Small bowel motility and transit after aortic surgery

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Objective: **The inability to tolerate feedings after aortic surgery prolongs hospitalization. The aim of this study was to define jejunal manometric and small bowel transit characteristics associated with the ileus that follows transperitoneal aortic surgery.**

Methods: **Five male patients who underwent transperitoneal infrarenal aortobifemoral bypass had intraoperative placement of a jejunal multilumen catheter. The open abdomen allowed precise placement of pressure recording ports at 20, 22, 24, 26, 28, and 38 cm past the ligament of Treitz. Three-hour manometric studies were done after surgery and for 3 postoperative days. The migrating motor complex was identified visually on the manometric tracings, and pressure waves were identified with computer and a motility index calculated. Motility data were compared with healthy control data previously reported in the literature. Small bowel transit was determined with barium and serial abdominal radiographs.**

Results: **All patients had ileus develop with return of bowel sounds at 2 to 7 days (median, 6 days) and flatus at 3 to 9 days (median, 7 days) after surgery. Jejunal motor activity was present within 6 hours of surgery, but the motility index was less in patients then in control subjects. The postoperative migrating motor complexes differed from control subjects in having more phase I, less phase II, and more frequent phase IIIs. Phase III retrograde migration was common in the patients but not in the control subjects. Small bowel transit was 2 days or greater in all patients.**

Conclusion: **Motor activity is present in the jejunum shortly after aortic surgery. However, the activity is decreased in intensity and the fasting cycle differs from control subjects. Retrograde migration of phase III is the most likely abnormality, resulting in delayed small bowel transit. The data would predict a high rate of enteral feeding intolerance early after surgery. Future studies should focus on pharmacologic manipulation to rapidly return small bowel motility to a more normal state after aortic surgery. (J Vasc Surg 2002;36:19-24.)**

Adynamic ileus is one of the major unsolved problems of abdominal surgery.[1] Postoperative ileus is characterized by impaired intestinal motility and transit, absence of passage of flatus, diminished bowel sounds, abdominal distention, and intestinal dilatation. Ileus can result in pain, nausea, and vomiting and is a significant contributor to postoperative morbidity and mortality. In nonruptured abdominal aortic aneurysms, prolonged ileus increases the risk of mortality.[2] Postoperative adynamic ileus has been estimated to add 750 million dollars per year to healthcare costs in the United States.[1]

Previous studies have not clearly defined postoperative small bowel motor activity. Many studies suggest that the ileus is the result of an inhibition of intestinal contractility.[3] Other studies show continued but uncoordinated contractions.[4] No studies of small bowel motility motor patterns, including their migration, have been done after aortic surgery.

The current treatment for ileus is suction removal of gastric content and intravenous hydration. The exact pathophysiology of the ileus is unknown. However, increased sympathetic stimulation of the enteric nervous system is likely involved.[5] Pharmacologic treatment of ileus with various adrenergic inhibitors has provided inconsistent results, with no pharmacologic or stimulating agents being consistently beneficial.[6]

The aim of this study was to establish the manometric and transit characteristics that occur in the small bowel after transperitoneal aortic surgery. We chose to study small bowel motor activity in a group of patients who had transperitoneal graft replacement of abdominal aortic aneurysm. Patients have been shown to generally have a significant ileus after transperitoneal aortic surgery.[7,8]

METHODS

Patients at the Harry S Truman Veterans Administration Hospital and the University of Missouri Hospital who underwent aortic operations were offered entry into the study. Exclusion criteria were the use of systemic steroids, the need for emergency surgery, a history of previous gastrointestinal surgery, violation of the gastrointestinal tract, the presence of a single blood vessel supply to the bowel, or the presence of small intestinal disease. This study was approved by the Institutional Review Board of the University of Missouri and the Harry S. Truman Research and Development Committee. All subjects gave informed consent.

