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Open *Versus* Laparoscopic Appendectomy

A Prospective Randomized Comparison

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Objective

The authors compare open and laparoscopic appendectomy in a randomized fashion with regard to length of operation, complications, hospital stay, and recovery time.

Methods

Adult patients (older than 14 years of age) with the diagnosis of acute appendicitis were randomized to either open or laparoscopic appendectomy over a 9-month period. All patients received preoperative antibiotics. The operative time was calculated as beginning with the incision and ending when the wound was fully closed. Patients that were converted from laparoscopic to open appendectomy were considered a separate group. Return to normal activity and work were determined by questioning during postoperative clinic, telephone, or mailed questionnaire.

Results

There was a total of 169 patients randomized, 88 to the open and 81 to the laparoscopic group. The groups were similar demographically. Of the 81 laparoscopic patients, 13 (16%) were converted to open. In the open group, 70 patients (79.5%) had acute appendicitis and 21 (23.9%) had perforative appendicitis. In the laparoscopic group, 62 patients (76.5%) had acute appendicitis and 10 (12.3%) had perforative appendicitis. There was no statistical difference in the return to activity or work between the laparoscopic and open groups. The operative time was significantly longer in the laparoscopic group (102.2 minutes *vs.* 81.7 minutes, $p < 0.01$). The hospital stay of 2.2 days in the laparoscopic group and 4.3 days in the open group was statistically different ($p = 0.007$). There was no difference in the hospital stay for those with acute appendicitis (1.89 days *vs.* 2.61 days, $p = 0.067$) compared with those with a normal appendix but with pelvic inflammatory disease (1.1 days *vs.* 2.3 days, $p = 0.11$). There was a significant difference in patients with perforative appendicitis (1.5 days *vs.* 9.5 days, $p < 0.01$). The hospital cost for patients having laparoscopic appendectomy was $6077 and for an open appendectomy $7227 ($p = 0.164$). There were no increased complications associated with the laparoscopic technique.

Conclusion

Laparoscopic appendectomy is comparable to open appendectomy with regard to complications, hospital stay, cost, return to activity, and return to work. There was a greater operative time involved with the laparoscopic technique. Laparoscopic appendectomy does not offer any significant benefit over the open approach for the routine patient with appendicitis.

Laparoscopic techniques have been used therapeutically for a variety of intra-abdominal problems and is accepted treatment for cholelithiasis.[1-3] It is surprising that the first reported laparoscopic appendectomy was done in 1982,[4] and the efficacy and indications for this procedure are still debated. In an effort to examine the use of this procedure, we compared our laparoscopic appendectomies with open historical control subjects in 1993 and found that the hospital stay was significantly shorter in the laparoscopic group.[5] Despite these findings and those of others,[6-13] there is considerable reluctance to accept the routine use of laparoscopic appendectomy. We undertook this prospective randomized evaluation of open *versus* laparoscopic appendectomy to clarify the use of this technique.

METHODS

Adult patients (older than 14 years of age) with the presumptive diagnosis of acute appendicitis were randomized to have surgery performed using the conventional, open, or laparoscopic technique. Before randomization, patients were informed of the risks and benefits of each procedure and signed a consent form to participate in the study, which extended over a 9-month period. Appendectomy performed during diagnostic laparoscopy for another indication and incidental appendectomies were excluded.

All patients received 1 g of ceftriaxone preoperatively, and the antibiotics were continued based on the clinical course. Patients randomized to the open appendectomy group had a McBurney or Rockey-Davis right lower quadrant muscle splitting incision. Laparoscopic appendectomies were done using a standardized approach involving an open technique for trocar insertion. A 10-mm Hassan trocar was placed in the periumbilical area with a 12-mm trocar placed in the right midabdomen and a 5-mm trocar placed in the suprapubic location. The mesoappendix was divided using Endo-Clips (U.S. Surgical Corp., Norwalk, CT) or an Endo-GIA V30 (U.S. Surgical Corp.), and the appendix was divided using an Endo-GIA 30 (U.S. Surgical Corp.). The specimen was placed in an Endo-Catch (U.S. Surgical Corp.) or glove and removed through the 12-mm port. The procedures were performed by surgical residents at the University of Miami/Jackson Memorial Medical Center with attending supervision for all cases. Operative time was calculated from the time of incision until the time of wound closure and did not reflect the time required to set up the laparoscopic equipment.

