

## EDITORIAL UPDATE

# Review of the Pathophysiology and Management of Postoperative Ileus

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### Abstract

Investigations in the pathophysiology and treatment of postoperative ileus continue to evolve. Bowel rest is no longer a mandatory component of postoperative recovery. Tolerance of enteral nutrition and normalization of the abdominal examination are more accurate indications of the resolution of postoperative ileus than passage of flatus or first bowel movement. A multimodal "fast track" recovery approach incorporated into a clinical pathway provides a more rapid return of intestinal function and shortened hospital stay in patients undergoing major, uncomplicated gastrointestinal surgery.

Ileus was used in the past to refer to any obstruction of the intestines and is still occasionally used in this sense, for example, in the terms gallstone ileus and meconium ileus.<sup>1</sup> In current usage, however, ileus usually refers to a profound disturbance of bowel motility that is often clinically indistinguishable from a bowel obstruction and frequently the result of a noxious or injurious insult. Postoperative ileus occurs after a major surgical procedure and is an important cause of postoperative discomfort and prolonged hospital stay.<sup>2</sup> Recognized as a clinical entity since the late 19th century, this seemingly obligatory period of gastrointestinal quiescence is often thought of as having some sort of protective benefit, but its complex pathogenesis remains incompletely understood. Historically, treatment has been mostly supportive, including bowel rest, intravenous hydration, and nasogastric tube decompression—essentially the same as that of a true bowel obstruction. However, there is recent evidence to support the use of certain interventions that may shorten the duration of this enigmatic phenomenon and, more importantly, minimize the discomfort of patients who are affected by it.

### CLINICAL PICTURE

Postoperative gastrointestinal (GI) tract dysfunction occurs predictably after major abdominal operations but can occur after operations in other parts of the body or occasionally even after minor surgical procedures. In general, operations that involve large incisions, extensive manipulation of the intestines, or exposure of the peritoneum to irritants such as blood or pus are more likely to result in a postoperative ileus. It is characterized by a lack of coordinated intestinal activity and a substantial overall reduction in peristalsis. The clinical picture is variable, with some patients remaining essentially asymptomatic while others complain of cramping, abdominal pain, and nausea. Occasionally, patients may develop bloating and bilious emesis. Anorexia is typical, and bowel movements and passage of flatus are nearly always absent.

On physical examination, patients typically have some degree of abdominal distension and may also demonstrate tympany to percussion. Tenderness is a nonspecific finding and related more to the incision and the underlying disease process than the ileus itself. Traditional teaching has focused on the absence of bowel sounds upon auscultation of the abdomen as a necessary

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and specific finding associated with postoperative ileus. The return of bowel sounds was said to herald a return of normal bowel function and resolution of the ileus. Although there may be an approximate correlation between the quantity or quality of bowel sounds and bowel function, it has not been established as a definitive association, and bowel sounds are no longer relied upon to make important clinical decisions in the postoperative period.

No diagnostic test can confirm or exclude the diagnosis of postoperative ileus with certainty. Abdominal radiographs may demonstrate dilated air-filled loops of small and large bowel, but this is a nonspecific finding and by no means diagnostic. Computerized axial tomography (CT) and/or upper GI (UGI) contrast studies are useful in the rare situation when it becomes necessary to differentiate an ileus from a mechanical bowel obstruction. When an ileus has failed to resolve by approximately the fifth or sixth postoperative day, for example, it may be important to identify a specific cause, such as intra-abdominal abscess or anastomotic leak, and to exclude an early postoperative bowel obstruction due to adhesions, inflammation, or intussusception.<sup>3</sup>