Five male patients (age, 65 ± 6 years) were recruited for this study. The indication for surgery was abdominal aortic

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Competition of interest: nil.

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aneurysm. The patients had multiple comobidities. Three of the patients had previous coronary artery bypass grafting, and two patients had severe chronic obstructive pulmonary disease and needed prolonged postoperative ventilation (4 and 32 days). Two patients had previous abdominal surgery, and one had two benign mesenteric nodules removed at the time of aortic aneurysm repair. The replantation of a renal artery was necessary in one patient. The average operative time was 6 ± 0.4 hours (mean ± standard error of the mean [SEM]; range, 4 hours 17 minutes to 7 hours 15 minutes), with an average blood loss of 1220 ± 340 mL (range, 400 to 2200 mL). Ten healthy patients without previous abdominal surgery were used as the control subjects.[9]

Study procedures. All patients were admitted to the hospital, received a mechanical bowel preparation, and fasted after midnight. Anesthesia was induced with thiopental sodium and fentanyl citrate and maintained with enflurane. All patients had muscle paralysis with vecuronium. All patients underwent a midline transabdominal incision and bilateral groin incisions for an infrarenal aortobifemoral bypass. After completion of the graft replacement of the aneurysm, a 4-mm diameter multilumen polyvinylchloride nasojejunal tube was placed in the upper jejunum. This was done with placement of a wire into the proximal jejunum endoscopically. With the abdomen open and the surgeon holding the wire, the catheter was placed over the wire and positioned in the jejunum, such that the most proximal port was 20 cm distal to the ligament of Treitz (Fig 1). Patients with retroperitoneal aortic surgery were not included because the jejunal catheter could not be accurately positioned.

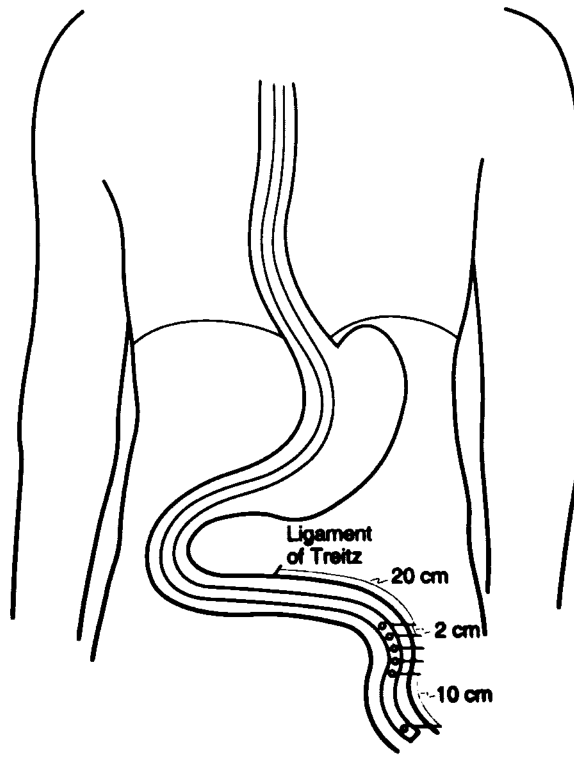

Fig 1. Diagram shows location of jejunal catheter and manometric ports.

Jejunal manometry was performed for 3 hours on the day of surgery, beginning 3 hours after the completion of skin closure. The patients also underwent a 3-hour study on each of the first 3 postoperative days. Postoperative analgesia consisted of meperidine hydrochloride or morphine. The patients did not receive any enteral or parental nutrient during the first 3 days after surgery. Computerized manometric data were obtained as previously reported.[9]

The small intestinal transit time was determined with barium placed in the small bowel. A 50-mL bolus of barium was given via the jejunal tube 3 hours after completion of the procedure. A flat-plate radiograph of the abdomen was taken 4 hours after instillation of the barium, and additional abdominal radiographs were obtained on postoperative days 1, 2, and 3. Location of the barium was divided into proximal small bowel, distal small bowel, and colon. The colon was identified by its characteristic outline. Barium was considered to be in the proximal small bowel if it was superior to or to the left of the second lumbar vertebra. Barium was considered to be in the distal small bowel if it was inferior to and to the right of the second lumbar vertebra.

