JOURNAL OF LAPAROENDOSCOPIC SURGERY
Volume 3, Number 5, 1993
Mary Ann Liebert, Inc., Publishers

Myoelectric Motility Patterns Following Open Versus Laparoscopic Cholecystectomy

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ABSTRACT

Laparoscopic surgery is associated with a lack of postoperative ileus. To determine if differences exist in postoperative motility patterns, 8 dogs were instrumented with bipolar electrodes 10–14 days prior to open (n = 4) or laparoscopic (n = 4) cholecystectomy. In both groups, Phase II activity disappeared in the first 24 h after operation. The appearance of the migrating myoelectric complex in the small intestine and the migrating colonic complex were used as criteria for recovery from postoperative ileus. Postoperative migrating myoelectric complex cycle length, migrating myoelectric complex, migration velocity, and colonic spike bursts/hour were also measured. No statistically significant differences were observed between groups in study parameters examined.

Postoperative myoelectric motility patterns in dogs undergoing open versus laparoscopic cholecystectomy are not different. Other factors may be responsible for the rapid return to oral intake following laparoscopic cholecystectomy.

INTRODUCTION

EACH YEAR OVER 10 MILLION intraabdominal surgical procedures are performed in the United States.[1] A significant number of these operations are accompanied by some degree of postoperative ileus, not infrequently resulting in increased time spent in the hospital and increased morbidity and mortality. The factors responsible for ileus are multiple and complex; present understanding of postoperative ileus is incomplete. However, human and animal studies have allowed us to reach some conclusions, one being that the extent of operative manipulation and dissection and length of operation have no bearing on the duration or severity of postoperative ileus.[2–5]

Since its introduction in 1989, laparoscopic cholecystectomy has quickly become the standard method for removal of a diseased gallbladder.[6,7] This change has been prompted by numerous advantages that the laparoscopic technique appears to have over the standard, open technique. One advantage is the apparent lack of postoperative ileus. This clinical observation raises many interesting questions. If extent and length of

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operation have no bearing on postoperative ileus, then why do patients undergoing laparoscopic cholecystectomy routinely resume eating the day of surgery or the day after, when patients undergoing standard cholecystectomy often must wait two to three days before beginning a diet? Is it possible that the myoelectric gastrointestinal patterns of recovery following laparoscopic operation are no different than those following open operation? Is the difference in duration of ileus only perceived? The aim of this study was to begin to answer these questions by studying the postoperative small and large bowel myoelectric motility patterns in dogs undergoing open versus laparoscopic cholecystectomy.

MATERIALS AND METHODS

Experiments were conducted in 8 mongrel dogs. The protocol for this study was approved by the Animal Welfare Committee of the Medical College of Wisconsin (MCW). Animals were housed at the fully equipped animal facility at the MCW. Each dog was instrumented with 8 bipolar recording electrodes, as previously described,[8] 4 on the small bowel and 4 on the left colon.

The distance between the small bowel electrodes was 20 cm with the first electrode placed 50 cm from the Ligament of Treitz. On the left colon, electrodes were placed 10 cm apart. Instrumentation was carried out under sterile conditions after an overnight fast. Operation was conducted under general anesthesia induced with pentobarbital sodium (25 mg/kg). The laparotomy was performed through a left lower quadrant paramedian incision so as not to create midline adhesions that would interfere with later cholecystectomy.

Dogs were allowed to recover for 10–14 days. Baseline myoelectric recordings were then made in the fasting state for 6–8 h per day for 3 days. Myoelectric signals were recorded using a polygraph, Grass model 7 (Grass Institute, Quincy, MA).

Dogs were then randomly assigned to undergo either open or laparoscopic cholecystectomy. Operations were again carried out after an overnight fast under sterile conditions using pentobarbital sodium 25 mg/kg IV or general anesthesia. Open cholecystectomy was carried out through a right upper quadrant subcostal incision. The abdominal incision was closed in layers with running 2–0 nylon sutures used for the fascia and a 3–0 polyglycolic acid subcuticular suture used for the hide.

Laparoscopic cholecystectomy was performed in the standard fashion using monopolar electrocautery. CO_2 was used for pneumoperitoneum and clips were used to ligate the cystic duct and artery. Intraabdominal pressure was maintained at 13 mmHg. Stab incisions in the upper abdomen were closed at the hide level with 3–0 polyglycolic acid subcuticular sutures and the umbilical incision was closed with the same suture at both the fascial and the hide layers. The bipolar recording devices and their leads were not disturbed during either the open or the laparoscopic operations.

