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RETROSPECTIVE STUDY

New strategy during complicated open appendectomy: Convert open operation to laparoscopy

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Abstract

AIM: To introduce a new strategy during complicated open appendectomy - converting open operation to laparoscopy.

METHODS: We retrospectively reviewed databases at two institutions between October 2010 and January 2013, identifying 826 patients who had undergone complicated appendectomy for histologically confirmed acute or chronic appendicitis. They included 214 complicated appendectomies: 155 lengthened-incision open appendectomies (LIA group) and 59 open appendectomies with conversion to laparoscopy (OACL group).

RESULTS: A total of 214 patients with complicated appendectomies were included in the study, including 155 cases of LIA and 59 cases of OACL. No major complication leading to death occurred in the study. Patient characteristics of the two groups were similar. Several parameters showed a significant difference between the two groups. For the OACL *vs* LIA groups they were, respectively: incision length (3.8 ± 1.4 cm *vs* 6.2 ± 3.5 cm, $P < 0.05$); time to flatus recovery (2.3 ± 0.6 d *vs* 4.2 ± 0.8 d, $P < 0.05$), drainage rate (61.0% *vs* 80.0%, $P < 0.05$); pain level (3.6 ± 1.8 *vs* 7.2 ± 2.4, $P < 0.05$); hospital stay (5.1 ± 2.7 d *vs* 8.7 ± 3.2 d, $P < 0.05$); complication rate (8.5% *vs* 14.7%, $P < 0.05$). Other factors showed no significant differences.

CONCLUSION: Lengthened-incision open appendectomy increases the incidence of complications and prolongs the hospital stay. Conversion of open to laparoscopic appendectomy is feasible and efficient in complicated cases. It decreases the rate of incisional and abdominal infections, allows faster return of bowel movements, and shortens the hospital stay.

Key words: Complicated appendectomy; Open; Laparoscopy; Conversion; Complication

Core tip: In the present paper, we introduce a new strategy during complicated open appendectomy: convert to laparoscopy. It is an effective and safe technique when comparing the length of incisions. Moreover, in this report, we describe some techniques applied in laparoscopic appendectomy to minimize complications.

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INTRODUCTION

Laparoscopic appendectomy has rapidly developed since Semm[1] published an article reporting the first complete

removal of the appendix *via* laparoscopic surgery in 1983 and Schreiber[2] performed the first laparoscopic appendectomy in a patient with acute appendicitis in 1987. Although open appendectomy remains the gold standard worldwide for treating complicated appendiceal disease[3-7], the laparoscopic technique has improved and appendectomies are being increasingly performed by laparoscopy. Laparoscopy converted to an open procedure is a conventional strategy during complicated appendectomies. A much larger incision than that needed for laparoscopy is routinely applied in those procedures, resulting in a high rate of complications, such as incisional infections, which in turn cause a prolonged hospital stay and high level of pain for the patient[8-10]. Since October 2010, we have attempted to convert open appendectomies to laparoscopic procedures during complicated cases instead of lengthening the incision. This new strategy has produced good clinical results.

MATERIALS AND METHODS

Patients and methods

From October 2010 to January 2013, a total of 826 appendectomies (519 open, 307 laparoscopic) were performed at The Second Affiliated Hospital Zhejiang University School of Medicine. Having to choose between a lengthened incision or conversion to laparoscopy during the appendectomy procedure was considered a "complicated" appendectomy. Based on this definition, 214 complicated appendectomies had been performed, including 155 lengthened-incision appendectomies (LIA group) and 59 open appendectomies that were converted to laparoscopy (OACL group). The indication for appendectomy in the study was acute or chronic appendicitis. The initial strategy for all 214 cases was open appendectomy. Because of difficulty during the procedures, however, they were changed to either LIA or OACL. The outcomes of the two approaches were compared on an intention-to-treat basis.

The mean ages of the OACL and LIA groups were 29.6 ± 14.2 years *vs* 30.1 ± 16.7 years, respectively. The patients' characteristics and perioperative data were recorded before and after surgery. The characteristics are shown in Table 1.

Surgical technique for conversion of open to laparoscopic appendectomy

Among the 214 open appendectomies, 59 operations were converted to laparoscopic appendectomy (OACL group) because it was difficult to complete the procedure through a normal incision. The remaining 155 other appendectomies continued as open procedures but were performed after lengthening the incision (LIA group).

All of the OACL patients were converted to general endotracheal anesthesia. A 10-mm trocar was placed in the open incision, after which the incision was closed by suture to make sure no gas could pass through. We used a conventional three-port technique. After the first trocar was placed (Figure 1), CO_2 gas was input to keep the pressure between 12 and 15 mmHg. A supraumbilical port was created for the camera, and another was placed medial to the left anterosuperior iliac spine. Figure 2 shows laparoscopic visualization of the appendix during OACL.