Diagnostic studies are generally not necessary in the early postoperative period, as one can usually recognize the presence of a postoperative ileus on the basis of several more-or-less characteristic signs and symptoms that occur in the proper clinical setting. On the other hand, determination as to when a given patient has recovered from a postoperative ileus is somewhat less precise. The traditional endpoint is the passage of flatus or a bowel movement. This was based on the fact that colonic motility appears to be the last to recover after an abdominal operation. Studies in which bowel motility is measured in real time suggest that the small bowel returns to normal peristaltic function within 12–24 hours, the stomach within 24–48 hours, and the colon in 3–5 days.<sup>4</sup> However, although waiting for passage of flatus or a bowel movement after surgery may ensure that the entire gastrointestinal tract is peristalsing, there is no evidence that this is necessary before allowing the patient to resume oral intake. In fact, more recent studies suggest that the use of these arbitrary endpoints forces most patients to be denied nutrition for longer than is necessary because most will tolerate oral intake even before the entire intestinal tract regains motility. The endpoint is even more imprecise in patients who develop constipation, which is commonly observed in patients exposed to general anesthesia, abdominal surgery, and postoperative narcotics.

Other clinical criteria have been used over the years to help determine when a postoperative ileus has resolved. The return of bowel sounds on auscultation of the abdo-

men, as mentioned previously, was felt to signal the resumption of normal peristalsis, but this is no longer considered reliable. Another nonspecific indicator that is still sometimes used to decide when an ileus has resolved is the volume of nasogastric tube drainage based on the notion that normal bowel function should allow more GI secretions to pass distally. Clinical evidence suggests that this is an unreliable and overly conservative measure of normal bowel function. Some place more significance on a change in the color of nasogastric tube drainage from green to clear, as the absence of bile in the stomach is probably a more specific indicator of normal bowel transit than a decrease in the amount of drainage. When used in a traditional postoperative regimen that includes nasogastric tube decompression and bowel rest, this allows patients to be relieved of the tube sooner and to be fed earlier.

The most physiologic indication that an ileus has resolved is the patient's ability to tolerate oral intake without pain, bloating, or emesis. However, there is no accurate measurement of diet tolerance short of a trial of oral intake, which inevitably puts some patients at risk of vomiting and aspiration. This forms the basis of the approach, discussed below, in which patients are given small feeds very soon after surgery, which are then increased gradually as tolerated. Nevertheless, the time when it is safe to resume oral intake after an abdominal operation is inherent in most discussions of postoperative ileus and continues to be enshrouded in controversy.

## PATHOGENESIS

GI motility is controlled by several physiologic mechanisms, including the autonomic nervous system, GI hormones, and inflammatory mediators (Table 1). Anesthesia and surgery typically alter the activity of one or more of these modifiers and therefore can have profound effects on bowel motility. Limiting these effects forms the basis of many therapeutic options that are used to try to limit the severity and duration of postoperative ileus.

In the fasting state, peristaltic activity of the stomach and small intestine is characterized by slow, irregular waves of contractility referred to as the migrating motor complex (MMC) while the fed state is characterized by more forceful, frequent, and regular peristaltic waves of contraction.<sup>5</sup> Changes in the pattern of motility are regulated by neurologic and hormonal mechanisms, principally by direct action on the intrinsic nervous system of