A standardized abdominal examination was obtained in these patients daily for 1 week. Bowel sounds (0, none; 3, normal; 4, hyperactive), abdominal distention (0, none; 4, maximal), and tenderness (0, none; 4, maximal) were quantitated . The total amount and route of narcotics given was recorded. Parameters to evaluate resolution of ileus included the first day of consistent flatus as reported by the nurse, first day of bowel movement, and day of oral fluid and solid intake.

Data analysis. Manometric tracings were examined visually to identify the phases of the migrating motor complex (MMC). In health, the fasting small bowel has a predictable well-defined contraction sequence that cycles every 90 to 120 minutes.[10] This motor complex can be divided into three phases. Phase I is a period of inactivity lasting up to 50% of the cycle, phase II, lasting 50% to 75% of the cycle, shows intermittent contractions, and phase III, lasting approximately 5% of the cycle, has contractions at the maximal rate. This motor complex migrates from the stomach or duodenum to the distal ileum, taking 1½ to 2 hours to progress over the entire small bowel. Although all phases of the MMC migrate down the small bowel, it is most easily discerned in phase III.

Time periods of each phase were determined in each recording channel, and then a mean was developed for each patient. The direction and speed of migration of the migrating complex were determined at both the beginning and the end of phase III. Pressure waves were identified with previously developed programs, and amplitudes were determined.[9] To evaluate overall motility, a ***motility index***

Table I. Patient clinical data

Days after surgery	*Bowel sounds (0-4)*	*Distension (0-4)*	*Tenderness (0-4)*	*Serum sodium (mg/d)*	*Urine output (mL/24 h)*	*Pulse (bpm)*
Before surgery	3	0	0	139 ± 1	–	70 ± 2
0	0*	1	0.5	139 ± 2	1813 ± 457	83 ± 6
1	0*	1	1	138 ± 1	1787 ± 258	94 ± 5*
2	0*	2*	0	134 ± 2*	2614 ± 408	96 ± 5*
3	0	1	0	135 ± 2*	4215 ± 939	102 ± 5*
4	0	1	2*	136 ± 1	3404 ± 452	100 ± 15*
5	0	1.5	1	137 ± 1	3190 ± 450	91 ± 2*
6	1.5	1.5	0	137 ± 1	1286 ± 725	86 ± 7
7	1	1	0	138 ± 2	2267 ± 534	94 ± 3*

Values are displayed as median or mean ± SEM.
*$P < .05$ versus before surgery.

Table II. Duration of MMC periods (MMC)

Days after surgery	*Phase I*	*Phase II*	*Phase III*	*Total*
0	21 ± 7 (71 ± 10)*	1 ± 1 (6 ± 3)	5 ± 1 (23 ± 8)	27 ± 7
1	24 ± 7 (65 ± 11)*	3 ± 2 (12 ± 9)*	7 ± 1 (23 ± 5)	34 ± 6*
2	16 ± 4 (60 ± 11)*	4 ± 3 (15 ± 12)*	7 ± 1 (25 ± 4)	27 ± 2*
3	22 ± 3 (63 ± 8)*	4 ± 2 (13 ± 6)*	8 ± 1 (25 ± 2)	34 ± 1*
Control	29 ± 11 (29 ± 8)	54 ± 8 (58 ± 8)	11 ± 1 (13 ± 2)	94 ± 8

Data expressed as mean ± SEM minutes (% of MMC).
$P < .05$ versus control.

was defined as $\log_e$ (Σ amplitudes × S pressure peaks + 1) per 30 minutes.

