

# Intra-abdominal Abscess After Laparoscopic Appendectomy for Perforated Appendicitis

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**Hypothesis:** The incidence of postoperative intra-abdominal abscess is higher after laparoscopic compared with open appendectomy for perforated appendicitis.

**Methods:** A historical cohort study of pediatric patients operated on for suspected appendicitis by open appendectomy or laparoscopic appendectomy compares the incidence of postoperative intra-abdominal abscess for each procedure.

**Setting:** A tertiary care center.

**Patients:** Five hundred thirty-eight pediatric patients were operated on for suspected appendicitis at our institution between 1974 and 1999. Of these, 453 were included in the study. Of the excluded patients, 9 had incomplete medical records, 69 had normal or interval appendectomies, and 7 had appendixes removed by methods other than laparoscopy or right lower quadrant incision.

**Interventions:** Open appendectomy performed through a right lower quadrant incision or laparoscopic appendectomy performed through a 3-trocar approach by 1 of 3 pediatric surgeons at our institution.

**Main Outcome Measure:** The incidence of postoperative intra-abdominal abscess after laparoscopic vs open appendectomy.

**Results:** In perforated appendicitis (170 patients), the incidence of postoperative abscess after laparoscopic appendectomy was 24% vs 4.2% after open appendectomy. The relative risk ratio of developing a postoperative abscess after perforated appendicitis was 5.6 (confidence interval, 2.1-16.0) after laparoscopic vs open appendectomy. The results remained significant when controlled for age, sex, intraoperative irrigation, and preoperative antibiotics. Postoperative abscess in all acute, gangrenous, and perforated appendicitis after laparoscopic appendectomy was 6.4% vs 3.0% after open appendectomy. This was not statistically significant.

**Conclusion:** There is a significant increase in the incidence of postoperative intra-abdominal abscess with perforated appendicitis after laparoscopic compared with open appendectomy in pediatric patients.

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Prior to the advent of laparoscopy, appendectomies were performed as an open technique with excellent outcomes.<sup>1</sup> While other laparoscopic procedures such as cholecystectomy have shown a benefit over the open technique, the benefit of laparoscopic appendectomy has not been demonstrated as clearly. There have been many prospective randomized controlled trials in the adult population comparing laparoscopic appendectomy with open appendectomy. Two meta-analyses of these trials have found lower wound infection rates, faster recovery, and less postoperative pain with the laparoscopic approach.<sup>2-7</sup> Other studies have found no difference in these outcomes.<sup>8-10</sup> More recently, the literature has suggested an increased rate of postoperative intra-abdominal abscesses in perforated appendi-

citis using the laparoscopic technique.<sup>11-13</sup> Because of this finding, it is important to determine whether infectious complications are more frequent in the laparoscopic appendectomy compared with open appendectomy in the treatment of acute, gangrenous, or perforated appendicitis in children.

Since 1992, Maine Medical Center (Portland) has performed laparoscopic appendectomies in pediatric patients for all types of appendicitis and this method is currently our preferred approach. Prior to 1987 our rate of postoperative intra-abdominal abscess was 1.4%,<sup>14</sup> and recently that rate has increased. Thus, we undertook this retrospective study of our pediatric population to compare rates of postoperative intra-abdominal abscess and wound infection in patients who underwent laparoscopic appendectomy with those who underwent open appendectomy at our institution since 1974.

## METHODS

The medical records of 538 consecutive pediatric patients who underwent appendectomy from 1974 to 1999 at Maine Medical Center were retrospectively reviewed. Three pediatric surgeons and associated house staff had performed the operations. Information obtained from the records included patient age, sex, type of appendicitis, antibiotic use, procedure performed, and occurrence of postoperative intra-abdominal abscess and wound infection. Eighty-five patients were excluded from the study for the following reasons: 9 patients had incomplete records, 69 patients had a normal appendix or an interval appendectomy, and 7 patients had their appendixes removed by a method other than laparoscopy or standard right lower quadrant incision.

Open appendectomy was performed through a right lower quadrant muscle-splitting incision. The appendix was tied at the base and then divided. The stump was inverted with a purse-string suture. Laparoscopic appendectomy was performed using a Veress needle for insufflation and then a standard 3-trocar technique. The appendix was divided at the base using an endoscopic stapling device or tied at the base and then divided. It was then removed from the abdomen in a plastic bag through the umbilical port.

The type of appendicitis was determined by the surgeon at the time of operation. The appendicitis was considered acute if the appendix appeared inflamed without necrotic tissue and was considered gangrenous if areas of tissue necrosis were present but there was no evidence of perforation. If free rupture of intraluminal contents was found, the appendicitis was considered perforated.