**Table 1.**  
Postoperative ileus: contributing factors

Category	Specific factors	Physiologic effects
Pharmacologic	<ul style="list-style-type: none"> <li>• Opioids</li> <li>• Anesthetic agents</li> </ul>	<ul style="list-style-type: none"> <li>• Inhibition of intrinsic GI nervous system and musculature</li> </ul>
Inflammatory	<ul style="list-style-type: none"> <li>• Peritonitis</li> <li>• Local tissue trauma</li> </ul>	<ul style="list-style-type: none"> <li>• Stimulation of sympathetic activity via splanchnic nerves</li> <li>• Inhibition of intrinsic GI nervous system and musculature</li> </ul>
Hormonal	<ul style="list-style-type: none"> <li>• Substance P</li> <li>• VIP</li> <li>• Nitric oxide</li> </ul>	<ul style="list-style-type: none"> <li>• Inhibition of intrinsic GI nervous system and musculature</li> <li>• May inhibit regulation of GI motility</li> </ul>
Metabolic	<ul style="list-style-type: none"> <li>• Endogenous opiates</li> <li>• Hypokalemia, hyponatremia, hypomagnesemia</li> <li>• Acidosis</li> <li>• Hypothermia</li> <li>• Hypoxia/reperfusion injury</li> </ul>	<ul style="list-style-type: none"> <li>• Nonspecific inhibition of intrinsic GI nervous system and musculature</li> <li>• Exact mechanisms are unknown</li> </ul>
GI physiology	<ul style="list-style-type: none"> <li>• NPO</li> <li>• Nasogastric tube decompression</li> </ul>	<ul style="list-style-type: none"> <li>• Lack of diet-induced GI stimulation</li> <li>• Interruption of normal GI reflexes triggered by orogastric secretions</li> </ul>
Neurologic	<ul style="list-style-type: none"> <li>• Pain</li> <li>• Tissue trauma</li> </ul>	<ul style="list-style-type: none"> <li>• Increased sympathetic tone (via splanchnic nerves) and decreased parasympathetic tone (via vagus nerves), both of which decrease GI motility</li> <li>• Autonomic nervous system may be the final common pathway for some other factors that affect GI motility</li> </ul>
Psychological	<ul style="list-style-type: none"> <li>• Inflammation</li> <li>• Anxiety</li> <li>• Patient's expectations of prolonged recovery</li> </ul>	<ul style="list-style-type: none"> <li>• Inhibit GI motility by increasing sympathetic tone</li> <li>• Nonspecific inhibition of intrinsic GI nervous system and musculature</li> </ul>
Miscellaneous	<ul style="list-style-type: none"> <li>• Bed rest</li> <li>• Bowel edema from excessive IV hydration</li> </ul>	<ul style="list-style-type: none"> <li>• Nonspecific inhibition of intrinsic GI nervous system and musculature</li> </ul>

GI: gastrointestinal; VIP: vasointestinal polypeptide; NPO: *nil per os* (nothing by mouth); IV: intravenous.

the gut. Motility of the colon, consistent with its role in absorbing water and eliminating waste, is marked by slow rhythmic contractions that vary little between fasting and fed states but can be slowed significantly by both internal and extrinsic factors. Recovery of bowel motility after an operation is marked by a return of the fed pattern of contractility. As described above, this occurs in a step-wise and predictable fashion: the small intestine recovers first, the stomach next, and the colon last, with the entire intestinal tract in most cases having recovered within 3–5 days. How this recovery is coordinated and what factors are involved in making it happen are unknown.

The autonomic nervous system plays an important role in the regulation of GI motility.<sup>6</sup> Parasympathetic nerve activity (vagal input) stimulates bowel activity by inducing the release of acetylcholine in the myenteric plexus. Sympathetic nerve activity reduces acetylcholine release and inhibits bowel motility. This appears to be the principal physiologic mechanism involved with control of bowel motility in the postoperative period. Afferent neural input due to irritation or inflammation of the peritoneum

results in an increase in sympathetic efferent neural activity via the splanchnic nerves. As a result, the balance between parasympathetic stimulation and sympathetic inhibition is shifted toward an overall decrease in gut activity.

Although it is known that GI hormones such as motilin and vasoactive intestinal peptide play an important role in the regulation of gut motility, the exact nature of these interactions and how they fluctuate to regulate motility in the postoperative period is unknown. More importantly, attempts to modify the activity of gut hormones to decrease postoperative ileus have been disappointing. Neurotransmitters also seem to play a role in producing postoperative ileus.<sup>7</sup> It has been proposed, for example, that a substance P antagonist might be useful someday in limiting postoperative ileus.<sup>8</sup> Nitric oxide is a potent inhibitor of GI motility that acts locally in the myenteric plexus.<sup>9</sup> Nitric oxide synthesis inhibitors decrease postoperative ileus in animal studies, but the potential usefulness of this class of drugs in humans is unclear.<sup>10</sup> Finally, endogenous opioids are assumed to play a role in

postoperative ileus, but their role is likely to be rather small.<sup>11</sup> Despite numerous studies, the role of GI hormones, neurotransmitters and other humoral factors in postoperative ileus remains something of a mystery. Until more is known about these complex interactions, it appears unlikely that any useful intervention designed to modify their effects will become available in the near future.