Statistical methods. The primary parameters evaluated were the periods and migration of the MMC, the overall motility index, small intestinal transit, and abdominal distention. Normally distributed data were reported as mean ± SEM, and comparisons were made with a two-tailed Student *t* test. Nonparametric data were reported as a median and compared with the Wilcoxon rank sum test. Categoric data were compared with Fisher exact test. Associations were evaluated with linear regression analysis. Results were considered significant at $P < .05$.

RESULTS

Clinical findings. After surgery, patients had clinical evidence of ileus with absent flatus and bowel movements. Although bowel sounds were normal in all patients before surgery, these sounds disappeared after surgery and did not return until a median of postoperative day 6 (range, 2 to 7 days). Patients had some distention, and abdominal tenderness was variable (Table I). The urine output and pulse rate were greatest on postoperative days 3 and 4, probably corresponding to the resorption of the perioperative third space fluid. The first consistent flatus occurred at a median of 7 days (range, 3 to 9 days); increased operative time and blood loss correlated positively with a delayed passage of flatus. The first bowel movement occurred at a median of 9 days (range, 5 to 18 days) and was liquid in character in all patients. The patients tolerated liquids and solids at a median of 8 and 11 days after surgery.

Patients were discharged from the hospital at 8, 10, 14, 25, and 77 days after surgery. All patients had prolongation of their hospitalization because of complications, The patient discharged at 8 days had dysphagia develop necessitating 2 extra days of hopitalization. The patient discharged at day 10 needed 4 days on the ventilator and had slow respiratory recovery. The patient discharged at 14 days had atrial arrhythmias and congestive heart failure that delayed discharge. The patient discharged at 25 days had the longest procedure, replantation of a renal artery, chronic obstructive pulmonary disease, and a history of myocardial infarction and coronary artery bypass grafting. The patient had ileus or partial small bowel obstruction necessitating multiple attempts at feeding before discharge with a regular diet. The patient discharged at 77 days needed prolonged pulmonary rehabilitation.

Visual manometric analysis. The total cycle of the MMC was markedly shorter in patients than in control subjects (Table II). For the individual phases, the time in phase I was significantly increased and the time in phase II significantly decreased (Fig 2; Table II) compared with the control subjects. The phase III duration did not differ between patients and control subjects. This motor pattern was consistent for the 4 days that recordings were done.

Most of the phase IIIs migrated in an antegrade manner (Fig 2). An unexpected finding was the large number of phase IIIs with retrograde migration (Fig 3). Retrograde migration was seen in all patients until postoperative day 3 (the duration of the recording). This was seen at both the beginning and the end of the phase III for migration (Table

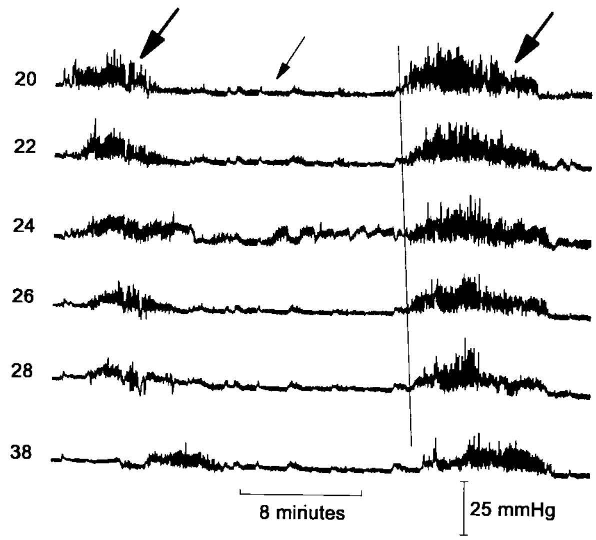

Fig 2. Recording of pressure waves after transabdominal aortic aneurysm repair. Phase III *(large arrows)* can be seen migrating in usual antegrade direction *(solid line)*. *Small arrow* points to phase I. Minimal phase II is present.