None of the dogs received analgesics following cholecystectomy. Myoelectric recordings (using the Grass model 7 polygraph) were resumed immediately following operation and was continued for 3 days. After extubation and full recovery from general anesthesia, all dogs were allowed free access to water.

Baseline and postcholecystectomy myoelectric recordings were analyzed and four parameters were evaluated: (1) migrating myoelectric complex (MMC) cycle length; (2) MMC migration velocity; (3) number of colonic spike bursts per hour; and (4) morphology, presence or absence of Phase I, II and III, of the MMC.

Following cholecystectomy in both groups of dogs, the time from completion of operation to the appearance of the first MMC in the small bowel and the first migrating colonic complex (MCC) in the large bowel was recorded.

Statistical analysis between group differences was analyzed using the Wilcoxon Rank Sum Test. Statistical significance was accepted for $p < 0.05$.

RESULTS

All dogs tolerated instrumentation and cholecystectomy well and there were no complications related to any of the surgical procedures.

Baseline recording data is shown in Table 1. There were no differences between the groups with regard to MMC cycle length, migration velocity, or number of colonic spike bursts per hour. In all MMC's Phases I, II,

TABLE 1. MYOELECTRIC RECORDING DATA

		Cycle Length (min)	*Mean ± SD Migration Velocity (cm/min)*	*Colonic Spike Bursts (1 hr)*
Open cholecystectomy	Pre-op	113.8 ± 3.8	3.3 ± 0.2	28.8 ± 7.3
(n = 4)	Post-op	118.2 ± 39.5	3.0 ± 0.6	27.5 ± 3.1
Laparoscopic cholecystectomy	Pre-op	112.5 ± 7.3	3.0 ± 0.8	28.2 ± 6.3
(n = 4)	Post-op	123.5 ± 33.3	2.9 ± 0.7	25.6 ± 6.4

and III were present (Fig. 1). Following cholecystectomy in both the open and laparoscopic groups, there was complete absence of spiking activity as seen in Figure 2. There was, however, preservation of slow waves. This quiescent period lasted for a variable period of time before disorganized spiking activity appeared in the small bowel and then in the large bowel. Eventually, organized activity returned. The time durations from completion of operation to the reappearance of MMC and MCC are listed in Table 2. As can be seen, the differences were not statistically significant.

The postcholecystectomy MMC cycle length (CL), migration velocity (MV), and number of colonic spike bursts per hour were also analyzed for the open and laparoscopic groups. These data are listed in Table 1. The differences, again, are not statistically significant.

Examination of MMC morphology in the postcholecystectomy period revealed a striking finding. In both the open and the laparoscopic groups, Phase II of the MMC was absent for approximately the first 24 h after operation. During this period, Phase III cycled normally but it lacked Phase II activity (Fig. 3).

DISCUSSION

It has long been recognized that the two factors most responsible for patients remaining in the hospital after abdominal surgery are the need for parenteral narcotic administration and the inability to tolerate a diet (ileus). With the advent of laparoscopic surgical techniques, these two problems appear to be solved.

The authors were primarily interested in understanding why there appeared to be little if any ileus following a laparoscopic procedure when the operation performed was not different (other than the incision) than one done in the conventional manner. It was hoped that insight would be gained by studying the postoperative myoelectric patterns of recovery following open versus laparoscopic cholecystectomy.

In order to study the differences in the recovery patterns this pilot study was undertaken. The findings were unexpected. In both groups of dogs there was complete absence of small and large bowel activity following

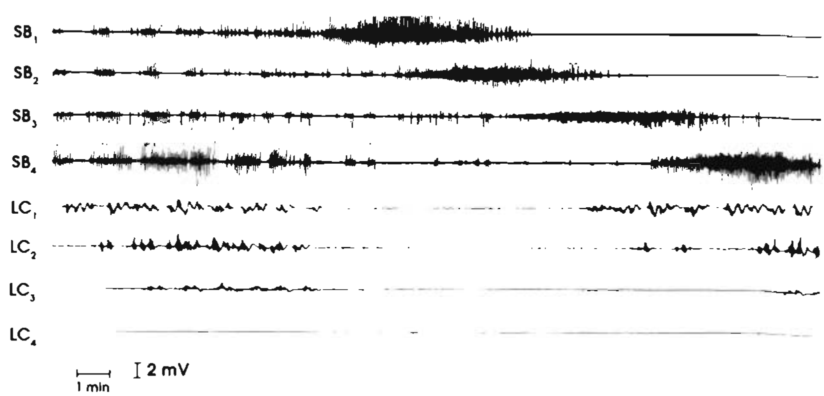

FIG. 1. Typical recording made during the baseline period, demonstrating a migrating myoelectric complex (SB_1–SB_4) with Phase I, II, and III and a migrating colonic complex (LC_1–LC_3).