Inflammatory mediators probably play a significant role, but the exact nature and extent of their role remains poorly understood.<sup>11</sup> It seems reasonable to assume that tissue trauma might lead to the release of cytokines and other inflammatory mediators, the combined effect of which is to decrease GI motility. We know that when severe inflammation is present, the postoperative ileus that results can be particularly severe, for example, in the case of chemical peritonitis after perforated viscus or purulent ascites from perforated appendicitis. Moreover, techniques designed to minimize inflammation, such as minimally invasive surgery and gentle handling of tissues during an operation, appear to minimize postoperative ileus.<sup>12</sup> Furthermore, several studies suggest that the use of anti-inflammatory drugs such as ketorolac are beneficial in reducing postoperative ileus,<sup>12,13</sup> but whether this is principally due to its anti-inflammatory properties or its opiate-sparing effect is not clear.

Anesthetic agents themselves decrease bowel motility, an effect that is enhanced by opioid analgesics. Anesthetic regimens that use thoracic epidural administration of bupivacaine appear to minimize these effects,<sup>14,15</sup> as does minimizing the use of opiates in the perioperative period. Studies are underway looking at whether specific  $\mu$ -receptor opioid antagonists might reduce the deleterious effects on the GI tract without decreasing the beneficial central effects of opioids in postoperative patients.<sup>16</sup>

In summary, although there are many factors of which the cumulative effect is to decrease bowel motility after surgery, there is yet to be identified either a single uniquely important mechanism or a final common pathway by which the others exert their influence. Thus far, the most likely candidate for such a mechanism is sympathetic neural input though its exact role is still unclear.

## PREVENTION AND TREATMENT

### Traditional Treatment

The mainstay of treatment for postoperative ileus has included bowel rest and nasogastric tube decompression.

This empirical regimen has been espoused by generations of surgeons, with the belief not only that it hastens recovery from postoperative ileus but that it improves outcomes by reducing the incidence of complications such as infection and anastomotic dehiscence. These tenets have been reexamined in light of more recent data and have largely been shown to be fallacious. But despite growing evidence that these practices should be abandoned, many practitioners continue to apply them routinely in the care of their patients.<sup>17,18</sup>

Bowel rest was purported to shorten the time of postoperative ileus, possibly due to the observation that some patients who were fed "too soon" after their operation became nauseated and uncomfortable. This was considered a sign that the ileus was made worse by feeding. Moreover, bowel distension was thought to contribute to complications, especially when a bowel anastomosis was involved. While it is true that postoperative distension and nausea are sometimes made worse by large meals in the immediate postoperative period, it is now understood that small feedings actually stimulate the GI tract and reduce the period of postoperative ileus.<sup>19,20</sup> In addition, several studies have refuted the notion that bowel rest improves outcomes or reduces the complication rate after GI surgery.<sup>21</sup>

Nasogastric tube decompression has also long been recommended as a treatment for postoperative ileus, presumably for the same reasons that bowel rest was considered useful. Minimizing gaseous distension and the stimulation caused by GI secretions was felt to be important for the proper "resting" of the gut. As a result, nasogastric tubes were kept in place for several days after an operation, typically until the patient passed flatus or in some cases until he or she had a bowel movement. This period usually lasted 3–5 days or longer, depending on the nature of the operation and other factors. It is now known that nasogastric tubes do not hasten recovery from postoperative ileus.<sup>22–24</sup> They are probably useful in some patients as a comfort measure to prevent severe abdominal distension and vomiting but are unnecessary in up to 95% of patients.<sup>25</sup> In addition, their routine use is associated with a higher rate of aspiration and pneumonia in some patients. The routine use of nasogastric tube decompression after abdominal surgery is no longer recommended, except perhaps after certain types of operations (gastric or duodenal surgery) and for the rare patient who develops severe abdominal distension or intractable vomiting after surgery.