Table 1 Patient characteristics for the open appendectomy converted to laparoscopy and lengthened-incision appendectomy groups

Variable	OACL group (n = 59)	LIA group (n = 155)	P value
Age, yr, mean ± SD	29.6 ± 14.2	30.1 ± 16.7	NS
Sex, female/male, n	32/27	75/80	NS
WBC counts (× 10^9/L), mean ± SD	14.8 ± 4.2	13.9 ± 3.4	NS
C reactive peptide, U/L, mean ± SD	18.8 ± 3.9	20.1 ± 4.5	NS
Localized abdominal tenderness n (%)	48 (81.4)	119 (76.8)	NS
Preoperative scale of pain (range 1-10), mean ± SD	2.9 ± 1.5	2.7 ± 1.8	NS

OACL: Open appendectomy converted to laparoscopy; LIA: Lengthened-incision appendectomy; WBC: White blood cell.

Figure 1 Positions of trocars.

The following procedures were nearly the same for both the OACL and LIA groups. During the operation, three strategies were applied for three situations: (1) the appendix was in the right upper abdomen, but all of it could be found easily; (2) the base of the appendix could be identified easily, but the tip was difficult to identify; and (3) a mass was present because the appendix was perforated, which made it difficult to distinguish the appendix from adjacent intestine. In the first situation, harmonic shears (Harmonic Scalpel; Ethicon EndoSurgery, Somerville, NJ, United States) were used to separate the appendix by dividing the mesoappendix. As the appendix was separated completely, it was ligated at its base and cut. It could then be removed in a specimen bag through the large incision. In the second situation, we performed a retrograde appendectomy by separating and then ligating the base of the appendix. We then used harmonic shears to divide the appendix from its base to its tip. In the third situation, we performed a submucosal appendectomy, a technique which has been introduced by Hannan and Hoque[11]. An incision was made on the

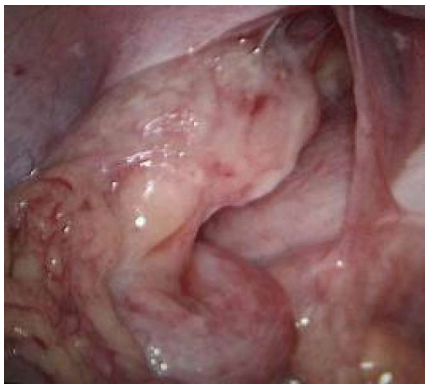

Figure 2 Appearance of the appendix during the open appendectomy converted to laparoscopy procedure.

Table 2 Perioperative data for the open appendectomy converted to laparoscopy and lengthened-incision appendectomy groups *n* (%)

Variable	OACL group (*n* = 59)	LIA group (*n* = 155)	*P* value
Operative time, min, mean ± SD	45.6 ± 17.2	43.8 ± 16.1	NS
Length of incision, cm, mean ± SD	3.8 ± 1.4	6.2 ± 3.5	< 0.05
Flatus, d, mean ± SD	2.3 ± 0.6	4.2 ± 0.8	< 0.05
Drain placed	36 (61.0)	124 (80.0)	< 0.05
Scale of pain (range 1-10), mean ± SD	3.6 ± 1.8	7.2 ± 2.4	< 0.05
Days of drainage, d, mean ± SD	2.1 ± 1.1	2.7 ± 1.6	NS
Reoperation	0 (0)	2 (1.3)	NS
Hospital stay, d, mean ± SD	5.1 ± 2.7	8.7 ± 3.2	< 0.05
Complications	4 (6.8)	23 (14.7)	< 0.05
Intra-abdominal abscess	1 (1.7)	7 (4.5)	< 0.05
Wound infection	2 (3.4)	11 (7.1)	< 0.05
Ileus	1 (1.7)	1 (0.6)	NS
Fecal fistula	0 (0)	2 (1.3)	NS
Bleeding	0 (0)	2 (1.3)	NS
Histopathology			NS
Acute	40 (67.8)	93 (60.0)	
Phlegmonous	8 (13.6)	18 (11.6.)	
Gangrenous or perforated	9 (15.3)	28 (18.1)	
Periappendicular abscess	2 (3.5)	16 (10.3)	

OACL: Open appendectomy converted to laparoscopy; LIA: Lengthened-incision appendectomy.

antimesenteric wall of the appendix, and the mucosal sleeve was pulled out, leaving the muscular wall in place. The base of the tube was then ligated flush with the cecum and divided distally. The muscular tube was left alone. Normal saline was used to clean the peritoneal cavity. Closed suction drain tubes were placed in most of the cases that were in the second and third situations described earlier.