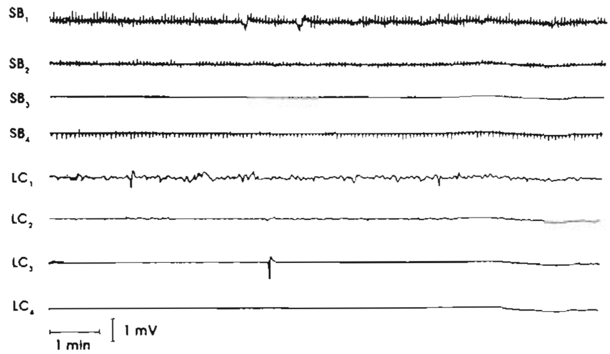

FIG. 2. Typical recording made during the early postoperative period, demonstrating normal slow waves in the small (SB_1–SB_4) and large bowel (LC_1–LC_4) with no spiking activity.

cholecystectomy. This was followed by disorganized activity. These are normal patterns following an abdominal operation. In both groups of dogs, however, within 5 to 6 h of operation, MMC cycling had resumed and within 10 to 11 h, MCC activity had returned. There was no difference between the two groups. Migration velocity, MMC cycle length, and number of colonic spike bursts per hour were also not different between the two groups.

Close examination of the recordings revealed that while MMCs appeared to be cycling normally, they lacked Phase II activity for approximately 24 h. This lack of Phase II activity has been reported to occur in the early postoperative period[9,10] and during peritonitis,[11] but the significance of these observations has received little attention.

Lang et al[12] have conducted experiments examining the generation of Phase I and Phase II of the MMC in dogs. Their findings led to the conclusion that rather than being an integral part of the MMC cycle, Phase II activity may simply represent background activity, the limits of which are determined by the occurrence of Phase III.

The lack of Phase II in the early postoperative period may represent the inhibition of normal, uncoordinated background small bowel activity in patients undergoing cholecystectomy. Ducerf and colleagues[10] postulated that the reappearance of Phase II activity in the jejunum was accounted for by a progressive reorganization and coordination of the intestinal tract.

If there are no differences in myoelectric recovery patterns following open versus laparoscopic cholecystectomy, then how can the clinical situation be explained?

It is believed that it can most easily be explained on the basis of the difference between the amount of pain experienced by those undergoing open versus laparoscopic cholecystectomy. Numerous reviews have documented the dramatic difference in postoperative narcotic requirements when comparing the open to the laparoscopic technique. In a series reported by Soper and colleagues,[13] no patient undergoing laparoscopic cholecystectomy received parenteral narcotics after leaving the operating room. In contrast, the average patient required approximately 35 mg of morphine sulfate in the first 24 h after open cholecystectomy. In Schirmer's[6] series, 36% of patients undergoing laparoscopic cholecystectomy required no postoperative narcotic, 25% required only oral narcotic, and only 39% required parenteral narcotic (average only 6–8 mg

TABLE 2. TIME FROM END OF CHOLECYSTECTOMY OPERATION TO RETURN OF MMC AND MCC

	Mean ± SD	
	MMC (min)	*MCC (min)*
Open cholecystectomy (n = 4)	381 ± 175	660 ± 264
Laparoscopic cholecystectomy (n = 4)	328 ± 105	600 ± 187

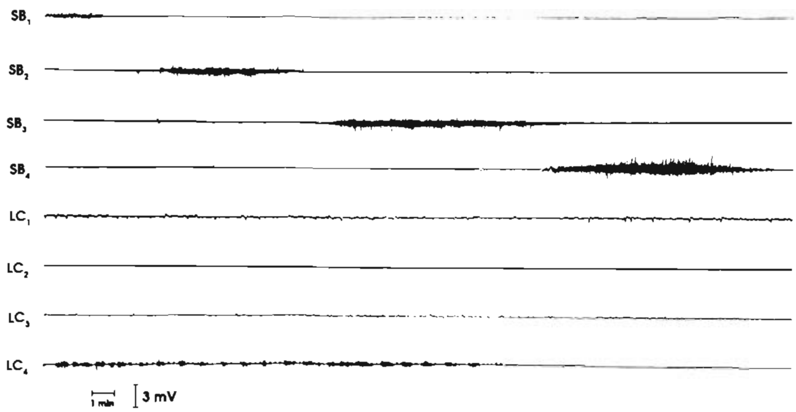

FIG. 3. Typical recording made during the first 24 h after operation, demonstrating the lack of Phase II activity in an otherwise normal appearing MMC (SB_1–SB_4).

morphine sulfate). In 13 patients who underwent conversion (laparoscopic to open) cholecystectomy, 11 used a patient-controlled analgesia pump for 2 or more days after operation.