It has long been part of the traditional teaching that ambulation stimulates GI motility and hastens recovery from postoperative ileus. Although the benefits of early

ambulation after surgery are numerous and indisputable, and while it may be true that strict bed rest may contribute to reduced GI activity, there is no evidence that patients can shorten the time of postoperative ileus by increasing ambulation.<sup>26</sup> More recent evidence suggests that patients should ambulate early to reduce the overall complication rate but that excessive walking is probably not helpful as a specific treatment for postoperative ileus.<sup>12</sup>

In summary, traditional postoperative regimens that emphasize bowel rest and nasogastric tube decompression for the treatment of postoperative ileus do not hasten return of normal bowel function and often prolong recovery and hospital stay. Moreover, there is no evidence that they are beneficial in reducing complications such as infection and anastomotic dehiscence, as previously believed. This is not to say that patients should be treated as though postoperative ileus does not exist and that they should be allowed to eat normally after GI surgery, but only that a new approach that emphasizes patient comfort and one based on available evidence should be considered.

## NOVEL APPROACHES

Enteral nutrition in the early postoperative period may actually stimulate the return of normal GI function and thus may shorten the recovery time of postoperative ileus.<sup>19,20</sup> One interesting study reports that even sham feeding in the form of gum chewing may shorten the time to recovery from laparoscopic colectomy.<sup>27</sup> Other studies have confirmed that enteral feedings in the early postoperative period are well tolerated in the majority of patients and may shorten the time to first flatus and overall recovery time after abdominal surgery.<sup>19,20,28</sup> In addition, it has been known for some time that the early administration of enteral nutrition to trauma patients decreases the incidence of septic complications and hastens recovery.<sup>29,30</sup> It appears that a period of strict bowel rest after surgery may needlessly delay recovery of bowel function in patients who have had major abdominal surgery and that early postoperative feeding, once considered dangerous and heretical, may actually be beneficial.

Administration of a local anesthetic through a thoracic epidural catheter may decrease postoperative ileus.<sup>14,15</sup> The mechanisms of action are thought to include disruption of afferent inhibitory signals from the abdominal viscera, reduction of sympathetic neural input, increased blood flow to the gut, and possibly an anti-inflammatory effect of local anesthetics absorbed systemically. The

effect is not seen with lumbar epidural catheters or when opiates are used. To be effective, the catheter should be placed in a midthoracic location (T6–T8), and administration should continue for 48–72 hours postoperatively.<sup>31</sup> Some have favored the routine use of thoracic epidural bupivacaine as part of a multimodal protocol for patients undergoing abdominal surgery and have found that it significantly shortens the period of postoperative ileus and the length of hospital stay.

Inflammation of the peritoneum and tissues of the GI tract appears to play a role in promoting postoperative ileus, and anti-inflammatory drugs have been used in an attempt to blunt this response. The use of nonsteroidal anti-inflammatory drugs (NSAIDs) such as ketorolac decreases the duration of postoperative ileus, presumably because of an opiate-sparing effect, but an additional benefit may be the reduction of postoperative inflammation.<sup>32</sup> A single dose of dexamethasone given intraoperatively decreases the incidence of postoperative nausea and vomiting, perhaps through a similar mechanism.<sup>15</sup>

Perhaps the best way to minimize inflammation is to use minimally invasive techniques, such as laparoscopy, whenever possible. When laparotomy is necessary, smaller incisions and gentle handling of tissues should be the rule. On the other hand, a recent and very cleverly designed study in which patients were randomized and blinded to undergo either laparoscopic or open colonic resection showed no difference between the two groups when both were treated using a fast-track postoperative recovery regimen.<sup>33</sup>

There has always been an emphasis on maintenance of normal hydration and electrolyte balance in the postoperative period. On the other hand, it has been suggested that excessive hydration and subsequent bowel edema may contribute to postoperative ileus. Indeed, it is often observed that patients who are excessively hydrated sometimes develop significant bowel edema during the operation, though whether this contributes to postoperative ileus is unclear. In a recent study, patients undergoing colectomy for carcinoma were randomly assigned to receive either standard hydration or a protocol in which water and sodium were restricted.<sup>34</sup> It was found that patients on the restricted pathway had significantly shorter gastric emptying, earlier time to first flatus and first bowel movement, and a median hospital stay that was 3 days shorter than the standard hydration group. Excessive hydration can cause other deleterious effects in the postoperative period, such as pulmonary edema and heart failure in some patients and perhaps some limitation in activity due to total body edema. In general, excessive intraoperative administration of fluids should be avoided.

