Surg Endosc (2004) 18: 969–973
DOI: 10.1007/s00464-003-8262-2

SURGICAL ENDOSCOPY
and Other Interventional Techniques

Laparoscopic appendectomy for complicated appendicitis

An evaluation of postoperative factors

C. G. Ball,[1,2,3] J. B. Kortbeek,[1] A. W. Kirkpatrick,[1] P. Mitchell[2]

[1] Department of Surgery, Foothills Medical Centre, University of Calgary, 1403-29 Street NW, Calgary, Alberta, Canada T2 N 2T9
[2] Department of Surgery, Peter Lougheed Centre, University of Calgary, 3500 26 Avenue NE, Calgary, Alberta, Canada T1Y 6 J4
[3] University of Calgary, Calgary, Alberta, Canada

Received: 2 October 2003/Accepted: 16 January 2004/Online publication: 21 April 2004

Abstract
Background: The use of laparoscopic appendectomy for complicated appendicitis is controversial. Outcomes were compared between patients who had complicated appendicitis and those who had uncomplicated appendicitis
Methods: Consecutive patients (n = 304) who underwent laparoscopic appendectomy were studied. Patients undergoing open appendectomies also were compared ad hoc. Analgesia use, length of hospital stay, return to activity, and complication rates for the complicated and uncomplicated appendicitis subgroups were analyzed.
Results: Complete data were available for 243 patients (80%). There were no statistical differences in characteristics between the two groups. The operating times, lengths of hospital stay, return to activity times, complication rates, and analgesia requirements, both in the hospital and after discharge, were equivalent. A greater number of complicated cases required open conversion. Considering those with complicated appendicitis, the open group had a significantly longer mean hospital stay and a higher complication rate than those treated with laparoscopic appendectomy.
Conclusions: The minimally invasive laparoscopic technique is safe and efficacious. It should be the initial procedure of choice for most cases of complicated appendicitis.

Key words: Laparoscopic appendectomy — Acute appendicitis — Complicated appendicitis

Although the first laparoscopic appendectomy was performed nearly 25 years ago, the debate between open and laparoscopic appendectomy for acute appendicitis remains active. Despite the brief recovery time and generally good results of the open technique, the laparoscopic approach for uncomplicated appendicitis holds a slight advantage in the available literature. All meta-analyses of prospective randomized trials conclude that the minimally invasive technique is better than [3, 5, 6, 17, 18], or as good as [14], open appendectomy in terms of postoperative wound infections, analgesia requirements, hospital stay, return to work intervals, and overall recovery.

Complicated appendicitis is defined as acute appendicitis in which perforation or an intraabdominal abscess is present. This can involve a significant proportion of cases [1]. The evidence supporting the use of the laparoscopic technique for managing complicated appendicitis is much more tenuous than the evidence supporting its use for uncomplicated appendicitis. To date, the literature consists of small retrospective analyses and does not include any large prospective, randomized trials. On the basis of their experience managing 34 cases of gangrenous or perforated appendicitis, Frazee and Bohannon [4] were among the first to conclude that laparoscopic appendectomy is safe and beneficial for such patients.

Other series, ranging in size from 6 to 171 patients, have shown that the risks of intraabdominal complications, including abscess and fistula formation, are statistically similar between the laparoscopic and open techniques for complicated appendicitis [7–9, 12, 13, 15, 16, 19, 20]. In the largest series of such cases, Wullstein et al. [19] convincingly showed that abdominal wall complications including wound infections, abscesses, hematomas, and bleeding were reduced with the laparoscopic approach. This led to a lower overall complication rate.

Brosseuk and Bathe [2] farther described the utility of laparoscopic appendectomy for complicated appendici-

Presented at the Canadian Association of General Surgeons meeting in Vancouver, British Columbia, Canada, 18 September 2003

Correspondence to: C. G. Ball

tis. All 11 of their patients with perforated appendicitis were treated laparoscopically and discharged home as ambulatory cases without a single complication.

With this literature in mind, the European Association for Endoscopic Surgery and other interventional techniques stated the laparoscopic approach can be applied to cases of complicated appendicitis if the "proper expertise is available." This reflects the observation that surgeons with less laparoscopic experience have a higher rate of conversion to on open procedure [11].

