it from continuing.

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About the authors: Annette Bisanz, MPH, RN, CNS, is Clinical Nurse Specialist for Bowel and Symptom Management, University of Texas MD Anderson Cancer Center, Houston.

J. Lynn Palmer, PhD, is Associate Professor of Biostatistics, University of Texas MD Anderson Cancer Center, Houston.

Suresh Reddy, MD, SFARCS, is Associate Professor of Palliative Care and Rehabilitation Medicine, University of Texas MD Anderson Cancer Center, Houston.

Lynn Cloutier, MSN, RN, ACNP, is Nurse Practitioner, Department of Gynecologic Oncology, University of Texas MD Anderson Cancer Center, Houston.

Teresa Dixon, MS, RD, CNSD, is Senior Clinical Dietitian, University of Texas MD Anderson Cancer Center, Houston.

Marlene Z. Cohen, PhD, RN, FAAN, is with the University of Texas, Houston.

Eduardo Bruera, MD, is Professor of Palliative Care and Rehabilitation Medicine, University of Texas MD Anderson Cancer Center, Houston.

Correspondence to: Annette Bisanz, MPH, RN, CNS, University of Texas MD Anderson Cancer Center, 1515 Holcombe, Houston, TX 77030 (e-mail: abisanz@mdanderson.org).

Recently published reports indicate that all patients develop ileus postoperatively. The resolution of ileus is marked by the first passage of flatus or stool, the ability to tolerate a clear liquid diet, and progression to food intake (Miedema & Johnson, 2006). Ileus is a transient impairment of intestinal motility following abdominal surgery (Han-Geurts et al., 2007). An indicator that ileus has resolved is toleration of diet without nausea, vomiting, pain, or distention (Mattei & Rombeau, 2006). Small-intestine function returns to normal first, often within several hours of surgery. Gastric motility returns to normal within 24–48 hours after surgery. The colon is the final portion of the gastrointestinal (GI) tract to regain normal motility, which usually occurs 48–72 hours after surgery (Behm & Stollman, 2003). Resnick, Greenwald, and Brandt (1997a, 1997b) diagnosed paralytic ileus on the basis of patients' postoperative self-reports of nausea, emesis, bloating, and a sense of abdominal fullness. Luckey, Lingsont, and Tache (2003) described paralytic ileus as a form of ileus lasting more than 3 days after surgery. In the United States, the annual cost associated with the treatment and duration of hospital stay for gut dysmotility is close to $1 billion (Correia, Davisson, & Gomes da Silva, 2004).

Many factors, including early feeding, local intestinal inflammation, anesthesia, postoperative analgesia drug adverse effects, hydration, and early mobilization, influence the development of paralytic ileus. The importance of ileus led us to form an interdisciplinary team. This team reviewed the literature and used this to develop eight hypotheses about factors producing ileus. After developing a data collection tool, data were collected from a review of 101 medical records of patients who had abdominal surgery. In the following discussion, literature is reviewed about factors influencing ileus and some potentially beneficial preventive measures are outlined.

Factors Influencing the Development of Ileus

Intestinal Distention Leading to Reflex Hypomotility and Stasis

Bowel distention inhibits peristalsis. Activation of cutaneous/visceral afferent fibers might also mediate ileus. This can occur when the sympathetic system is inactivated because of stress and surgery resulting in altered bowel motility during the postoperative period. These extrinsic pathways play an important role in postoperative ileus as evidenced by the inhibition of bowel function following surgery not involving the peritoneum. Untreated abdominal distention progresses from a physical finding to a contributing factor in the development of postoperative ileus (Livingston & Passaro, 1990). Excessive intravenous hydration is identified as a risk factor for postoperative ileus and should be avoided to minimize bowel edema (Mattei & Rombeau, 2006).