Opiates are known to slow gut motility, and their use is thought to contribute to postoperative ileus. Drugs such as ketorolac, which can decrease the need for narcotic analgesics, have been promoted by some as part of a multimodal approach to reducing ileus.<sup>35</sup> The use of opiate receptor antagonists such as naloxone have not been shown to be effective in reducing postoperative ileus.<sup>4</sup> Current research has focused on the differential effects of the various opiate receptors. For example, lipid-soluble  $\mu$ -receptor antagonists have been developed that do not cross the blood-brain barrier and may therefore selectively inhibit the effect of opioids on the gut.<sup>16,36</sup> In a recent phase III trial, the  $\mu$ -selective opioid antagonist alvimopan (Adolor) produced a modest but statistically significant reduction in time to recovery of bowel function in 469 patients who underwent bowel resection or radical hysterectomy.<sup>37,38</sup> Similarly, studies continue with  $\mu$ -receptor agonists, which could potentially produce effective analgesia without intestinal effects.<sup>39</sup> It is likely that selective opiates that maximize pain relief and minimize side effects will become available in the near future.

Drugs that are purported to stimulate GI motility would seem to be an obvious choice for use in the treatment of postoperative ileus, but despite numerous trials, no single pharmacologic agent has been shown to be especially effective.<sup>40</sup> Metoclopramide hydrochloride is a dopamine antagonist and cholinergic agonist that is commonly used for the treatment of postoperative emesis. Despite its prokinetic effects, it has not been shown in several controlled studies to have a significant effect on the duration of postoperative ileus.<sup>41,42</sup> Other cholinergic agonists have been studied, and although some benefit was observed, it was offset by significant adverse effects.<sup>5</sup> Neostigmine is an acetylcholinesterase inhibitor and is sometimes used to stimulate colonic motility. Although it has shown some promise in reversing postoperative colonic pseudo-obstruction, its usefulness in reducing more conventional postoperative ileus is less evident.<sup>28</sup> Erythromycin is a motilin agonist that promotes gastric motility but was not shown to be effective in reducing postoperative ileus in several clinical trials that have been conducted thus far.<sup>43,44</sup> The results for cisapride, a serotonin agonist that promotes acetylcholine activity and motility in the GI tract, were mixed, with some studies showing a benefit and others showing no effect.<sup>40</sup> It has since been removed from the market because potentially fatal arrhythmias were associated with its use, and no substitute for the drug has become available. Clinical trials in the 1980s revealed some benefit of the synthetic cholecystokinin agonist ceruletide; however, adverse effects such as nausea and vomiting have limited its clinical usefulness

and may account for the lack of more recent studies.<sup>45,46</sup> Unfortunately, there is currently no prokinetic drug that has been found to be safe and effective for the treatment of postoperative ileus.

Laxatives and rectal suppositories are used with some frequency in the treatment of postoperative ileus though few clinical trials have been conducted to support their use. In one study, 20 women who underwent radical hysterectomy were treated postoperatively with twice-daily milk of magnesia and daily bisacodol suppositories.<sup>47</sup> The authors reported a 50% reduction in time to first flatus and length of hospital stay compared with historical controls. Some studies have included laxatives as part of a multimodal approach to the treatment of postoperative ileus,<sup>48</sup> but the specific benefit of laxatives, if any, is difficult to discern. Laxatives may be helpful in reducing postoperative ileus but can also cause cramping, abdominal pain, and bloating. The routine use of rectal suppositories may help to induce the first bowel movement after surgery, which may in turn help to stimulate recovery of normal bowel function. They can be safely used after most surgical procedures and may also improve patient comfort.