The postoperative course was monitored for number of hospital days, use of antibiotics, and complications. For determination of when patients returned to normal activity and work, they were questioned during follow-up visits, by telephone, and by mailed questionnaire. Due to the nature of the patient population, some patients did not have conventional employment, and we used the time they returned to full-time work-related activity.

The data were analyzed using the Student's t test or analysis of variance. The actual probability value is reported unless it was less than 0.01, in which case it is reported as such. Statistical significance was determined to be a probability value less than 0.05.

Table 1. PATIENT DISTRIBUTION

	Laparoscopic	Open
No. of patients	88	81
Age (yr)	27	29
Male:female	1.4:1	1.5:1
Acute appendicitis (p = 0.38)	63 (71.6%)	53 (65.4%)
Perforated appendicitis (p = 0.08)	20 (22.7%)	10 (12.3%)

RESULTS

There were 169 patients entered into the study, 88 in the open appendectomy group and 81 in the laparoscopic appendectomy group. Of the 81 patients in the laparoscopic appendectomy group, 13 were converted to an open procedure. In the open group, 63 patients had acute appendicitis (79.5%), and 20 (23%) had perforative appendicitis. In the laparoscopic group, 53 patients had acute appendicitis (65.4%) and 10 (12.3%) had perforative appendicitis (Table 1).

Laparoscopic appendectomy was converted to an open procedure in 13 patients (16%). In this group, eight patients had acute appendicitis, four patients had perforative appendicitis, and one patient had a normal appendix with evidence of pelvic inflammatory disease. The reasons for conversion to an open procedure included inadequate exposure secondary to adhesions in nine patients (69%), inadequate exposure due to perforation in two patients (15.4%), and excessive bleeding due to inflammation in two patients (15.4%), which included the patient with a normal appendix and pelvic inflammatory disease.

The results for the laparoscopic and open groups are

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Table 2. COMPARISON OF ALL LAPAROSCOPIC PATIENTS AND OPEN PATIENTS

	Laparoscopic	Open	p Value
No. of patients	81	88	—
OR minutes	102.2	81.7	0.0002
Hospital days	2.2	4.3	0.0007
Days to normal activity	12.2	12.8	0.92
Days to work	23.3	23.6	0.99

summarized in Table 2. The mean operative time in the open appendectomy group was 81.7 minutes; for the laparoscopic group, 102.2 minutes ($p < 0.01$). The converted patients required 119.8 minutes for the completion of surgery, and when these patients are considered as a separate group, the time of laparoscopic appendectomy is 98.8 minutes ($p < 0.01$ compared with the open group). The overall hospital stay was 4.27 days in the open group and 2.2 days in the total laparoscopic group ($p < 0.01$). However, when the converted laparoscopic patients are excluded, the length of stay for the patients who underwent the complete laparoscopic procedure was 1.63 days ($p < 0.01$). The converted patients had a length of stay of 5.46 days, which is similar to that of the patients having an open appendectomy.

When the open and laparoscopic groups are divided into subsets based on disease, the advantage in terms of early discharge is lost for those patients who had acute appendicitis or a normal appendix (Tables 3 and 4). The operative times were longer in the laparoscopic group with acute appendicitis than in the open group ($p = 0.007$). The mean hospital stay of 1.89 days in the laparoscopic group and 2.61 days in the open group was not statistically different ($p = 0.067$). Considering those patients who had a perforated appendix (Table 5), there was no difference in operating time, but the hospital stay was significantly shorter in the laparoscopic group, 1.5 *versus* 9.5 days ($p < 0.01$). Those patients who had their perforated appendix removed laparoscopically also received fewer days of antibiotics than those who had an open appendectomy: 1.3 days *versus* 7.3 days ($p < 0.01$). There were no significant differences between the patients in the laparoscopic and open groups regarding time required for return to normal activity (12.2 days *vs.* 12.8 days) or work (23.3 days *vs.* 23.6 days) overall or in any of the groups based on pathology except for return to activity in those patients with a normal appendix (10.1 days *vs.* 16.7 days, $p = 0.02$).