Electrolyte Deficiencies and Hypoalbuminemia

The association between postoperative ileus and electrolyte imbalances is documented in the literature (Rusinak & Winstead, 2007). Research has demonstrated the relationship between ileus and low plasma chloride, low plasma sodium, low sodium potassium, and hypomagnesemia (Schuster & Monte, 2002). A question remains, however, whether the relationship between hypoalbuminemia and postoperative paralytic ileus is causal or consequential. A reduction in intravascular serum albumin due to exudative loss and redistribution, combined with dilution by non–albumin-containing fluids following surgery, explains the predominance of postsurgery low albumin levels.

Decreased total body albumin levels due to malnutrition-induced reduction in synthesis and catabolism also results in reduced serum levels of albumin. This reduction can be identified independent of the aforementioned sequelae by a preoperative albumin measure. Reduction in serum albumin concentration results in a corresponding reduction of all functions attributable to albumin, including maintenance of colloid osmotic pressure, and regulation of vascular permeability (Margarson & Soni, 1998).

Studies have documented that hypoalbuminemia accompanied by impaired intestinal fluid absorption and motility within the small bowel and stomach causes an inability to tolerate oral diets or enteral feedings (Becker, 1998; Foley, Borlase, Dzik, Bistrian, & Benotti, 1990; Ford, Jennings, & Andrassy, 1987; Graber, Schulte, Condon, & Cowles, 1982; Pietsch, 1985; Woods et al., 1978). Despite these findings, in a study comparing patients with hypoalbuminemia to patients requiring exogenous albumin administration to restore normal plasma albumin levels, no significant difference was observed regarding hastened return of or enhancement of bowel function (Woods & Kelley, 1993). The role of serum hypoalbuminemia as either a marker of possible malnutrition-induced pathology affecting bowel function or a functional cause of postoperative ileus is not yet clear.

Alteration of the Gastric Pacemaker, GI Motility, and Increased Catecholamine Levels

As a part of the physiologic response to injury, the body initiates a "fight or flight" response that is driven by increased release of catecholamine by the sympathetic nervous system. Stimulation of this response in patients is well documented perioperatively as a result of trauma and anesthesia and is suggested to inhibit GI motility. A key initiator of GI peristalsis is located in the gastric pacemaker in the upper third portion of the greater curvature of the stomach. The pacemaker generates a peristaltic wave called the major migratory complex (MMC) and is responsible for sweeping the GI tract to carry large particles through the gut. Surgical manipulation of the bowel or resection of this area of the stomach has been correlated with diminished or absent MMC activity, with resulting delayed gastric emptying, gastric dilatation, and paralytic ileus (Miedema & Johnson, 2003).

Transient postoperative ileus can affect the GI system in different degrees following surgery. The small intestine myoelectric motility pattern returns quickly, whereas spiked activity occurs within hours of surgery. Coordinated activity in this area may be abnormal for days. The colon is usually the last organ to recover after transient postoperative ileus (Miedema & Johnson, 2003).

Achlorhydria With or Without Pernicious Anemia

No evidence exists in the literature that achlorhydria caused by medications used to decrease gastric acid (i.e., H2 blockers) causes delayed or absent gastric emptying, thus promoting postoperative ileus.

Early Feeding

In an attempt to prevent postoperative ileus following laparotomy, traditional feeding protocols include withholding oral intake until return of bowel function, followed by a slow advancement from clear liquids to solid foods (Fanning & Yu-Brekke, 1999). This traditional method has been taught for years, without supporting evidence.

In a study of 20 women who had undergone radical hysterectomy, it was found that aggressive bowel stimulation with milk of magnesia initiated on Postoperative Day 1 and biscolic suppositories initiated on Postoperative Day 2 resulted in an early return of bowel function (Fanning & Yu-Brekke, 1999). Once patients experienced flatus or bowel movement, a clear liquid diet was begun. None of the patients required readmission for ileus or bowel obstruction within the first 30 postoperative days. In another trial, 20 women undergoing radical hysterectomy were premedicated with an antiemetic followed by Fleet® phospho-soda beginning on Postoperative Day 1. A clear liquid diet was given immediately following the administration of Fleet® phospho-soda. Patients were discharged after passage of flatus or stool. No significant intestinal complications were observed (Kraus & Fanning, 2000).

