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Identification of Preoperative Risk Factors Associated With the Conversion of Laparoscopic to Open Appendectomies

Natasha Gupta, David Machado-Aranda, Keturah Bennett, Vijay K Mittal

Department of Surgery, Providence Hospital and Medical Centers, Southfield, Michigan, USA and

Department of Surgery, Providence Park Hospital, Novi, Michigan, USA

Our goals were to (1) identify risk factors associated with conversion from laparoscopic to open appendectomies and (2) establish criteria that predict the possibility of conversion to an open technique. We did a retrospective chart review of all patients who underwent laparoscopic appendectomies during a 5-year period (2004–2008). Preoperative risk factors, intraoperative findings, and postoperative complications were compared. We found that of 763 patients who had undergone laparoscopic appendectomy, 44 patients were converted to open technique (conversion rate of 5.8%). For these 44 patients, the male to female ratio was 2 to 1, and the men were older (45 versus 37 years of age, $P < 0.001$). Conversion rates decreased with time (8.7% in 2004 versus 3.5% in 2008). Past surgical history was insignificant. However, a duration of symptoms of >5 days as well as a white blood cell count >20,000 were found to have a direct correlation. Incidence of postoperative complications did not increase in converted patients. The conversion rate is highest in male patients above 45 years of age, with over 5 days' duration of symptoms, leukocytosis >20,000, and ruptured appendicitis on computed tomography scan. The presence of 3 to 4 of these risk factors should lower the threshold for consideration of conversion to open appendectomy.

Key words: Conversion – Open appendectomy – Risk factors – Appendectomy – Laparoscopic

Laparoscopic appendectomy has gained acceptance over the last few years as a standard approach to acute appendicitis.[1,2] There have been several randomized trials and meta-analyses to compare the advantages and disadvantages of the laparoscopic versus conventional open technique.[3–6]

Reprint requests: Natasha Gupta, MD, 1618 S Washtenaw Ave, Unit 1, Chicago, IL 60608.
Tel.: 248 464 0451; E-mail: docnatasha3@gmail.com

In contrast to laparoscopic cholecystectomy, neither appendectomy technique has yet shown definitive superiority.[7,8]

Through different trials,[3,4,6,9–11] proponents of the laparoscopic procedure have demonstrated a faster recovery time, shorter hospital stay, better cosmesis, better long-term quality of life, and lower wound infection rate. On the other hand, the open appendectomy is already considered a minimally invasive technique, with a shorter operative time and lower cost than the laparoscopic technique.[12,13] No significant difference has been found in regards to mortality or severe postoperative complications with either technique.[14]

The majority of the time, the decision to perform either approach is based on the experience and subjective judgment of the surgeon. Since neither approach has proven to be superior, objective criteria that could assist in the decision-making process should be studied. Our aim is to identify any preoperative risk factors that could prevent an unnecessary conversion from laparoscopic to open appendectomy.

Materials and Methods

A retrospective analysis was performed of 764 patients who underwent an emergent laparoscopic or attempted laparoscopic appendectomy at either of 2 community-based teaching hospitals, during a 5-year period spanning January 2004 to December 2008. A total of 1230 patients underwent appendectomies. Of the 764 that were laparoscopic procedures, 44 were converted to an open technique (CA group), and 720 successfully completed a laparoscopic procedure (LO group). All other patients screened had an open procedure (428) or went for differed management (laparoscopic interval appendectomy; 38) and were excluded from our analysis (Fig. 1). Analysis was performed comparing the CA group to the LO group.

All computerized data on these patients had been de-identified prior to collection. Their preoperative risk factors, intraoperative findings, and postoperative complications were compiled, including patient demographics, white blood cell (WBC) count at initial presentation, duration of symptoms prior to admission, computed tomography (CT) scan findings, and previous abdominal surgery history. Pathology reports were also reviewed for all the 764 patients, and we reported the incidence of pathologically negative appendix specimens, excluding open approach and interval appendectomies. The Institutional Review Board at Providence Hospital and Medical Centers, and its affiliate Hospital Providence Park, gave approval and verified de-identification and patient privacy protection.