Table 4. PATIENTS WITH A NORMAL APPENDIX

	Laparoscopic	Open	p Value
OR minutes	95.1	80.5	0.23
Hospital days	1.1	2.3	0.11
Antibiotic days	0.67	1.2	0.28
Days to normal activity	10.1	16.7	0.02
Days to work	20.2	27.2	0.09

The cost of the hospitalization is compared for each patient group in Table 6. The overall cost was greater in the open group, but this was not statistically different. The costs in the perforated group were significantly more for those patients having an open appendectomy ($p = 0.05$). That the cost in the open perforated group was almost double that in the laparoscopic group is not surprising given the much longer length of stay for the patients in the open group. The cost was approximately equal in the acute appendicitis and normal appendix groups.

There were two intraoperative complications in the open group, consisting of one small-bowel injury and one case in which the appendiceal stump could not be closed and a tube cecostomy was placed. There was one intraoperative complication in the laparoscopic group involving an abdominal well hematoma at the site of a 5-mm trocar port, which was treated conservatively. There were ten readmissions in the open group and nine in the laparoscopic group, an average of 4.2 days and 8.7 days after discharge, respectively. One patient in the laparo-

Table 3. PATIENTS WITH ACUTE APPENDICITIS

	Laparoscopic	Open	p Value
OR minutes	99	78.5	0.007
Hospital days	1.89	2.61	0.067
Antibiotic days	1.21	2.26	0.34
Days to normal activity	11.1	13.2	0.18
Days to work	21.8	23.3	0.5

Table 5. PATIENTS WITH PERFORATED APPENDICITIS

	Laparoscopic	Open	p Value
OR minutes	109	92.5	0.13
Hospital days	1.5	9.5	0.00004
Antibiotic days	1.3	7.3	0.00008
Days to normal activity	13.5	7.6	0.43
Days to work	24	21.8	0.77

Table 6. COST ANALYSIS OF LAPAROSCOPIC AND OPEN PATIENTS

	Laparoscopic ($)	Open ($)	p Value
All patients	6077	7227	0.164
Acute	6189	5277	0.074
Perforated	7465	13,670	0.05
Normal	5088	5515	0.51

scopic converted group was readmitted 6 days after discharge. Cause for readmission was nausea or inability to tolerate a diet for five patients and for a total of 15 infectious complications in both groups. Wound infections occurred in six open and three laparoscopic patients, and intra-abdominal abscesses occurred in three open and three laparoscopic patients (p = NS). Each of the intra-abdominal abscesses was treated successfully by percutaneous drainage, except for one pelvic abscess in a patient who had an open perforated appendix and underwent transrectal drainage without complication. There were no deaths in either the open or the laparoscopic group.

DISCUSSION

Despite the success of conventional appendectomy, there have been numerous attempts to improve the diagnostic accuracy and outcome of patients with acute appendicitis, because the negative appendectomy rate in most series is still in the range of 20% to 30%.[14] Additionally, the recovery time after an open appendectomy can be significant. Initially, laparoscopy was used as a diagnostic tool to decrease the rate of negative appendectomy while minimizing complications.[15–17] The surgical technique for laparoscopic appendectomy is now well described, and several methods have been developed.[18–20] These involve a 3- or 4-trocar technique, and the base of the appendix can be divided by intracorporeal or extracorporeal suturing, Endoloop placement, clip application, or stapling device.

On the basis of our preliminary experience with laparoscopic appendectomy,[5] we undertook this prospective randomized study to evaluate the time of operation, hospital stay, return to activity and work, and incidence of complications. There was no statistical difference between the open and laparoscopic patients. We had a 16% rate of conversion from laparoscopic to open procedure during the study. This seems excessive when compared with the results of Pier et al.,[9] who reviewed 625 laparoscopic appendectomies in 678 patients with presumptive appendicitis, with 2% requiring conversion to an open procedure. However, others have documented higher conversion rates. Richards et al.[21] had a conversion rate of 11% due to inability of the surgeon to dissect the appendix, and Scott-Conner et al.[22] reported 16 patients undergoing laparoscopic appendectomy, with success in 12 patients and 2 patients (12.5%) undergoing conversion to open for bleeding or perforation. Although the rate of conversion to an open procedure contributes to the increased costs often associated with laparoscopic surgery, the safety of the procedure is of paramount importance. In our series, there was only one intraoperative complication in the laparoscopic group, and this was not due to dissection in the area of the appendix, but rather to trocar insertion.