In randomized clinical trials, it was found that early feeding versus traditional feeding schedules decreased the duration of ileus. "It is known that early feeding improves wound healing, increases splanchic flow, stimulates gut motility, decreases intestinal stasis, and impacts the incidence of morbidity and mortality" (Correia et al., 2004, p. 580). In studies in which both flatus and defecation were assessed, defecation was given a higher priority than flatus (Kehlet & Holte, 2001).

Early postoperative feeding may also decrease length of hospital stay for patients recovering from surgery. In a study of women undergoing major abdominal surgery, two groups were studied to determine whether early postoperative feeding was warranted within the group. One group (n = 47) was treated by traditional oral intake, which was initiated only after documentation of bowel function. The second group (n= 49) was given a clear liquid diet on Postoperative Day 1. Once 500 ml of clear liquids was tolerated, a regular diet was given. Early postoperative feeding decreased the length of hospital stay and was well tolerated (Schilder et al., 1997).

Early enteral feeding has been shown to be safe and tolerated as early as 4–12 hours postoperatively. Early enteral feeding can stimulate a reflex that produces coordinated propulsive activity and elicits the secretion of GI hormones, shortening the duration of postoperative ileus instead of causing it. A study by Anderson et al. (2003) revealed that after colorectal surgery, the group of patients who received stimulatory measures such as early nutrition recovered faster with GI function restored earlier than the control group, with a statistically significant difference ($p < .001$). Although some research has found negative effects of early feeding, these effects can be minimized by titrating feeding according to the gut's reduced capability to tolerate food (Correia et al., 2004).

Patient Age

To determine whether age was a factor in the development of ileus, Delaney et al. (2003) conducted a study and found that early feeding did not benefit patients older than 70 years, but in patients younger than 70 years who received early feeding, hospital stay was reduced from 7.1 to 5 days. DiFronzo, Yamin, Patel, and O'Connell (2003) studied patients older than 70 years who underwent GI surgery, and found that 89.6% of patients tolerated early feeding and their average hospitalization time was 3.9 days.

Increased Catecholamine Levels

Anesthetic agents affect GI motility. The length of surgery time and anesthesia used is proportional to the extent of change in motility (Tweedle & Nightingale, 1989). Most anesthetic agents have an effect on neural membranes and primarily affect the colon, which depends on direct nerve cell communication. The stomach and small intestine are affected at a lesser extent (Livingston & Passaro, 1990). The choice of anesthesia may influence the onset and duration of ileus (Miedema & Johnson, 2003). Halothane and enflurane also depress electrical activity and decrease smooth muscle contraction in the colonic wall (Condon, Cowles, Ekbom, Schulte, & Hess, 1987). These agents may be a factor in the decline of GI motility in the postoperative period. Anesthesia decreases bowel function, and this is enhanced by narcotics taken postoperatively (Mattei & Rombeau, 2006).

Opiate Use

Decreased gut motility is often an unavoidable complication of the use of narcotic analgesics. Evidence supports that adverse effects of opioid use are dose dependent. Opioids affect the intestines by one of three mechanisms: altered propulsion of contents; increased absorption of water secondary to increased transit time; or decreased secretions secondary to opioids binding to opioid receptors in the small intestine resulting in decreased biliary, pancreatic, and intestinal secretions (Canty, 1994). Opioids delay return of GI function even after minor surgeries (Miedema & Johnson, 2003).