For continuous values, the Mann-Whitney U test was employed to analyze the differences between the laparoscopic group and laparoscopic converted to open groups. Parametric data is presented as mean $\pm$ SEM. Nonparametric data is presented as percentages of each study group. Variables underwent analysis using a one-tailed Fisher exact test, and a value of $P < 0.05$ was considered significant. A force entry logistic regression was used for multivariate analysis. These calculations were performed using SPSS 17.0 statistical software (IBM Corp, Somers, New York).

Results

Out of the 1230 patients that underwent appendectomies, 764 were laparoscopic procedures, of which 44 were converted to an open technique. The remaining 466 patients either had an open procedure (428) or interval laparoscopic appendectomy (38), or were excluded from analysis. The choice of operation technique was based on the surgeon's judgment and experience and was influenced by the more recent trend in performing laparoscopic appendectomies. At the beginning of our study period (2004), 50.7% of all cases were started with a laparoscopic approach. However, by the end of our study period (2008), this percentage had increased to 71.8% (Fig. 2). The overall conversion rate in our study was 5.8% of all cases initiated laparoscopically, and a gradual decrease was observed toward the end of the study period (Fig. 3).

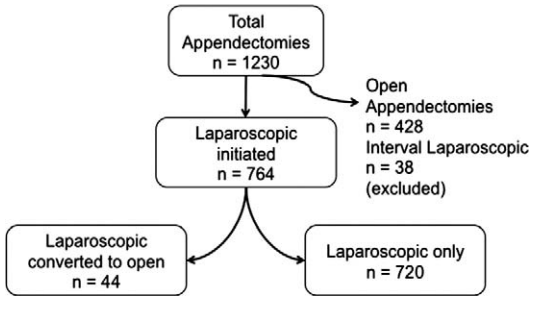

Fig. 1 Overall schematic of study population from two community-based teaching hospitals from 2004 to 2008.

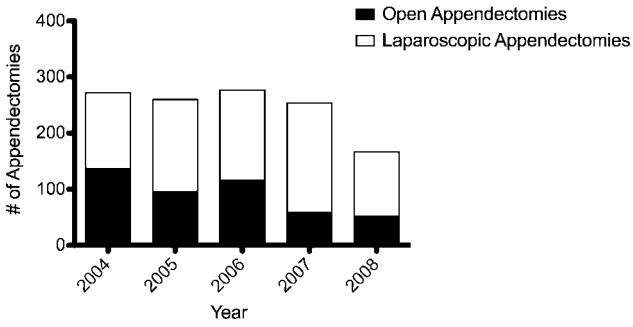

Fig. 2 Use of different techniques for appendectomy from 2004 to 2008.

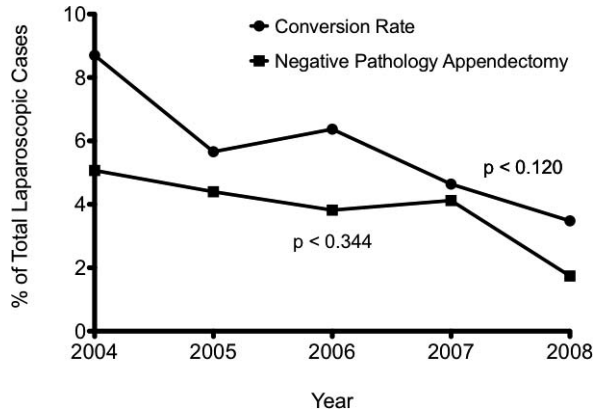

Fig. 3 Conversion rate of open to laparoscopic appendectomy and pathologic negative appendectomies among all laparoscopic cases during duration of study period (2004–2008).

Risk factors for conversion of laparoscopic to open appendectomies

Patients who belonged to the CA group were observed to be older (45.6 ± 2.69 years) compared with the LO group (37.11 ± 0.59 years). This difference was statistically significant ($P < 0.01$). A higher proportion of men (male to female ratio 2 to 1) was also seen in the CA group. A total of 367 men and 397 women underwent laparoscopic procedures, out of which 29 men and 15 women were converted to an open technique. The rate of conversion progressively increased with the duration of symptoms. The majority of the patients presented with a duration of symptoms of less than 24 hours, and at that time point very few of them were converted to open. A large proportion of people that presented with more than 5 days of symptom duration were converted to open. This difference only seemed to become statistically significant when a 48-hour threshold was considered.