In summary, there is evidence to support several newer concepts in the treatment of patients with postoperative ileus. A mandatory period of bowel rest and the routine use of nasogastric tubes are no longer recommended. Early postoperative feeding, starting with small amounts and increasing gradually as tolerated, appears to be safe and may stimulate the return of normal bowel function. Minimally invasive surgical techniques including laparoscopy should be used whenever possible, and measures to decrease peritoneal inflammation, such as gentle handling of tissues and avoidance of exposure to irritating secretions and blood, are efficacious. Opiate analgesics should be used judiciously, and alternatives such as ketorolac should be prescribed to minimize the need for narcotics. Laxatives and rectal suppositories may be helpful, as is early ambulation. Adequate hydration and electrolyte balance should be maintained, but excessive hydration should probably be avoided. Midthoracic epidural administration of bupivacaine may be useful when a regional anesthetic technique is being considered. There are no drugs to effectively reduce postoperative ileus, but recent experimental studies suggest that one may become available soon.

## MULTIMODAL APPROACH

While no single therapy can eliminate the phenomenon of postoperative ileus, the techniques described above,

**Table 2.**  
Prevention and management of postoperative ileus

Category	Specific action	Physiologic effect
Pharmacologic	<ul style="list-style-type: none"> <li>• Minimize opiates</li> <li>• Regional anesthesia techniques</li> <li>• (Prokinetic drugs)*</li> <li>• (<math>\mu</math>-agonists)*</li> </ul>	<ul style="list-style-type: none"> <li>• Decreases inhibitory effect of opioids</li> <li>• *(Investigational)</li> </ul>
Inflammatory	<ul style="list-style-type: none"> <li>• Gentle handling of tissues</li> <li>• NSAIDs</li> </ul>	<ul style="list-style-type: none"> <li>• Decreases inflammation</li> </ul>
Hormonal	<ul style="list-style-type: none"> <li>• (Substance P antagonist)*</li> <li>• (VIP antagonist)*</li> </ul>	<ul style="list-style-type: none"> <li>• *(Investigational)</li> </ul>
Metabolic	<ul style="list-style-type: none"> <li>• Maintain electrolyte homeostasis</li> <li>• Maintain acid–base balance</li> <li>• Maintain normothermia</li> </ul>	<ul style="list-style-type: none"> <li>• Decreases inhibitory effects of metabolic derangements</li> </ul>
GI physiology	<ul style="list-style-type: none"> <li>• Early postoperative feedings</li> <li>• Selective use of nasogastric tubes</li> </ul>	<ul style="list-style-type: none"> <li>• Stimulates bowel function</li> </ul>
Neurologic	<ul style="list-style-type: none"> <li>• Thoracic epidural bupivacaine</li> </ul>	<ul style="list-style-type: none"> <li>• Decreases sympathetic nervous activity</li> </ul>
Psychological	<ul style="list-style-type: none"> <li>• Educate patient regarding expectations of early discharge</li> </ul>	<ul style="list-style-type: none"> <li>• Reduces anxiety</li> </ul>
Miscellaneous	<ul style="list-style-type: none"> <li>• Ambulate early</li> <li>• Avoid excessive IV hydration</li> </ul>	<ul style="list-style-type: none"> <li>• Stimulates bowel activity</li> <li>• Minimizes bowel edema</li> </ul>

NSAID: nonsteroidal anti-inflammatory drug; VIP: vasointestinal polypeptide; IV: intravenous.

each of which appear to have a small individual benefit, could, in theory, be very effective when combined (Table 2). Several groups have tried to incorporate these techniques in the form of a clinical pathway and have shown that postoperative ileus and hospital stay can be shortened significantly without compromising patient comfort or safety.<sup>48,49,50</sup>

A multimodal approach that emphasizes continuous midthoracic epidural bupivacaine in addition to early enteral feedings, early ambulation, laxatives, and nonnarcotic analgesics has been studied extensively and promoted by Holte and Kehlet in Denmark.<sup>11,28</sup> Several randomized studies have confirmed the benefit of such a regimen in reducing the duration of postoperative ileus and length of hospital stay.<sup>51,52</sup> More recently, however, a randomized study showed that a postoperative regimen that uses patient-controlled analgesia (PCA) was equally effective in reducing postoperative ileus and hospital length of stay compared with thoracic epidural analgesia.<sup>53</sup> They also noted no significant increase in complications or readmissions with either regimen and a 20% epidural failure rate in the epidural arm of the study. Others have used a multimodal regimen as part of a “fast-track” clinical pathway, which seems to result in a faster overall recovery from major abdominal surgery, including more rapid return of GI function.<sup>49,51,54</sup>