If the patient was thought to have a perforated appendix preoperatively by history, physical, and laboratory

findings, antibiotic treatment was begun immediately. Otherwise it was started intraoperatively when the appendix was found to be gangrenous or perforated. Antibiotics were continued 5 to 7 days postoperatively or until the patient was afebrile and the white blood cell count returned to normal. The parenteral antibiotic management regimen included ampicillin sodium (200 mg/kg per day), gentamicin sulfate (6 mg/kg per day), and clindamycin phosphate (40 mg/kg per day). Patients who were allergic to penicillin received vancomycin (40 mg/kg per day) instead of ampicillin. Prior to 1990, the incision of a patient who underwent open appendectomy for gangrenous or perforated appendicitis was left open and packed with povidone iodine gauze. On postoperative day 5, the dressing was removed and the skin was approximated with Steri-Strips (3M, St Paul, Minn). After 1990, most of the open appendectomy incisions were closed. All wounds in the laparoscopic appendectomy group were closed regardless of the type of appendicitis.

Statistical analysis was performed using Stata (version 5, StataCorp, College Station, Tex). After the exclusions described above, the frequency of infectious complications after open and laparoscopic appendectomy were evaluated for each type of appendicitis using a  $\chi^2$  test or the Fisher exact test as appropriate. Point estimates for the risk ratio and 95% confidence intervals (CIs) were reported. Risk ratios for which the CI included 1 were not considered statistically significant. Logistic regression modeling was also used to assess the possible confounding effects of age, sex, use of preoperative antibiotics, and use of intraoperative irrigation on the occurrence of postoperative abscess after operation for perforated appendicitis. Analyses were repeated including the cases that had been converted from the laparoscopic to the open technique in one group or the other.

## RESULTS

We retrospectively analyzed 453 patients operated on for appendicitis at our institution between 1974 and November 1999. One hundred forty appendectomies were performed using the laparoscopic method and 302 were performed using the open method. Eleven patients underwent conversion from laparoscopic to open appendectomy: 1 for acute appendicitis, 4 for gangrenous appendicitis, and 6 for perforated appendicitis. Statistical analysis of the converted group did not alter the significance of the outcome. No complications occurred in the converted group and they were not included in the remainder of the study.

Of the 140 laparoscopic appendectomies performed, 90 (64%) were for acute appendicitis, 21 (15%) were for gangrenous appendicitis, and 29 (21%) were for perforated appendicitis. Of the 302 open appendectomies performed, 118 (39%) were for acute appendicitis, 43 (14%) were for gangrenous appendicitis, and 141 (47%) were for perforated appendicitis (**Table 1**).

The overall incidence of postoperative wound infection was 2.8% in the laparoscopic appendectomy group and 1.6% in the open appendectomy group. The wound infection rate for laparoscopic appendectomy was 4.4% for acute appendicitis, 0% for gangrenous appendicitis, and 0% for perforated appendicitis. The wound infection rate in open appendectomy was 1.7% for acute ap-

pendicitis, 0% for gangrenous appendicitis, and 2.1% for perforated appendicitis. The difference in wound infection rates between laparoscopic and open appendectomy was not significant when comparing acute, gangrenous, and perforated appendicitis (**Table 2**).

The complication rate for postoperative intra-abdominal abscess following laparoscopic appendectomy was 6.4% and following open appendectomy was 3.0%. The risk ratio of 2.2 (CI, 0.9-5.3) was not significant. The postoperative intra-abdominal abscess rate for laparoscopic appendectomy was 2.2% in acute appendicitis, 0% in gangrenous appendicitis, and 24% in perforated appendicitis. The postoperative intra-abdominal abscess formation rate for open appendectomy was 2.5% for acute appendicitis, 0% for gangrenous appendicitis, and 4.2% for perforated appendicitis. The difference in postoperative intra-abdominal abscess was statistically significant only for perforated appendicitis (risk ratio, 5.6; CI, 2.1-16.0 for laparoscopic appendectomy compared with open appendectomy) (**Table 3**).

## COMMENT

Our study compares the complication rates in laparoscopic vs open appendectomy for acute, gangrenous, and perforated appendicitis. No statistically significant difference was found in wound infection rates for any type

**Table 1. Appendectomy Method Performed for Each Type of Appendicitis\***

Method	Type of Appendicitis			Total
	Acute	Gangrenous	Perforated	
Converted	1	4	6	11
Open	118	43	141	302
Laparoscopic	90	21	29	140

\*Data are given as number of operations performed.