No direct correlation was seen between the WBC count and the conversion rate. However, a trend toward higher conversion (9.43% versus 4.63%) was seen when a WBC >20,000 was noted at initial presentation. The highest rate of negative appendices was also present in patients with a normal WBC count of 4000 to 11,000 (10.53% of 764 cases).

Several CT scan findings, such as ruptured appendicitis (22.5%) and phlegmons (12.5%), could be associated with a converted operation. A history of abdominal surgery did not impact the overall rate of conversion. Of the risk factors mentioned above, only an age >45 years, duration of symptoms >48 hours, abnormal (ruptured/phlegmon) CT scan findings, and male gender were considered significant (Table 1). However, when multivariate analysis was applied, only age and duration of symptoms over 48 hours were predictive of conversion (Table 2).

Intraoperative findings

Of the 44 patients for which a decision was made to convert to open, gross findings that would increase technical difficulty were present in 26 cases (as noted in the operative note by the surgeon) and included phlegmon, ruptured appendix, adhesions, peritonitis, abscess, and other pathology. This was found to be highly significant ($P < 0.001$) compared to the laparoscopic-only (LO) group [odds ratio (OR): 8.367; 95% confidence interval (CI): 4.432–15.80].

Postoperative complications

The overall complication rate for all cases was 4.9% (38/764). The frequency of complications postappendectomy was doubled [CA: 9% (4/44) versus LO: 4.7% (34/720)] when the laparoscopic procedure was converted to open (OR: 2.929; 95% CI: 1.075–7.976), a finding that is moderately significant ($P < 0.05$). Postoperative abscess formation was the most frequent complication noted with both laparoscopic and converted cases.

Negative appendectomies

Of the 44 patients that required open conversion from a laparoscopic procedure, only one patient had a diagnosis divergent from acute appendicitis (ruptured ovarian cyst with serositis). Of the 720 LO appendectomies, 10 had normal appendices

Table 1 Univariate analysis by Fisher exact test of risk factors for conversion from laparoscopic appendectomy

Risk factors	Definition threshold	Conversion rate	*P* value	OR (CI: 95%)
Abnormal CT findings	Abscess, phlegmon, rupture	9/44 versus 31/636 (17.0% versus 4.6%)	0.001	4.196 (1.881–9.363)
Age	>45 y	23/254 versus 21/509 (9.1% versus 4.1%)	0.006	2.314 (1.255–4.266)
Symptoms duration	>48 h	13/125 versus 21/554 (10.4% versus 3.8%)	0.012	2.890 (1.312–6.339)
Gender	Male	29/366 versus 15/397 (3.8% versus 7.9%)	0.011	2.191 (1.155–4.416)
WBC count	>20,000	5/57 versus 33/657 (8.8% versus 5.0%)	0.178	1.818 (0.681–4.855)
Previous abdominal surgery	Yes	6/150 versus 30/522 (3.8% versus 5.4%)	0.285	0.696 (0.284–1.704)

reported on pathology. We also performed a separate analysis of patients who underwent interval laparoscopic appendectomies, and not surprisingly, 34 of the 38 cases had a normal appendix. Fig. 3 shows the trend of negative appendices over our study period.

Discussion

The introduction of laparoscopic appendectomies as a way to treat acute appendicitis has been fairly recent.[2] Laparoscopic surgery may have considerable advantages over traditional open techniques in other areas, such as in the case of cholecystectomies. However, the distinct advantages that laparoscopic appendectomies have over open appendectomies—such as less postoperative pain, shortened hospital stay, faster recovery to work, and lower wound infection rates—are balanced out by longer operating times, more complex instrumentation or setup, and increased technical skills, which can translate to a higher cost.[14]

In order to maximize the efficient use of available laparoscopic resources for the best outcomes, a screening process should be applied allowing from the beginning for the identification of patients that should be selected for a conventional open technique, thus avoiding the unnecessary and costly conversion from laparoscopic to open while in the operating room.[1,14]

The great majority of reports examine direct head-to-head comparisons of laparoscopic versus open techniques. The present study was designed to evaluate the differences between laparoscopic and converted appendectomies (CA). Our institutional experience reflects the overall changing trend in treatment of acute appendicitis.[1,15] We have collected over 5 years' worth of data, including over 1200 patients from two community-based teaching hospitals. The overall conversion rate averaged 5.8% annually. At the beginning of the study, the conversion rate was 8.7%, but it tapered to 3.5% toward the end. We believe that several factors could have played a role in this trend, including a better selection of patients assigned directly to open technique, better diagnostic resolution given by CT scans, and an improved learning curve of surgical staff. Possibly for these same reasons, a similar trend could be observed for the rate of pathological negative appendectomies during our study period. A great proportion of patients was seen by the resident staff service with different levels of experience, but this does not seem to have impacted the conversion rate (data not shown).