Decreased Inhibitory Levels of Prostaglandins

Prostaglandins, depending on the type, have either a positive or a negative impact on GI motility (Ferraz et al., 1995). Prostaglandins located in the small intestine have been shown to have an inhibitory effect on GI motility (Kelley, Hocking, Marchand, & Sninsky, 1993). The release of histamine, prostaglandins, and kinins has been shown to be associated with abdominal surgery (Rimback, Cassuto, & Tollesson, 1990). The inhibitory effect is believed to be due to prostaglandins, which modulates the release of the agents on the gut. Nonsteroidal anti-inflammatory drugs (NSAIDs), such as ketorolac, inhibit prostaglandin synthesis and may attenuate postoperative ileus (Kelley et al., 1993; Resnick et al., 1997a, 1997b). When nonopioid NSAIDs are substituted for narcotics in the management of postoperative pain, the duration of paralytic ileus has been shown to be reduced by almost 50% and length of hospital stay can be reduced from 4.2 to 2.3 days (Ferraz et al., 1995).

Preventive Treatments

Correia et al. (2004) cited two interventions, gum chewing and preoperative carbohydrate loading, as showing promise in decreasing ileus. An increase in fiber intake may result in shorter transit time through the GI tract. In a study by Sculati et al. (1981), 86 patients who had undergone gynecologic or obstetric surgical procedures and who were given a bran-enriched diet preoperatively had quicker resolution of postoperative ileus than patients who received their usual diet; however, it was essential that the bran be eaten for at least 8–10 days before surgery.

Another study of patients undergoing elective cholecystectomy confirmed the benefits of intake of an 8-day preoperative bran-enriched diet. This study demonstrated a significant difference in the duration of postoperative ileus: 24 hours in the treatment group and 54 hours in the control group (Sculati et al., 1982). The consumption of a bran-enriched diet is a simple and inexpensive way to reduce postoperative ileus after abdominal surgery.

Other strategies that have been shown to be beneficial in the care of patients with paralytic ileus include psychologic preparation (Disbrow, Bennett, & Owings, 1993; Mumford, Schlesinger, & Glass, 1982; Rogers & Reich, 1986) and non-narcotic interventions typically used for pain relief (e.g., back rub, distraction, music, electrical stimulation). Although walking was not shown to reduce the occurrence of postoperative ileus, Waldhausen and Schirmer (1990), in a study of 34 patients, concluded that the intervention might need to be studied further in a larger sample. Early postoperative feeding with liquids or the use of laparoscopic versus open procedure has also been found to be effective in reducing the occurrence of paralytic ileus (Nunley & Fitz Harris, 2004).

Although prokinetic drugs have been shown to increase GI motility, the use of prokinetic agents (i.e., erythromycin and metoclopramide) and routine use of nasogastric tubes have proven ineffective in reducing the occurrence of paralytic ileus. There were no published studies between 1980 and 2000 on prokinetic drugs and ileus. Smith et al. (2000) studied erythromycin as a stimulant for motilin receptors and, in a randomized, placebo-controlled, double-blind study of 134 patients undergoing colon and rectal surgery, found that erythromycin did not alter the incidence of postoperative ileus.

In contrast, Chan et al. (2005) found metoclopramide to be effective in preventing postoperative paralytic ileus in patients with advanced gastric cancer who were undergoing resection and intraperitoneal chemotherapy. This study supported the finding that the combination of metoclopramide and epidural pain management might achieve a decrease in time to resumption of oral soft diet intake and metoclopramide has a role in the prevention of postoperative paralytic ileus.

Methods

Hypotheses

On the basis of our review of the literature, we hypothesized that

1. initiation of a clear liquid diet on Postoperative Day 1 or 2 can reduce the likelihood that ileus will develop;
2. the development of ileus is associated with positive fluid balance;
3. higher opioid doses (mean equivalent daily dose [MEDD]) are associated with a greater likelihood of the development of ileus;
4. the use of prokinetic drugs reduces the likelihood that ileus will develop;
5. the use of ketorolac/NSAIDs decreases the likelihood of ileus and the opiate dose;
6. development of ileus is associated with time and higher doses of anesthetic agents;
7. development of ileus is associated with electrolyte abnormalities; and development of ileus is associated with albumin levels below 3.5.