Postoperative management

Liquids were allowed 6 h after the operation. Feeding was allowed after flatus recovery in the majority of cases of both groups. A few patients with a fragile appendiceal base had their feeding restricted until complete recovery of bowel movements. The drainage tube was removed only when there was no collection in the drainage bag. There were some rare cases of drainage continuing after discharge from the hospital. In such cases, the drainage tube was removed once there was no collection and no fever.

Statistical analysis

Numerical data were expressed as the mean ± SD. Statistical significance was evaluated by Student's *t*-test or the χ^2 analysis between the two groups with SPSS 17.0 for Windows software (SPSS Inc., Chicago, IL, United States). $P < 0.05$ was considered statistically significant.

RESULTS

All 59 patients in the OACL group underwent surgery that was successful. No reconversion to open surgery or reoperation was necessary. In contrast, 2 of 155 LIA patients required reoperation because of incisional bleeding and intra-abdominal bleeding, respectively. All patients were ultimately discharged in good health.

The patient characteristics, including sex, age, C-reactive peptide, and scale of pain showed no significant difference between the two groups. The factors that were significantly different between the two groups were the following (with respective values for the OACL *vs* LIA groups): length of incision 3.8 ± 1.4 cm *vs* 6.2 ± 3.5 cm; time to flatus recovery 2.3 ± 0.6 d *vs* 4.2 ± 0.8 d; rate of drainage 61.0% *vs* 80.0%; scale of pain 3.6 ± 1.8 *vs* 7.2 ± 2.4; hospital stay 5.1 ± 2.7 d *vs* 8.7 ± 3.2 d; complication rate 6.8% *vs* 14.7%. Other perioperative data were not significantly different for the two groups. Among the complications, abdominal abscess and incision infection were found more often in the LIA group than in the OACL group. Two cases of fecal fistula occurred in the LIA group and contributed to prolonged hospital stays, but the occurrence rate was not different in the two groups. The perioperative data are shown in Table 2.

All patients were followed up at the clinic or by telephone interview for 2 to 22 mo, during which time no major complications occurred.

DISCUSSION

Laparoscopy offers more advantages than the open technique in terms of postoperative outcomes, including less pain, fewer complications, and faster recovery. Unlike laparoscopic cholecystectomy, which became the "gold standard" for removing gallbladder disease, laparoscopic appendectomy still has some controversial issues. This is especially true in regard to complicated appendectomies[12-15]. As the instrumentation improves and experience increases, some surgical centers consider laparoscopic surgery the first choice for treating acute appendicitis. However, open appendectomy is still accepted as the gold standard and is widely performed, and it remains first choice for appendicitis in many institutions world-wide. Over a 3-year period during 2010-2013, a total of 519 open and 307 laparoscopic appendectomies were performed in our institution. The open technique is considered reliable and easily performed, with a low

incidence of morbidity[16]. Therefore, the conventional appendectomy strategy is laparoscopy with conversion to open surgery or open appendectomy directly. When difficulties arise during open appendectomy, however, a larger incision may be needed to search for and then divide the appendix. The problem is that a large incision and confused anatomy may lead to a high complication rate[17-20]. Beginning in October 2010, we attempted to convert open appendectomies to laparoscopy when it was difficult to find the appendix and/or to separate it. We achieved good results when we applied a new strategy - converting the open procedure to laparoscopic appendectomy - and compared it to simply lengthening the incision to complete the open operation.

The OACL has the same advantages as laparoscopic appendectomy (LA). There are differences between OACL and conventional three-port LA, however. The position of the trocar on the right abdomen for OACL is at the McBurney point, whereas for LA it is at a higher position, which leads to some differences in the technique. The short distance between the trocar and the appendix during OACL makes it difficult to manipulate the instruments. To solve this problem, the trocar at the McBurney point is sometimes used for the camera. The other difference is the method for removing the appendix. It is removed through a McBurney incision during OACL but through a supraumbilical incision during LA.

Retrograde and submucosal appendectomies have been performed by both open and laparoscopic methods when difficulty is encountered during a procedure[21]. A subserosal appendix has been described with extensive serosal adhesions, which generally cover the body and tip of the appendix but not the base[22]. Retrograde appendectomy is useful for this situation. As the base of the appendix is divided, clips (Lapro-Clip, Covidien, Mansfield, MA, United States; or Hem-o-lock, Weck Closure Systems, Research Triangle Park, NC, United States) are used to ligate it, after which it is cut. Harmonic shears are used to separate the appendix from the base to the tip. The key to the maneuver is that harmonic shears can go beyond the wall of the cecum and approach the appendix. Submucosal appendectomy was reported to be an effective technique for most cases of complicated appendicitis[11]. Once the appendix is identified, the serosal and muscular layers are incised by hook cautery, taking care not to perforate the mucosa (unless it was perforated already). In the case of perforation, divisions begin at the perforation. A metal aspirator with a blunt tip is useful for separating layers between muscular tissue and mucosa. The division continues (as above) until the mucosal tube of the appendix is separated completely, leaving the serosal and muscular tube with an incision on its surface. The procedure is easily performed. Minor bleeding might occur but is easy to control by hook cautery or harmonic shears. The advantages of submucosal laparoscopic appendectomy are as follows: (1) it is not necessary to divide the appendix and cecum, which avoids perforating the wall of the cecum; (2) it is not necessary to divide the mesoappendix, which contains the appendiceal artery and vein, which could easily be injured; and (3) it is not necessary to separate the appendix from adjacent intestine and peritoneum. For some cases, the combined technique is feasible.