To identify if there were any elements in clinical presentation that would have predicted the conversion from laparoscopic appendectomy to open appendectomy, we looked retrospectively at patient charts. We found that a disproportionate number of patients had a combination of risk factors—including age over 45, being of the male sex, symptom duration over 2 days, a WBC count over 20,000, and CT scan findings showing a ruptured appendix or phlegmonous inflammatory reaction—that seem to be predictive of abnormal intraoperative findings that prolong the laparoscopic surgery or force the need to convert to open. Whenever a CT scan showed a normal appendix, the frequency of negative appendectomy was quite high. Surprisingly, the presence of an abdominal surgery history or the designation of emergency versus elective interval case had no impact in the conversion rate. This is in accordance with previous findings by Wu *et al*[16], which concluded that prior abdominal surgery had no significant impact on laparoscopic appendecto-

Table 2 Multivariate analysis by force logistic regression of risk factors for conversion from laparoscopic appendectomy

Risk factors	*P* value	OR (CI: 95%)
Age >45 y	0.006	2.737 (1.336–5.608)
Symptoms duration >48 h	0.025	3.059 (1.153–8.114)
WBC > 20,000	0.080	2.508 (0.894–7.034)
Gender (male)	0.104	1.872 (0.878–3.991)
Abnormal CT findings	0.169	2.181 (0.717–6.631)
Previous abdominal surgery	0.534	0.736 (0.281–1.932)

my outcomes, especially when a Hasson open technique was employed.

We recognize several limitations in our study that could have influenced our findings. First of all, this is a retrospective, 2-institution review of cases, and thus is highly dependent on the quality of information contained in the medical chart. For example, not all operative notes were highly descriptive in their narrative, possibly limiting exploration of the surgical thought process. Conversely, we might find that an enriched and detailed operative note could be subject to selection bias—as the surgeon justifies the decision to convert to open, this in turn induces differences in management that could influence outcomes (such as selection of antibiotics). Secondly, the original intention of our study was only to review the conversion rate in laparoscopic cases. However, different findings could be derived by comparing this data to the open appendectomy group. It would be interesting to see if risk factors, as identified in this study, were excessively present in this group (open appendectomy) and were already leading the surgeon to favor an open technique. Prospective studies are currently ongoing in our institution to address these interesting questions. In addition, further studies should focus on analyzing cost and resource utilization among these different study groups.

We found that postoperative complications were statistically higher in the conversion group (9%) than in the LO group (4.7%). By comparison, the complication rate for open appendectomies is reported to be 2.5% to 25%.[1,17–19] Such variation highlights the problematic lack of consensus in definitions of postoperative complications in this literature. Unfortunately, randomized clinical trials have been poorly designed or insufficiently powered to show clinical relevant differences in terms of complications among surgical techniques.[20] Intra-abdominal abscesses were our most important complication after surgery. The pathophysiology of intra-abdominal abscesses is still unclear and controversial. While some may advocate that the pneumoperitoneum may have an effect in bacterial translocation, others may point out that open appendectomy may have a limited view to aspirate spillage and achieve adequate source control.[20] These considerations should be especially important in the context of an acutely ill surgical population with low physiologic reserve, which may not be able to tolerate any significant intra-abdominal infection or complication. Based on our data, the surgeon may initiate open appendectomy or aim to have a low threshold of conversion if our aforementioned risk factors are present. This in turn could decrease operative time and start necessary postoperative measures in anticipation of possible complications (*e.g.*, adequate selection of antibiotics).

The surgeon at present has two equally effective techniques to treat acute appendicitis. Lacking still are specific criteria that would allow an objective decision for the particular technique that should be used. We believe that this study is an adequate initial step into establishing those criteria.

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