Study Design and Procedures

An interdisciplinary group composed of nurses, pharmacists, anesthesiologists, and clinical nutritionists from the GI, genitourinary, and gynecology services formed an ileus study group. The group met regularly with the objective of searching the literature to identify factors reported to be associated with postoperative paralytic ileus. The objective was to gain a better understanding of the condition and develop interventions to prevent it.

An Ileus Data Collection Form was developed on the basis of the reviewed literature and feedback from clinical experts (Figure 1). Using the instrument, data were collected from a retrospective review of 101 medical records of patients who had open abdominal surgery recorded from the preoperative visit through Postoperative Day 7. For the purpose of this study, *paralytic ileus* was defined as lack of return of bowel function; no passage of flatus; unable to tolerate oral intake; abdominal distention, nausea, and vomiting; and absence of bowel movement by Postoperative Day 3.

Forty-four patients developed ileus postoperatively and 57 patients did not. Of the 44 patients who developed ileus, 43 had exhibited signs of the condition by Postoperative Day 3. One patient exhibited signs by Day 4. Patients were categorized into two groups: those for whom a clear liquid diet was introduced on Day 1 or 2 and those for whom a clear liquid diet was introduced on Days 3–7.

Fluid balance was calculated as the average amount of "fluids out" the first 3 days postoperatively, which was then subtracted from the average amount of "fluids in" the first 3 days postoperatively (i.e., fluids in minus fluids out). The analysis was based on data for patients with complete records.

To obtain the MEDD, we first calculated the total equivalent intravenous doses of morphine, hydromorphone, and meperidine administered over 5 days (presurgery and Days 0–3). We then calculated the equivalent oral doses of these agents by multiplying the intravenous doses by a factor of 3. We used appropriate conversion equivalent factors to convert an opioid dose to a morphine equivalent. To report sums in terms of morphine equivalents, summed values of hydromorphone were multiplied by 5 and summed values of meperidine were divided by 10. Finally, the summed values of morphine, hydromorphone, and meperidine were added for a final MEDD value. A Wilcoxon two-sample test was used to make these comparisons because the values for MEDD were highly skewed. Similar results were found when comparing means using Student's t tests.

Different types of surgery are associated with different lengths of operation time. For this analysis, we grouped patients undergoing small- and large-bowel surgical procedures together and those undergoing pancreas and other procedures together. A third group was composed of patients in whom the bowel was not included in the surgical procedure.

We tested whether the average values of potassium, magnesium, sodium, and chloride on Days 1, 2, and 3 were associated with the occurrence of ileus. We first defined a low level of potassium as less than 3.5 mEq/L.

Descriptive analysis methods were used to summarize the data. For continuous data, a Student's t test was used to compare two groups or a Wilcoxon two-sample test was used if the data were not approximately normally distributed. When three groups were being compared, an analysis of variance test was used in combination with Duncan's multiple range tests to

Service	Height (cm)	Weight (kg.)	If ostomy "take down" surgery, length of time since surgery for ileostomy (_______Mos.)
__ GI			

Surgical Procedure	Anesthetic Agent (MACs)
Colon Anastamosis	
• Stapled	• Halothane
• Hand sewn	• Enflurane
• NA	
Length of Surgery:	
Hrs Min	

Lab Test	Fluid
Potassium	Input
Magnesium	Output
Sodium	
Chloride	
Albumin	

Highest Pain Level (0 to 10 scale)

Medications	Prokinetics	Pain Meds
H2 Blockers	• Cisapride (Propulsid)	NSAIDS
• Pepcid,	• Reglan (Metoclopramide)	• Toradol
• Zantac,		• Ibuprofen
• Tagamet		• Naprosyn
Antiemetics	Erythromycin (E-mycin)	Epidural
• Compazine		
• Phenergan		
• Zofran		

IV Opioids	PO Opioids
Morphine	Morphine
Hydromorphone	Hydromorphone
Meperidine	Meperidine
Codeine	Codeine
	Hydrocodone

FIGURE 1. Ileus data collection form.

further compare two groups at a time. Categorical variables were compared using the chi-square test or Fisher's exact test if assumptions of the chi-square test were not met. All analyses were made using SAS statistical software (version 9.1.3, SAS Institute Inc., Cary, NC). Results were considered to be statistically significant if the significance level was less than .05.