**Table 2. Wound Infection Rate by Appendectomy Method and Type of Appendicitis\***

Method	Type of Appendicitis			All
	Acute	Gangrenous	Perforated	
Laparoscopic, No. (%)	4 (4.4)	0	0	4 (2.9)
Open, No. (%)	2 (1.7)	0	3 (2.1)	5 (1.7)
Risk ratio (CI)	2.6 (0.49-14.0)	...	...	1.7 (0.47-6.3)

\*CI indicates confidence interval; ellipses, not applicable.

of appendicitis. Postoperative intra-abdominal abscess rates after perforated appendicitis were much higher (24% in the laparoscopic appendectomy group compared with 4.2% the open appendectomy group). There was no difference in postoperative intra-abdominal abscess rates for acute or gangrenous appendicitis.

There have been several recent reports in the literature showing an increase in postoperative intra-abdominal abscess for perforated appendicitis using the laparoscopic technique in adults. Frazee and Bohannon<sup>11</sup> published a retrospective analysis of 15 patients with gangrenous appendicitis and 19 patients with perforated appendicitis who underwent laparoscopic appendectomy. They found a 7% rate of postoperative intra-abdominal abscess in the gangrenous group and a 26% rate of postoperative intra-abdominal abscess in the perforated group. These groups were not statistically compared. A prospective randomized study by Bonnani et al<sup>12</sup> found that among adult patients, 2 of 66 patients undergoing open appendectomy for complicated (gangrenous or perforated) appendicitis developed postoperative pelvic abscesses. Three (27%) of 11 patients developed postoperative pelvic abscesses following laparoscopic appendectomy for complicated appendicitis, and 1 patient developed a postoperative hepatic abscess. These were not statistically compared. Tang et al<sup>13</sup> found a postoperative intra-abdominal abscess rate of 11% for perforated appendicitis treated laparoscopically compared with a rate of 3% treated by the open method ( $P > .05$ ). They found no difference in postoperative intra-abdominal abscess rates between open and laparoscopic appendectomy for treatment of gangrenous appendicitis.

The pediatric literature has also had recent emphasis on perforated appendicitis. Horwitz et al<sup>15</sup> performed a retrospective study of 56 children treated for complicated (gangrenous or perforated) appendicitis. Nine percent of the open appendectomy group developed postop-

**Table 3. Postoperative Intra-abdominal Abscess Rate by Appendectomy Method and Type of Appendicitis\***

Method	Type of Appendicitis			All
	Acute	Gangrenous	Perforated	
Laparoscopic, No. (%)	2 (2.2)	0	7 (24)	9 (6.4)
Open, No. (%)	3 (2.5)	0	6 (4.3)	9 (3.0)
Risk ratio (CI)	0.9 (0.15-5.1)	...	5.6 (2.1-16.0)	2.1 (0.86-5.3)

\*CI indicates confidence interval.

erative intra-abdominal abscesses compared with 41% of the laparoscopic appendectomy group ( $P = .01$ ). Paya et al<sup>16</sup> published a prospective study of 75 children with perforated appendicitis. Ten underwent laparoscopic appendectomy and the remainder underwent open appendectomy. There were no postoperative abscesses in the laparoscopic group but 2 (3.1%) of 65 patients who had open appendectomies developed postoperative intra-abdominal abscesses. There was no statistical analysis. A study of 1500 pediatric laparoscopic appendectomies by Steyaert et al<sup>17</sup> found that 14 (5.8%) of 240 patients with peritonitis developed postoperative intra-abdominal abscess. They support the use of laparoscopic appendectomy in children, but feel that the incidence of residual intra-abdominal abscess is controversial.

The ability of our study to identify differences in the wound infection rate is poor because of the difference in the management of the wound in the open technique. Until recently, the incision in open appendectomies for gangrenous and perforated appendicitis was left open and packed with povidone-iodine gauze, thereby eliminating the possibility of wound infection. The wounds in the laparoscopic group were all closed. It is interesting to note that in the laparoscopic cases, all of the wound infections occurred in the acute appendicitis group at the umbilical trocar site. The reason for these infections is not clear, since the appendix is removed through the umbilical incision in a plastic bag.

There are several possible reasons for the increased incidence of postoperative intra-abdominal abscess in laparoscopic appendectomy when the appendix is perforated. The infected contents may spread throughout the abdominal cavity during pneumoperitoneum. One would expect that the location of abscesses would be throughout the abdomen, but most of the abscesses we studied for both methods of appendectomy occurred in the right lower quadrant. Another possibility is that with the open technique, the appendix is usually divided outside the abdominal cavity and the stump is inverted after division, possibly decreasing the incidence of intraperitoneal contamination. However, dissection and division of the appendix take place within the peritoneal cavity in the laparoscopic appendectomy.