Despite the increasing belief that a minimally invasive technique plays a significant role in the treatment of complicated appendicitis, there is a surprising paucity of objective data on the postoperative factors that have justified opinions supporting a minimally invasive approach for uncomplicated appendicitis.

This study is the first to offer a comparison of these factors, including precise in-hospital and postdischarge analgesia requirements, length of hospital stay, return to regular activity intervals, and complication rates, between patients with uncomplicated and those with complicated appendicitis. We present a series of 243 patients who underwent laparoscopic appendectomy and 99 who had open appendectomies over an 8-year period.

Materials and methods

Consecutive patients who underwent appendectomy for acute appendicitis from January 1995 to March 2003 at a university teaching hospital were studied. The appendectomies were preformed by a senior surgeon and his surgical trainees. There was no minimum age for entry. In addition to prospective comparisons between laparoscopic groups, a series of open appendectomies for both complicated and uncomplicated appendicitis performed by another Board-certified surgeon were used as an ad hoc retrospective control group. An extensive chart review detailed results for a control group of open appendectomies completed over the same 8-year period.

Immediately after appendectomy, the following surgical and patient-related data were recorded by the primary surgeon on a prepared form: sex, age, height, weight, total patient time in the theater, actual operating time, history of previous abdominal surgeries, Foley catheter use, pneumoperitoneum technique (open vs Veress needle), stump control (loop vs linear stapler vs clips), mesoappendix control (linear stapler vs cautery vs clips), specimen extraction technique (bag vs through the trocar), technical difficulties and conversion to open procedures. At the postoperative clinic follow-up assessment, in-hospital and postdischarge analgesia requirements, length of hospital stay, return to normal daily activity interval, and complications were recorded on the same form. All data were compiled using Excel software (Microsoft, Redmond, WA, USA).

Complicated appendicitis was defined by a pathology report describing the diagnostic features of complicated disease such as perforation or abscess. The final pathologic diagnosis ensured proper group placement. The total operating room time was defined as the elapsed time from the patient's entry into the operating suite until the patient's exit. The actual operating time was defined as the elapsed time from the initial incision until the last closing abdominal suture. The total length of in-hospital stay was defined as the patient's number of days in the hospital rounded up to the nearest whole day. The total time until return to normal activities was defined as return not only to work, but to all normal activities of daily living and leisure. Patients with conversion to open appendectomies were included in their corresponding laparoscopic group for intention to treat" purposes. Tests for statistical significance included the Chi-square and Fisher's exact tests, as well as logistic regression (for comparison of open and laparoscopic appendectomy groups) from the SPSS statistical program (SPSS, Chicago, IL, USA). Differences were considered significant at a p value less than 0.05.

Surgical technique

All laparoscopic appendectomies were supervised by a senior surgeon. A Foley catheter was rarely used (15% of cases). Pneumoperitoneum was attained using a Veress needle in 99% of the cases. Three trocars were used: one 10- or 5-mm periumbilical trocar (for the camera), one 5-mm trocar in the suprapubic midline, and one 5-mm trocar equidistant from the other two. The mesoappendix was divided using either clips (78%) or a linear stapler (21%). The appendiceal stump was controlled using either two separate Endoloop ligatures (59%) (Ethicon, Cincinnati, OH, USA) or a linear stapler (40%). The appendix was extracted either with an EndoCatch bag (68%) (EndoCatch; USSC, Norwalk, CT, USA) or through the trocar itself (32%). Suction/irrigation was used under direct visualization for frank perforation or abscess. Open appendectomy was typically performed (94%) using a classic McBurney's incision.

In cases of complicated appendicitis, antibiotics were used postoperatively. These typically included several intravenous drug regimens during the hospital stay and oral ciprofloxacin–flagyl for a total of 7 days after discharge. Patients were not kept in the hospital after they had improved clinically solely for the administration of intravenous antibiotics. All the patients received a single preoperative dose of antibiotics. Conversion to open appendectomy was performed using a lower midline incision. All abdominal wounds were closed primarily.