Results

Demographics

Most of the patients were Caucasian (79%); in addition, 12% were Hispanic and 4% were African American. The sample was composed of 47% male patients and 53% female patients (Table 1). The average age of patients in whom ileus developed was 61.7 years (SD = 13.7 years) and 60.1 years (SD = 13.0 years) for those who did not have ileus. No statistical significance was observed between the groups (Student's t test, $p = .53$).

No statistically significant difference in the occurrence of paralytic ileus was observed by ethnicity, neither in the chi-square analysis of Caucasians versus all other ethnicities (42.5% vs. 47.6%, respectively; $p = .67$) nor in Fisher's exact test comparing all groups ($p = .95$). When the occurrence of paralytic ileus was compared in men and women, no statistical significance was found (36% vs. 50%, respectively; chi-square test, $p = .16$).

TABLE 1

Patient Characteristics (N = 101)

	Frequency	%
Ethnicity		
African American	4	3.96
Hispanic	12	11.88
Caucasian	80	79.21
Turkish	2	1.98
Asian	2	1.98
Russian	1	0.99
Gender		
Male	47	46.53
Female	34	53.47

Note. Age range = 24–91 years; mean (*SD*) = 60.88 (13.22).

The mean height of patients with ileus was 165.1 cm (*SD* = 14.5) and for those without ileus it was 170.7 cm (*SD* = 13.4). This comparison was made using Student's *t* test and the difference was not statistically significant (p = .046). Likewise, there was no statistically significant difference in weight (mean = 76.2 kg [*SD* = 22.2] vs. mean = 83.2 kg [*SD* = 31.9]; p = .22).

Hypothesis 1. Initiation of a clear liquid diet on Postoperative Day 1 or 2 can reduce the likelihood that ileus will develop.

Ileus did not develop in 31 of 44 patients (79%) who received early initiation of clear liquids (Day 1 or 2) or in 23 of 50 patients (46%) who received late initiation of clear liquids. This difference was statistically significant (chi-square test, p = .017).

Hypothesis 2. Development of ileus is associated with positive fluid balance.

Because the variable of fluid difference was approximately normally distributed, group differences were tested using Student's *t* test. No significant difference was found between the average fluid difference score (p = .22).

In addition, to answer the question, "Were patients with fluid differences of ≥ 500 ml more likely to develop ileus than those with fluid differences < 500 ml?", a chi-square test was performed. Twenty-five of 66 persons with fluid differences of less than 500 ml developed ileus (38%) in comparison with 16 of 30 persons with values of 500 ml or more (53%). This difference was not statistically significant (p = .16).

The same analysis was performed with a cutoff value of 1,000 ml. In this case, 29 of 77 patients (38%) with fluid difference values of less than 1,000 ml developed ileus in comparison with 12 of 19 patients (63%) with values of 1,000 ml or more (63%). This difference was statistically significant (p = .04).

Hypothesis 3. Higher opioid doses (MEDD) are associated with a greater likelihood of the development of ileus.

TABLE 2

Association Between the Use of Prokinetics and Surgery Type

	Received Prokinetics	
Surgery Type	No (N = 62)	Yes (N = 39)
Small/large bowel	31/40 (77.5)	9/40 (22.5)
"No bowel"	20/31 (65)	11/31 (35)
Pancreatic/multiple surgical procedures	11/30 (37)	19/30 (63)

Note. Values given are number (percentage). Chi-square test; p = .0022.