Our study shows a statistically significant increase in the rate of postoperative intra-abdominal abscess following laparoscopic appendectomy in pediatric patients with perforated appendicitis. There was no difference between methods in postoperative intra-abdominal abscesses in acute or gangrenous cases. Our findings, along with others pre-

viously published, suggest caution in the use of laparoscopy for perforated appendicitis. This study also indicates a need for a prospective randomized controlled trial of open vs laparoscopic appendectomy in the pediatric population that specifically addresses perforated appendicitis, since a large percentage of these patients have perforated appendixes at the time of intervention.

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## DISCUSSION

Craig Lillehei, MD, Boston, Mass: It is certainly quite fitting in this New England surgical year of historical focus that we begin our clinical discussion with appendicitis—an old friend of all of us who practice general surgery. It was after all a New England pathologist, Dr Reginald Fitz, who was widely credited with clarifying the nature of this disease in 1886. Despite this awareness dating back over 100 years, appendicitis is a disease with which we continue to struggle, refining and reevaluating both our diagnostic and therapeutic strategies.

Laparoscopy has clearly proven to be a useful tool in our surgical armamentarium, and it has been particularly helpful in evaluating those patients with abdominal pain of unclear etiology. Furthermore, laparoscopy has been purported to offer the advantages of smaller incisions, less postoperative pain, and more rapid recovery. I might add that these advantages are less clear in children for whom small open incisions can frequently be utilized. Recently, debate has focused on the utility of laparoscopic appendectomy for perforated appendicitis. Experience in both adults

and children has suggested a higher risk of intra-abdominal abscesses following laparoscopic management of perforated appendicitis. The 2 preceding articles offer very different views.

Dr Krisher and her colleagues at the Maine Medical Center report a retrospective review of more than 500 children operated on within the last 25 years. In 1992, they began performing laparoscopic appendectomies and since that time it has become their preferred approach. However, they noted an alarming rate of intra-abdominal abscesses when laparoscopy was used for patients with perforated appendicitis—27%.

This finding is certainly troublesome but one must recognize the limitations of their study. It is a retrospective review largely based on historical controls. One wonders to what extent management, that is, antibiotic treatment, length of stay, etc, has changed during that 25-year interval. Furthermore, this review incorporates whatever learning curve there might have been when laparoscopic appendectomy was introduced. And finally, it is not clear that the open and laparoscopic groups are comparable. Despite similarities in age and gender, etc, 47% of their open appendectomies were for perforated appendicitis compared with only 21% of their laparoscopic cases. Recognizing these limitations, the authors actually suggested a prospective study.

Dr Oka and his colleagues at Hasbro Children's Hospital offer us a prospective randomized study incorporating over 250 children during a recent 14-month interval. They noted the rates of complications in both the open and the laparoscopic groups were quite similar, amounting to about 10% to 12%, but the numbers in their study are relatively small. The total number of children with perforated appendicitis was 60 or 70, and the specific complication of intra-abdominal abscess was seen in 3 of 18 laparoscopic cases, which was a 16% incidence, compared with 3 of 43 open cases, a 7% incidence. Although this difference is certainly not statistically significant, one wonders whether there might indeed be a trend. It is also interesting to see that the operative times were similar in both laparoscopic and open cases, since many are concerned that laparoscopy might prolong the operations. However, it is curious that the length of stay was similar in the open and the laparoscopic approaches, since one potential advantage of the laparoscopic approach is decreased length of stay. Laparoscopic cases requiring conversion to an open approach and no interval appendectomies were described. Was percutaneous drainage of an established appendiceal abscess ever utilized? Selective use of drains was mentioned, and it would be interesting to know how often.

Finally, open and laparoscopic appendectomy can be used safely for children with appendicitis. Is there room for selective application of the open and laparoscopic techniques?

Dr Krisher: The analysis of our study is right. There are limitations, given that it is a retrospective study and that it has a historical component, with laparoscopic appendectomies not being performed until 1992. The only change in our management of open appendectomy during some of that time period after 1990 was that some of the appendectomy wounds were closed for gangrenous and perforated appendicitis, but the incidence of abdominal abscess was not related to whether the wounds were closed or not. The antibiotics remained the same and antibiotic courses remained the same.

The difference in our use of laparoscopy, primarily using the open appendectomy for perforated appendicitis or gangrenous appendicitis as opposed to the laparoscopic method, is due to the fact that when we first instituted the use of laparoscopy at our institution, more of the people who were thought to have complicated appendicitis received open appendectomies. As time has progressed, we have transitioned to performing laparoscopy on the majority of our patients that present with appendicitis. Dr Browne first started using laparoscopy and then Dr Curci and Dr Dibbins started to use it.