Harmonic shears are much more useful than hook cautery during OACL. They are effective for the first two of the three situations mentioned above - appendix on the right upper abdominal but easily found; base of appendix easily identified but not the tip; a mass owing to appendiceal perforation, making it difficult to distinguish it from adjacent intestine. The mesoappendix and adhesions could be divided by harmonic shears directly without ligation, which decreases the incidence of bleeding and shortens the operative time. Ligation of the mesoappendix is sometimes uncertain during open appendectomy and causes a threat. In one patient who underwent LIA abdominal bleeding occurred because of uncertain ligation, and reoperation was necessary to stop it. In our experience, harmonic shears are not as important in the third situation as in the other two situations. A metal aspirator would be helpful for aspiration and for blunt separation.

Incisional infections and intra-abdominal abscesses are common complications after appendectomy[23,24]. It was recently reported that these two complications are less common after laparoscopy than after open appendectomy[23,25-27]. We found the same results for OACL *vs* LIA: the intra-abdominal abscess and incisional infection rates were 1.7% and 3.4%, respectively, after OACL, which were significantly lower than those for LIA. Conversion to laparoscopy in our patients allowed direct visualization during peritoneal toileting. The cleaner peritoneal cavity led to a lower occurrence of intra-abdominal abscesses. Compared with LIA, the OACL procedure was completed under closed incisions (in the peritoneal cavity), which contributed to a lower chance of incisional contamination and certainly a lower incidence of incisional infection.

Fecal fistula and ileus are serious complications of appendectomy, although they occur at low rates[28,29]. These two complications delay bowel movement recovery and prolong hospital stay. Early physical movement and drainage removal are effective measures to prevent ileus. Restricted feeding for patients whose appendiceal base was fragile helps prevent and/or decreases the seriousness of the fecal fistula. In our study, the incidences of fecal fistula and ileus in the OACL and LIA groups were low, with no significant differences between the groups.

A long incision increases the patient's pain and is a poor-healing wound. Postoperative pain was correlated with recovery of bowel movements, which was one of the reasons why time to flatus recovery was shorter in the OACL group than in the LIA. Feeding was started after bowel movement recovery, which enhanced wound healing in the OACL group and led to a shorter hospital stay.

Laparoscopic appendectomy can be the first choice in most cases of appendicitis. OACL is a safe, feasible procedure when difficulty is encountered during open appendectomy. It contributes to a low rate of complications and is in accord with the concept of minimally invasive surgery. It provides a new strategy for dealing with the open complicated appendectomy. Skilled laparoscopic technique is necessary for the OACL procedure.

COMMENTS

Background

Appendicitis is one of the most common diseases, with open appendectomy the gold standard treatment. During complicated appendectomy, a large incision is often necessary, increasing the possibility of complications. With improved laparoscopic technique, laparoscopic appendectomy has become the first choice for appendectomy. However, laparoscopic appendectomy for complicated appendicitis remains controversial and open operation is still applied world-wide.

Research frontiers

Laparoscopic appendectomy has been widely used for treatment of appendicitis. New techniques including single-port laparoscopic and natural orifice transluminal endoscopic surgery have been applied for appendectomy. Clinical outcomes and effects between traditional laparoscopy and new techniques for appendectomy have been compared.

Innovations and breakthroughs

Laparoscopy converted to an open procedure is a conventional strategy during complicated appendectomies. A much larger incision than that needed for laparoscopy is routinely applied in those procedures, resulting in a high rate of complications. The strategy is a reversal conception. Converting open to laparoscopy instead of lengthening incision was used for complicated appendectomy.

Applications

It is feasible and efficient to convert open to laparoscopic appendectomy when the procedure is difficult to perform by normal incision, which decreases the rate of incision infection and abdominal infection, and results in faster bowel movement and shortened hospital stay.

Peer review

It is a well written manuscript, which described a unique concept. The strategy is helpful for centers where open appendectomies as first choice are being done.

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