Results

A total of 304 patients underwent appendectomies during the study period. Of these, 243 had complete follow-up data and constituted the minimally invasive surgery group to be analyzed. Of the 61 incomplete cases, 49 involved uncomplicated appendicitis. These patients were lost to follow-up evaluation because they did not attend a postoperative clinic. The control group included 99 open appendectomies from the same 8-year period. Laparoscopic appendectomy was successful for 233 of 243 patients with complete data. Conversion to an open procedure was required for 10 patients because the appendix could not be mobilized after extensive cecal adhesions.

Of the 233 laparoscopic procedures performed, 161 (69%) were for uncomplicated and 72 (31%) for complicated appendicitis. There were no statistical differences between the two groups in terms of sex, age, height, weight, or history of previous abdominal surgery (Table 1). There was, however, a difference in body mass index: 24 for the uncomplicated appendicitis group versus 28 for the complicated group ($p < 0.05$).

The total operative room times and actual operating times were equivalent between the two groups: 61 versus 68 min for the uncomplicated group and 37 versus 40 min for the complicated group ($p < 0.05$) (Table 1). There also was no difference in the total length of hospital stay (1.8 vs 2.2 days) or the time until return to normal activities (8.7 vs 9.3 days) between the patients with uncomplicated and those with complicated appendicitis ($p > 0.05$). There was an increase in the number of conversions to open procedures in the complicated group (2% vs 10%; $p < 00.05$).

The overall complication rates for laparoscopic appendectomy among patients with uncomplicated and

Table 1. Patient characteristics and operative and postoperative factors for all patients

	Surgeon A		Surgeon B	
	Laparoscopic appendectomy		Open appendectomy	
	Uncomplicated	Complicated	Complicated	Uncomplicated
Total patients *n* (%)	161 (69)	72 (31)	23 (23)	76 (77)
Sex *n* (%)				
Females	84 (52)	31 (43)	7 (30)[a]	32 (42)
Males	77 (48)	41 (57)	16 (70)[a]	44 (58)
Mean age (years) *n* (range)	33 (12–67)	35 (10–77)	41 (21–87)	31 (7–67)
Mean Height (cm)	172	166	NA	NA
Mean Weight (kg)	72	77	NA	NA
Mean body mass index	24	28[b]	NA	NA
Previous surgery *n* (%)	27 (17)	14 (19)	NA	NA
Mean total OR time (min) *n* (range)	61 (41–112)	68 (45–125)	NA	NA
Mean actual OR time (min) *n* (range)	37 (12–67)	40 (14–103)	NA	NA
Foley catheter *n* (%)	15 (9)	11 (15)	NA	NA
Conversion *n* (%)	3 (2)	7 (10)[b]	NA	NA
Mean length of hospital stay (days) *n* (range)	1.8 (1–7)	2.2 (1–9)	6.6 (2–13)[a]	2.5 (1–7)
Mean return to activity (days) *n* (range)	8.7 (0–58)	9.3 (2–61)	NA	NA
Complications *n* (%)	8 (5)	4 (6)	5 (22)[a]	5 (7)
Wound infections	4	1	3	2
Intraabdominal abscess	4	3	1	1
Hematoma	0	0	1	2

NA, not applicable; OR, operating room
[a] Comparison between complicated open and all other appendectomy groups ($p < 0.05$)
[b] Comparison between laparoscopic appendectomy groups ($p < 0.05$)

Table 2. In-hospital morphine equivalent requirements for patients with appendicitis

	Percentage of patients with appendicitis	
Morphine equivalents (mg)	Uncomplicated	Complicated
0	11	15
1–5	33	31
5.1–10	21	20
10.1–15	13	11
15.1–20	11	11
20.1–25	0	2
25.1–30	5	3
30.1–35	1	1
>35	5	6

Table 3. Postdischarge morphine equivalent requirements for patients with appendicitis

	Percentage of patients with appendicitis	
Morphine equivalents (mg)	Uncomplicated	Complicated
0	38	47
1.0–5	15	11
5.1–11	7	18
10.1–16	7	7
15.1–21	3	0
20.1–26	1	0
25.1–31	2	0
30.1–36	0	0
>35	27	17

those with complicated appendicitis were statistically equivalent (5% vs 6% respectively). There were four wound infections in the uncomplicated group and one in the complicated group ($p > 0.05$). There also were four intraabdominal abscesses in the uncomplicated group and three in the complicated group ($p > 0.05$).