The association between opioid use and development of ileus was not found to be statistically significant. Patients who received pain medicine before surgery were no more likely to develop ileus than those who did not (chi-square test, p = .64). Of the 23 who received medication before surgery, 9 (39%) developed ileus, whereas of the 74 who did not receive medications before surgery, 33 (45%) did not develop ileus.

Twenty-one medical records included patients' information about the types of medicines patients received before surgery. Two (25%) of the eight patients who did not receive opioids developed ileus, whereas 6 (46%) of the 13 who received opioids developed ileus. This difference, however, was not statistically significant (Fisher's exact test, p = .40) (Table 2).

Hypothesis 4. The use of prokinetic drugs reduces the likelihood that ileus will develop.

Of the 39 patients who received prokinetics at any time before surgery through Postoperative Day 3, 17 (44%) developed ileus, and 27 of the 62 patients (44%) who did not receive prokinetics developed ileus ($p > .99$).

The results of multivariate logistic regression modeling to determine whether the type of surgery, use of prokinetics, and length of surgery time were predictive of development of ileus were not statistically significant. This finding was not surprising because univariate analysis demonstrated that these variables were not statistically significant predictors of ileus. Significant differences were observed in the use of prokinetics and the type of surgical procedure done (see Table 2).

Hypothesis 5. Use of ketorolac/NSAIDs decreases the likelihood of ileus and the opiate dose.

The first analysis was based on any use of NSAIDs preoperatively through Postoperative Day 3. The association between the occurrence of ileus and use of NSAIDs was marginally statistically significant (p = .11). Twenty-four of 64 patients (38%) who did not receive NSAIDs developed ileus in comparison with 20 of 37 (54%) patients who did receive NSAIDs.

The use of ketorolac/NSAIDs was not significantly related to decrease in opioid use (p = .49 for differences in the MEDD between those who developed ileus and those who did not and $p = .81$ for differences in MEDD between the two groups).

Hypothesis 6. Development of ileus is associated with time and higher doses of anesthetic agents.

For patients in the small- and large-bowel surgical group, the mean length of the surgery was 184 minutes ($SD = 87$); for those in the no bowel surgery group, the mean length of surgery was 222 minutes ($SD = 115$); and for those who underwent pancreatic and other surgical procedures, the mean length of surgery was 417 minutes ($SD = 184$). Analysis of variance demonstrated that the differences in these times were highly significant ($p < .0001$). When Duncan's multiple range test was applied, the difference in the mean length of surgery associated with pancreatic and multiple other surgical procedures group was statistically significant in comparison with that of the other two groups ($p = .0005$). The difference in the mean lengths of surgery of the other two groups was not statistically significant.

The occurrence of ileus in these three categories was 53% in the pancreatic and other surgical procedures group; 40% in the small- and large-bowel surgical group; and 39% in the no bowel surgery group. Using the chi-square test, the three categories of surgery were compared and no statistically significant difference was found in their association with the likelihood of occurrence of ileus ($p = .43$). When the five surgical procedures were analyzed separately, there was still no statistically significant difference in their association with the occurrence of ileus ($p = .29$). Although type of anesthesia could affect ileus, this could not be tested because all patients received the same anesthetic agent.

Hypothesis 7. Development of ileus is associated with electrolyte abnormalities.

Analyses were done to determine the presurgery values of potassium, magnesium, sodium, and chloride. No patients had presurgery values of potassium <3.5 mEq/L, magnesium levels <1.8 mg/dl, sodium levels <135 mEq/L, or chloride levels <96 mEq/L. The significance levels associated with the levels of these substances were $p = .65$, $p > .99$, and $p > .99$, respectively.

In our comparison of patients with potassium levels <3.5 mEq/L with those with potassium levels ≥3.5 mEq/L, no statistically significant difference was found using Fisher's exact test ($p = .40$). *Low-level magnesium* was defined as being less than 1.8 mg/dl and again, using Fisher's exact test, the results were not statistically significant ($p = .35$). *Low-level sodium* was defined with a cutoff value of <135 mEq/L, and similarly, there was no statistically significant difference ($p = .84$). No mean values of chloride were below 96 mEq/L (the assigned cutoff value); therefore, analyses were not made for this variable.