The mean operative time in the laparoscopic group was significantly longer than in patients undergoing an open procedure (102.2 *vs.* 81.7 minutes). This is much longer than the reported operative times of 15 to 20 minutes.[9] However, this is comparable to the results of Frazee et al.,[23] who found an operative time of 87 minutes for the laparoscopic patients and 65 minutes for the open patients, which was statistically different in their study. In our series, all operations were performed by surgical residents with the assistance of the attending surgeon, and much instruction was involved. There was no difference in the staffing between the open and laparoscopic cases, so the times are probably comparable although they are generally longer than in most other series.[24]

Schirmer et al.[25] reviewed 122 nonrandomized patients who had either diagnostic laparoscopy and open appendectomy or laparoscopic appendectomy and found no difference in hospital stay, mortality, complications, or cost between the two procedures. They concluded that a randomized study would be needed to avoid selection bias, because their study did not show any significant benefit to laparoscopic appendectomy over the open procedure. Nowzaradan et al.[10] reviewed 43 patients with suspected appendicitis without perforation who had laparoscopic appendectomy and found that they had less postoperative pain, a shorter hospital stay, a faster return to activity, a lower morbidity rate, and a better cosmetic result that those who had an open appendectomy during the same time period. However, those patients with perforative appendicitis were excluded from the laparoscopic group, and this undoubtedly influenced the outcome. Ortega et al.[26] reviewed 253 patients randomized to three groups to compare laparoscopic and open appendectomy. They concluded that laparoscopic appendectomy produced less pain and more rapid return to normal activity (9 *vs.* 14 days, $p < 0.001$) and required a shorter hospital stay (2.16 days *vs.* 2.83 days when the appendix was stapled, $p < 0.05$). Our results showed a significant overall decrease in the number of hospital days in patients who underwent a laparoscopic appendectomy. However, when the groups were

examined based only on the patients who had acute appendicitis or a normal appendix, there was no statistical difference, whereas the patients with perforated appendices were discharged significantly earlier in the laparoscopic group. The open perforated patients received a much longer course of postoperative antibiotics than did the laparoscopic patients (7.3 days *vs.* 1.3 days, $p < 0.01$), which has been found by others to account for increased length of stay in open appendectomy patients.[17] Additionally, those patients who had a laparoscopic appendectomy and perforation may have had less inflammation than those having an open procedure. When the lengths of stay in other studies are examined based on the pathologic findings, the differences may not be as significant as when the total group is analyzed.

Although others[23] have shown a more rapid return to normal activity and work after laparoscopic appendectomy compared with open appendectomy, our data did not support this. The mean time to return to normal activity was between 1 and 2 weeks in both groups. These results are similar to those reported for laparoscopic appendectomy,[23] but the patients who had an open procedure seemed to return to activity more rapidly (12.8 days) than reported. In the study by Frazee et al.,[23] the patients in the open appendectomy group required 25 days to return to full activity. Also, the patients in both groups reported returning to work after approximately the same time period. This is similar to a report by Richards et al., who were unable to measure any advantage regarding return to physical activity after laparoscopic appendectomy.[21]