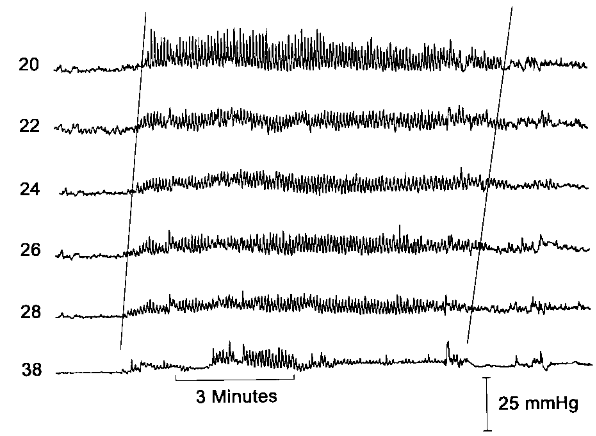

Fig 3. Recording of pressure waves during phase III. Migration is retrograde at both beginning and end of phase III *(solid lines)*.

III). The velocity of the phase IIIs migrating in the antegrade direction were quite constant, around 10 to 17 cm/min (Table III). However, retrograde velocity was more variable and was especially rapid on the day of surgery.

Computer analysis. The motility index was significantly greater for control subjects (12.3 ± 0.3) than for postoperative patients (9.9 ± 0.6, 10.3 ± 0.6, 10.7 ± 0.1, 9.2 ± 0.4 at postoperative days 0 to 3, respectively). Of interest is that the motility index was least on day 3, the last day of the recording, and was significantly (P = .01) less when compared with day 2.

Transit. On the day of surgery and the first postoperative day, all patients had barium located in the proximal jejunum. On postoperative day 2, four of five patients had barium primarily in the distal ileum, and on postoperative day 3, four of five patients had the barium primarily in the colon.

DISCUSSION

That major abdominal surgery is associated with a period of gastrointestinal inactivity is widely appreciated.[11] The ileus precludes the intake of oral hydration, which is the primary factor that delays discharge after aortic surgery. The median discharge after 14 days is comparable with other studies after aortic surgery[7,8] but is much longer than the 5 to 8 days currently achieved in patients at good risk.

The patients in this study showed a typical ileus with decreased bowel sounds, absent flatus, and variable abdominal distention, which was present for up to 1 week. Most other studies that evaluated ileus after aortic surgery have used time of nasogastric tube removal as the major endpoint to determine when ileus is over.[2,7,8,12] However, routine nasogastric decompression is oftentimes not necessary in the treatment of ileus.[13] When placed, the nasogastric tube is often removed before full resolution of the ileus, and, thus, time of nasogastric tube removal likely underestimates the duration of the ileus.

This study clearly shows that jejunal contractile activity is present early in the postoperative period during ileus. The MMC is present in the first few hours after surgery. However, the MMC is not normal. The most striking abnormality in the MMC is the presence of orally migrating phase IIIs over at least short segments of the jejunum for 3 days in all patients. Retrograde migration of phase III in the small bowel is not seen in health.[14] Antegrade phase III migration is stable and inherent in the orientation of the bowel. Reversal of the jejunal segment will result in retrograde phase III migration indefinitely.[15] Retrograde phase III migration has been reported in severe Roux-stasis syndrome[16] and in patients with idiopathic constipation.[17] Although these orally migrating phase IIIs may occur only in short segments of the jejunum, they may help explain the presence of an ileus despite the presence of jejunal contractions.

A second significant abnormality is the marked diminution of phase II in the early postoperative period. Phase II may represent the normal uncoordinated background small bowel activity in patients. In health, phase II occupies 50% to 75% of the fasting tracing.[14] This activity appears to be preferentially inhibited after surgery. Narcotics have been shown to reduce phase II activity but do not totally explain its marked diminution in this patient population.[18] It is also of interest that during sleep phase II activity is reduced.[17] Identification of the mechanism of phase II reduction may help explain the etiology of ileus.