In summary, an evidence-based, multimodal approach that emphasizes novel concepts, especially one that is incorporated within the framework of an established clinical pathway, hastens recovery from postoperative

ileus, shortens hospital length of stay, and improves patient comfort.

## CHILDREN

The treatment of children with postoperative ileus varies depending on patient age and the type of operation performed. In general, bowel rest and nasogastric tubes are used less often than in adults and mostly for comfort measures rather than a perceived safety benefit. There are no useful studies and therefore very little data regarding the treatment of postoperative ileus in children. However, there is an abundance of clinical experience with the use of more progressive regimens that avoid the routine use of bowel rest and nasogastric tubes and that emphasize early feedings and careful advancement of diet based on frequent physical assessment and evidence of diet tolerance.

In infants, and especially in premature newborns, abdominal distension can be life threatening due to competition for the diaphragmatic excursion that is so critical for proper ventilation in this age group. This is especially true in infants who are being mechanically ventilated, as positive-pressure ventilation tends to cause significant aerophagia and intestinal distension. Nasogastric tubes and bowel rest are therefore used more routinely in these patients.

Older children typically tolerate postoperative ileus better than adults, even when associated with emesis.

They will often self-restrict their oral intake of food and liquids appropriately. The routine use of bowel rest and nasogastric tubes, even after intestinal resection and anastomosis, is rarely necessary. Exceptions include some patients who, after appendectomy for perforated appendicitis with frank peritoneal soilage, have severe abdominal distension and discomfort. Other exceptions include patients who have undergone certain gastric or duodenal operations, including the Ladd procedure for malrotation, and children who have undergone an extensive retroperitoneal dissection or radical nephrectomy. These procedures often result in intractable vomiting and uncomfortable abdominal distension for several days after operation.

In summary, most children who have undergone major abdominal surgery can safely have sips of clear liquids with advance of regular diet, as tolerated, without a mandatory period of bowel rest or nasogastric tube decompression. Ambulation is encouraged and, in many cases, rectal suppositories are used if a bowel movement has not occurred by the third or fourth postoperative day.

## CONCLUSIONS

It is becoming increasingly clear that traditional postoperative regimens do not hasten recovery from postoperative ileus. A review of the literature provides several conclusions: (1) A period of bowel rest is not necessary or required after most major abdominal operations, and in fact, small early feedings are well-tolerated and may shorten the duration of postoperative ileus. (2) Nasogastric tube decompression is unnecessary in the vast majority of patients. They should be used restrictively for the occasional patient with severe abdominal distension or intractable vomiting and after certain surgical procedures in which clinical experience supports their use. (3) Minimally invasive techniques should be used whenever feasible to minimize postoperative discomfort and hasten recovery. (4) There are currently no specific pharmacologic agents available to normalize bowel motility. (5) Continuous thoracic epidural administration of bupivacaine might hasten recovery from postoperative ileus. (6) Minimizing the use of opiate analgesics and including the use of NSAIDs such as ketorolac appear to decrease duration and severity of postoperative ileus in most patients. (7) Tolerance of enteral nutrition and normalization of the abdominal examination are more accurate indicators that a postoperative ileus has resolved than the more traditional and arbitrary endpoints, such as passage of

flatus or first bowel movement after surgery. (8) The judicious use of rectal suppositories and/or laxatives may help induce a normal pattern of bowel evacuation and improve patient comfort after major abdominal surgery.

Finally, a multimodal approach, especially one that is incorporated as part of a clinical pathway, will likely result in improved patient outcomes, more rapid normalization of bowel function, and shorter hospital stay for healthy children and adults who have undergone an uncomplicated abdominal operation.

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