There was one intra-operative complication in the laparoscopic group involving trocar insertion and an abdominal wall hematoma. Gaining access to the abdominal cavity is the most common time for complications to occur during laparoscopic surgery.[27] For this reason we have used the open technique exclusively and visualize each trocar during insertion. There were no other intraoperative complications in this group. The rate of readmission to the hospital was equal in the open and laparoscopic groups, with wound infection or intra-abdominal abscess being the predominant reason. There were three intra-abdominal abscesses in each group, and although there were six wound infections in the open group and three in the laparoscopic group, this was not a significant difference. The rate of intra-abdominal abscesses is thought to be roughly equal for both laparoscopic and open procedures.[9] However, Bonanni et al.[28] found that in patients undergoing laparoscopic appendectomy with perforation, 45.5% required readmission to the hospital for infectious complications *versus* only 3% in the open group. The readmission rate overall was 10.6% in the laparoscopic group and 1% in the open group. The reasons for readmission in the laparoscopic group were pelvic abscess in four patients, and also included one phlegmon, one hepatic abscess, and one patient with urinary retention. In the open group, there were two cases of pelvic abscess and one case of deep vein thrombosis. Additionally, Ortega et al.[26] noted six intra-abdominal abscesses in laparoscopic and 0 in open appendectomy patients (p = NS), although wound infections were more common among open appendectomy patients (11 *vs.* 4, $p < 0.05$). The researchers believed that this may be a major advantage of the laparoscopic technique. Others have found that the rate of wound infection after laparoscopic appendectomy is low compared with that of the open procedure.[9,29] In the technical part of the laparoscopic procedure, incidence of wound infection can be reduced by placing the appendix in a bag or drawing it into the trocar for removal and not allowing the specimen to remain in contact with the wound. Further, use of the Endo-GIA instrument decreases operative time for laparoscopic appendectomy[21,30] and decreases the amount of potential contamination by not allowing the open end of the specimen in the abdominal cavity.

The cost of laparoscopic procedures is of major concern. In our study, there was no significant difference in cost between the open and laparoscopic procedures, except for cases involving a perforated appendix, in which the cost in the laparoscopic group was significantly less than that in the open group. This is due to the prolonged hospitalization in the open perforated group, 9.5 days, compared with the laparoscopic group, 1.5 days. Bonanni et al.[28] found that the operating room costs were significantly greater for laparoscopic appendectomy patients and were generally twice that for comparable open appendectomy patients. This probably reflects the increased operating room time and the cost of laparoscopic equipment. However, a decrease in hospital stay may offset this disadvantage, but in the Bonanni study and in our study, the length of stay was not significantly less, and the laparoscopic patients had increased overall cost compared with the open patients.

Laparoscopic appendectomy can be performed with similar morbidity to open appendectomy and may actually have a decreased wound infection rate. However, in the routine patient with the clinical diagnosis of acute appendicitis, it does not seem to offer any major advantages. The length of hospital stay is decreased over the open procedure when all patients are considered together, but when the patients are stratified according to pathologic findings, these differences do not seem to be significant. Additionally, the operative time is increased with laparoscopic appendectomy, and there is no benefit regarding hospital cost. Further, the time required for full physical recovery did not appear to be different. In the patients with vague clinical findings, especially

women of child-bearing age or obese patients, diagnostic laparoscopy may be useful, but based on our findings, we cannot recommend this procedure routinely.

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Discussion

PROFESSOR ALAN G. JOHNSON (Sheffield, England): I would like to congratulate you on doing this trial. A few years ago, we were being told that it was "unethical" to do trials because it was so obvious that the laparoscopic approach was better. I think you put your finger on the reason why patients stayed so long in hospital after perforation—just tradition.

The questions I would like to ask are: Who decided when the patients went home? Was it the doctors, the nurses, or the patients? Did they know which operation was being done? Nurses, for example, may determine the outcome by telling patients who are having the "new" operation that they can go home the next day but those having the "old" operation should stay for 9 days. Time in hospital is strongly influenced by patients' expectations and the instructions they are given.

We have just finished a similar trial of open small incision *versus* laparoscopic cholecystectomy. To eliminate the psychological influence, we "blinded" the patients, the surgeons and the nurses, beforehand, by randomizing in the operating room. Afterward, we "blinded" the nurses and patients to which operation had been done by covering the abdomen with identical dressings. We told the patients that they could eat, get out of bed and go home as soon as they felt like it. We found no difference between the two groups in hospital stay (the median postoperative being 2 nights for each) or time back to full activity but the laparoscopic operation took longer in the operating room. From our experience, I would endorse your results and conclusion. The apparent benefits of the laparoscopic approach for appendicectomy and cholecystectomy are mainly due to old-fashioned attitudes after open surgery.

DR. CAROL SCOTT-CONNER (Jackson): Laparoscopic appendectomy has gained acceptance more slowly than laparoscopic cholecystectomy, perhaps because the advantages are much less clear-cut over the open procedure. Dr. Sheffield has pre-