A third finding is that the MMC period in our postoperative patients was significantly shorter than in control subjects, which may also contribute to the slow small bowel transit. Shortened MMC cycles are present after truncal vagotomy and likely represent abnormal extrinsic neural

Table III. Migration velocity at beginning and end of phase III

Days after surgery	*Beginning of phase III*		*End of phase III*	
	Antegrade	*Retrograde*	*Antegrade*	*Retrograde*
0	13 ± 3 (61)	25 ± 12 (39)	13 ± 6 (88)	50 ± 35 (12)
1	10 ± 4 (72)	8 ± 3 (28)	18 ± 8 (79)	7 ± 5 (21)
2	10 ± 3 (80)	21 ± 16 (20)	14 ± 5 (85)	5 ± 1 (15)
3	14 ± 6 (71)	3 ± 1 (29)	16 ± 10 (81)	8 ± 4 (19)

Data expressed as mean ± SEM cm/min (% of phase IIIs).

input to the enteric nervous system.[19] Also, MMC cycle duration has been documented to be longer for those MMCs that originate in the antrum than in the duodenum. The short MMC period in our patients may be explained at least in part by selective postoperative suppression of gastric motility and suppression of the MMCs that originate from the stomach.[20]

In addition to abnormalities in the MMC, the overall motility as measured with the motility index was less in the patients compared with normal control subjects. This decrease in motility persisted at least 3 days after aortic surgery and was lower on day 3 than day 2 in our patients. Because the jejunal catheter was removed on the third day, the time needed for the motility index to return to normal after transperitoneal aortic surgery was not determined in this study.

Previous studies have found that the duration of postoperative ileus was independent of the extent, site, and duration of the operative procedure.[21] However, in our patients, the duration of the procedure and blood loss directly correlated with length of ileus. The previous abdominal surgery and concomitant procedures in this patient group resulted in a greater length of surgery and blood loss then usual. Our belief is that this resulted in the prolonged ileus seen in our patients. Factors that did not correlate with length of ileus included amount or type of narcotics received, serum sodium, urine output, or pulse rate. These data would indicate that expedient completion of the procedure and reduced blood loss will contribute to a shortened period of ileus.

Small bowel transit was markedly delayed in this group after aortic surgery. Barium did not consistently reach the colon until postoperative day 3 compared with 2 to 6 hours in health. Thus, although contractile activity is present, it is not propulsive. This delay of transit in postoperative aortic patients may have important clinical implications. These data would support the usual practice of maintaining these patients without enteral feedings for a few (2 to 4) days after surgery. We believe that the marked delay in transit is most likely the result of the presence of orally propagating phase III in these patients.

The primary deficiency of this study is the small number of subjects. We believe the small numbers can be justified by the striking differences when compared with control subjects. A second deficiency was that concurrent control subjects were not used. Because of the mark differences between a healthy control subject and a patient after abdominal aortic surgery, multiple factors such as analgesics, fluid shifts, and operative trauma could not be controlled. Thus, we believed historic controls would serve as well as concurrent controls. Finally, this patient group had a large number of comorbities, and the data may not be applicable to healthy patients, without comorbidities, having transperitoneal aortic surgery.

Some authors suggest that because small bowel motor function is present after surgery, patients should be fed enterally via a nasoduodenal tube to thus decrease the need for intravenous solution and possibly allow earlier discharge of patients.[22] Previous studies have documented up to a 65% incidence rate of enteral feeding intolerance the first week after major abdominal surgery.[23] Impaired transit of enteral feedings may impair respiratory function after surgery.[24] The motility findings in this study may explain the high incidence rate of jejunal tube feeding intolerance after surgery, despite contractile activity in the jejunum. Our study would indicate that early feeding carries a significant risk of intolerance in this patient group.

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