In terms of analgesia requirements (morphine equivalents), there was no statistical in-hospital difference between the uncomplicated and complicated groups ($p > 0.05$; Table 2). Most of the analgesia used in the inpatient setting was intramuscular morphine or oral acetaminophen with 30 mg of codeine. There also was no difference in postdischarge analgesia requirements (primarily acetaminophen with 30 mg of codeine) (Table 3; $p > 0.05$). The acetaminophen and antiinflammatory equivalents also were similar ($p > 0.05$).

For complicated appendicitis, the hospital stay (6.6 days) was significantly longer and the complication rate (22%) significantly higher in the retrospective open appendectomy group than in the prospective laparoscopic group ($p < 0.05$; Table 1). The complications included three wound infections, one intraabdominal abscess, and one wound hematoma. The open appendectomy group treated for uncomplicated appendicitis did not differ statistically in length of hospital stay (2.5 days) or complication rate (7%) from the laparoscopic group ($p > 0.05$; Table 1).

Discussion

There is a paucity of strong evidence-based data for determining the proper surgical management of complicated appendicitis. Although a few retrospective studies of varying methodologic quality have discussed the feasibility and anecdotal success of the laparoscopic approach, it was not until Wullstein et al. [19] reported a large case series, that any objective advantage of a

minimally invasive technique for complicated appendicitis was established.

As with uncomplicated appendicitis, the outcome of future debates about complicated appendicitis will rest on potential differences in postoperative factors such as analgesia requirements, length of hospital stay, return to regular activity intervals, and complication rates. In a prospective manner, this study shows that there is no significant difference in either post-operative in-hospital or postdischarge analgesia requirements between patients with uncomplicated and those with complicated appendicitis treated laparoscopically. Whereas Long et al. [10] identified reduced analgesia requirements as an advantage of minimally invasive surgery for uncomplicated appendicitis, the current study supports the use of the laparoscopic technique for all cases of appendicitis.

The advantage of laparoscopic appendectomy for complicated appendicitis also is supported by the similar lengths of hospital stay and return to regular activity intervals between the laparoscopic groups in the current series. Equally important, the rates of postoperative complications are the same between the two groups. Although the complication rate in this study is comparable with that in most other series, the conversion rate is lower and the operating time shorter. This is likely because our primary surgeon had extensive experience in laparoscopic surgery. A surgeon's experience has been shown to correlate with the rate of conversion to open procedures [15].

An unexpected finding was the statistically increased body mass index in the complicated appendectomy group. This may be a result of a less straightforward clinical examination for obese patients, and hence the concept that their presentation and treatment are later in the course of the disease. The consequences of local wound infection in larger patients can be severe, further encouraging a laparoscopic approach for all forms of appendicitis because it significantly reduces the incidence of wound infections [7–9, 12, 13, 15, 16, 19, 20].

For complicated disease, a cautious comparison of our retrospective open appendectomy group with prospective laparoscopic cohorts, showed that the minimally invasive technique is statistically superior in terms of hospital length of stay and complication rate. Although this comparison is important, there are four limitations. First, the sample size is smaller than for the larger laparoscopic groups. Second, the open appendectomy group includes significantly more males. Third, this group was not included as a prospective comparison group from the beginning of the study. Finally, these procedures were performed by different surgeons at adjoining hospitals, so their comparisons may not be generalizable to other centers or operators. It is noteworthy that the open appendectomies performed in our study for uncomplicated appendicitis over the same 8-year period were equivalent in terms of patient characteristics, length of hospital stay (2.5 days), and complication rate (6.5%) to those performed in both laparoscopic groups.

In summary, this study is the first prospective investigation to detail postoperative analgesia requirements and return to normal activity intervals after laparoscopic appendectomy among patients with complicated appendicitis. It also confirms the findings of smaller studies regarding length of hospital stay and complication rates. Because the efficacy of the laparoscopic technique for uncomplicated appendicitis has been proved, we have used this technique as a point of comparison for complicated disease. There is no difference in analgesia requirements, recovery, or complications when laparoscopic appendectomy, alone or in an intention-to-treat form, is compared between complicated and uncomplicated appendicitis groups. Furthermore, tenuous comparison of the laparoscopic appendectomy cohort with an open appendectomy group in cases of complicated disease also has shown the minimally invasive approach to be superior in terms of complication rates and length of hospital stay.