A final analysis was performed using actual values and cutoff values of each electrolyte to determine whether there was an association between them and development of ileus. For presurgery values, no statistically significant differences were found (all p's $> .15$). For 3-day average values, only potassium was statistically significant (Student's t test, $p = .03$). The ileus group had higher potassium levels than the nonileus group ($M = 4.2$ mEq/L vs. 4.0 mEq/L).

Hypothesis 8. Development of ileus is associated with albumin levels below 3.5.

A Fisher's exact test was used to test the association between the development of ileus and serum albumin levels; the difference was not found to be significant ($p > .99$); however, 57 patients did not have presurgery albumin levels drawn. Only eight patients had presurgery albumin levels below 3.5. Of these, three developed ileus and five did not. A total of 36 patients had albumin levels of 3.5 or more; of these, 15 developed ileus and 21 did not. Of patients for whom data were incomplete and there were no albumin values ($n = 57$), 26 developed ileus and 31 did not. Results of a 2 × 3 Fisher's exact test, including a separate category for missing data, did not demonstrate statistical significance ($p = .87$).

Findings

The goal of this study was to identify both risk factors and preventive treatment to minimize risks. Other factors identified in the literature that would be beneficial to study are the preoperative use of a high-fiber diet and carbohydrate loading and early postoperative use of milk of magnesia (Kehlet & Morgensen, 1999). Other suggestions that have been found effective in clinical practice that need to be systematically studied include the use of prune juice followed by a hot liquid to increase peristalsis, as well as rocking in a chair postoperatively to increase GI motility (Massey, Haylock, & Curtiss, 2004).

This study is limited by its small sample size and lack of specific laboratory data to facilitate adequate sampling for analyses; for example, albumin levels were not routinely collected from patients before surgery. A larger, multisite study might identify more significant risk factors.

Nursing Implications

Postoperative paralytic ileus or "paralytic ileus" can occur as a complication of many diseases and procedures. Care plans for patients having GI tract surgery should consider the factors that increase a patient's risk for this condition and should be individualized for each person. Based on this study, accurate intake and output and reporting and avoiding positive fluid balances may be beneficial. Early introduction of fluid and foods postoperatively is also recommended. It is suggested that treatment plans be based on findings from systematic clinical trials rather than on clinical observations. Prospective research in which more detailed data can be collected about all risk factors is essential.

The clinical implications of this finding are the importance of monitoring fluid intake and output in postoperative patients and identifying positive fluid balance early to prevent this from continuing. Also of importance is encouraging early oral intake. Future studies should focus on those measures that may increase GI motility postoperatively, such as chewing gum (Miedema & Johnson, 2003; Quah, Samad, Neathey, Hay, & Maw, 2006), early ambulation (Kehlet & Holte, 2001), the use of a rocking chair during the postoperative period (Massey et al., 2007), administering milk of magnesia (Kehlet & Morgensen, 1999), preoperative teaching to eat normal amount of bran 8–10 days preoperatively (Sculati et al., 1982), and preoperative carbohydrate loading (Correia et al., 2004). The role of hypothermia and the benefit of warm blankets in the operating room to prevent intraoperative hypothermia are mentioned in more recent literature (Fearon et al., 2005).

Conclusions

The only factors found to have a statistically significant effect on reducing the development of ileus were early postoperative introduction of fluids and food, avoidance of positive fluid balance, and avoiding potassium elevations over a 3-day period. These interventions were found to be beneficial in restoring normal bowel function after surgery, and the findings might be useful in modifying current clinical practice. The trends need to be studied both in a larger sample and in clinical trials to assess the effectiveness of the use of NSAIDs to reduce the dose of opiates needed and determine whether this decreases postoperative ileus. Elevated potassium levels may also increase postoperative ileus and needs to be studied in a larger sample.

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