Recent work from this laboratory in both subhuman primates[14] and humans[15] has demonstrated that postoperative narcotics disrupt the normal postoperative recovery patterns. Parenteral morphine sulfate in humans induces phasic, stationary (nonmigrating) spike bursts in the entire colon, most prominently in the left colon. In the work presented, narcotic analgesia was not used in the postoperative period in either group of animals, so that any disruption of the normal myoelectric recovery patterns was avoided. These results are not necessarily inconsistent with what has been observed clinically. It does appear that those patients undergoing laparoscopic cholecystectomy are able to tolerate a diet more quickly after operation than those undergoing the open procedure. It may simply be that this "less severe ileus" is not based on any real difference in return of normal myoelectric gastrointestinal activity. It may be based more on the dramatic decrease in pain and narcotic requirement.

During the last decade, the authors have been engaged in defining the myoelectric patterns of the human colon during the postoperative period.[5,16] In addition, attempts have been made at pharmacologic manipulation of the colon during ileus.[17,18] Using techniques developed during this research, gastrointestinal myoelectric activity after laparoscopic surgery in humans will be studied. Such studies could define the myoelectric recovery patterns of the human gastrointestinal tract following laparoscopic procedures, thus enabling a better understanding of the pathophysiology of postoperative ileus.

REFERENCES

1. 1987 Summary: National Hospital Discharge Survey, Advance Data, Vital Health Statistics of the National Center for Health Statistics 1989 Sept 159:3–9.
2. Woods JH, Erikson LW, Condon RE, Schulte WJ, Sillin LF: Postoperative ileus: a colonic problem? Surgery 1978;84:527–533.
3. Graber JN, Schulte WJ, Condon RE, Cowles VE: Duration of postoperative ileus related to extent and site of operative dissection. Surg Forum 1980;31:141–144.
4. Wilson JP: Postoperative motility of the large intestine in man. Gut 1975;16:689–692.
5. Condon RE, Frantzides CT, Cowles VE, Mahoney JL, Schulte WJ, Sarna SK: Resolution of postoperative ileus in humans. Ann Surg 1986;203:574–580.
6. Schirmer BD, Edge SB, Dix J, Hyser MJ, Hanks JB, Jones RS: Laparoscopic cholecystectomy: treatment of choice for symptomatic cholelithiasis. Ann Surg 1991;213:665–676.

7. Soper NJ, Stockmann PT, Dunnegan DL, Ashley SW: Laparoscopic cholecystectomy: the new "gold standard"? Arch Surg 1992;127:917–921.

8. Frantzides CT, Matsumoto T, Lang I, Condon RE: An intrinsic neural pathway for long intestino-intestinal inhibitory reflexes. Gastroenterology 1987;92:594–603.

9. Waldhausen JHT, Schirmer BD: The effects of tube feeding on postoperative ileus. Presented at Association for Academic Surgery, November 1989, Louisville, KY.

10. Ducerf C, Duchamp C, Pouyet M: Postoperative electromyographic profile in human jejunum. Ann Surg 1992;215:237–243.

11. Frantzides CT, Mathias C, Ludwig KA, Edmiston CE, Condon RE: Small bowel myoelectric activity in peritonitis. Am J Surg 1993;165:681–685.

12. Lang IM, Sarna SK, Condon RE: Generation of phase I and II of migrating myoelectric complex in the dog. Am J Physiol 1986;251:G201–G207.

13. Soper NJ, Barteau JA, Clayman RV, Ashley SW, Dunnegan DL: Comparison of early postoperative results for laparoscopic versus standard open cholecystectomy. Surg Gynecol Obstet 1992;174:114–118.

14. Frantzides CT, Condon RE, Schulte WJ, Cowles V: Effects of morphine on colonic myoelectric and motor activity in subhuman primates. Am J Physiol 1990;258:G247–252.

15. Frantzides CT, Cowles V, Salaymeh B, Tekin E, Condon RE: Morphine effects on human colonic myoelectric activity in the postoperative period. Am J Surg 1992;163:144–148.

16. Frantzides CT, Condon RE, Cowles VE: Early postoperative colon electrical response activity. Surg Forum 1985;36:163–165.

17. Carlson MA, Ludwig KA, Cowles VE, Frantzides CT, Condon RE: Effect of propranolol on human myoelectric activity. Surg Forum 1992:43:155–157.

18. Ludwig KA, Frantzides CT, Cowles VE, Carlson MA, Condon RE: Cholecystokinin and gastrin responses during postoperative ileus. Gastroenterology 1992;103:1382.

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