We conclude that in addition to its diagnostic advantage, the laparoscopic technique is safe and efficient on a therapeutic level. It should be the initial procedure of choice for nearly all cases of complicated appendicitis.

References

1. Al-Omran M, Mamdani MM, McLeod RS (2003) Epidemiologic features of acute appendicitis in Ontario, Canada. Can J Surg 46: 263–268
2. Brosseuk DT, Bathe OF (1999) Day care laparoscopic appendectomies. Can J Surg 42: 138–142
3. Chung RS, Rowland DY, Li P, Diaz J (1999) A meta-analysis of randomized controlled trials of laparoscopic versus conventional appendectomy. Am J Surg 177: 250–253
4. Frazee RC, Bohannon WT (1996) Laparoscopic appendectomy for complicated appendicitis. Arch Surg 131: 509–512
5. Garbutt JM, Soper NJ, Shannon WD, Botero A, Littenberg B (1999) Meta-analysis of randomized trials comparing laparoscopic versus open appendectomy. Surg Laparosc Endosc 9: 17–26
6. Golub R, Siddiqui F, Pohl D (1998) Laparoscopic versus open appendectomy: a meta-analysis. J Am Coll Surg 186: 543–553
7. Johnson AB, Peetz ME (1998) Laparoscopic appendectomy is an acceptable alternative for the treatment of perforated appendicitis. Surg Endosc 12: 940–943
8. Khalili TM, Hiatt JR, Savar A, Lau C, Margulies DR (1999) Perforated appendicitis is not a contraindication to laparoscopy. Am Surg 65: 965–967
9. Klingler A, Henle KP, Beller S, Rechner J, Zerz A, Wetscher G, Szinicz G (1998) Laparscopic appendectomy does not change the incidence of postoperative infectious complications. Am J Surg 175: 232–235
10. Long KH, Bannon MP, Zeitlow SP, Helgeson ER, Harmsen WS, Smith CD, Ilstrup DM, Baerga-Varela Y, Sarr MG (2001) A prospective randomized comparison of laparoscopic appendectomy with open appendectomy: clinical and economic analyses. Surgery 129: 390–400
11. Martin LC, Puente JL, Sosa JL, Bassin A, Breslaw R, McKenney MG (1995) Open versus laparoscopic appendectomy: a prospective randomized comparison. Ann Surg 222: 256–262
12. Piskun G, Kozik D, Rajpal S, Shaftan G, Fogler R (2001) Comparison of laparoscopic, open, and converted appendectomy for perforated appendicitis. Surg Endosc 15: 660–662
13. Senapathi PS, Bhattacharya D, Ammori BJ (2002) Early laparoscopic appendectomy for appendicular mass. Surg Endosc 16: 1783–1785
14. Slim K, Pezet D, Chipponi J (1998) Laparoscopic or open appendectomy? Critical review of randomized controlled trials. Dis Colon Rectum 41: 398–403

15. So JB, Chiong EC, Chiong E, Cheah WK, Lomanto D, Goh P, Kum CK (2002) Laparoscopic appendectomy for perforated appendicitis. World J Surg 26: 1485–1488
16. Stoltzing H, Thon K (2000) Perforated appendicitis: Is laparoscopic operation advisable? Dig Surg 17: 610–616
17. Surland S, Lafering R, Holthausen U, Neugebauer EA (1998) Laparoscopic versus conventional appendectomy: a meta analysis of randomized controlled trials. Langenbecks Arch Surg 383: 289–295
18. Temple LK, Litwin DE, McLeod RS (1999) A meta-analysis of laparoscopic versus open appendectomy in patients suspected of having acute appendicitis. Can J Surg 42: 377–383
19. Wullstein C, Barkhausen S, Gross E (2001) Results of laparoscopic vs conventional appendectomy in complicated appendicitis. Dis Colon Rectum 44: 1700–1705
20. Yao CC, Lin CS, Yang CC (1999) Laparoscopic appendectomy for ruptured appendicitis. Surg Laparosc Endosc Percutan Tech 9: 271–273