



## Operative Findings Are a Better Predictor of Resource Utilization in Pediatric Appendicitis



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### ABSTRACT

**Purpose:** Post-operative management following appendectomy is dependent upon intraoperative assessment. We determined concordance between surgical and histopathologic diagnosis to better predict resource utilization in pediatric patients undergoing appendectomy.

**Methods:** A retrospective analysis of 326 patients with operative appendicitis from July 2012 to July 2013 was performed. Based on operative findings, patients were classified as simple appendicitis (SA) or complex appendicitis (CA).

**Results:** The SA group included 194 (59.5%) patients while the CA group included 132 (40.5%) patients. There were significant differences in WBC, CRP, operative time, length of stay, and 30-day complications. Seventy percent of patients with intra-operative findings of SA were found to have complex pathology while 10.6% with intra-operative findings of CA were found to have simple pathology. There is poor agreement between intra-operative findings and histopathologic findings ( $\kappa = 0.173$ ). Although 70% of patients with intra-operative findings of SA were labeled as complex pathology, 86% followed a fast track protocol (same day discharge) with a low complication rate (1.7%).

**Conclusions:** Pathology findings that overestimate the severity of disease correlate poorly with the post-operative outcomes for appendicitis. We conclude that operative findings are more predictive of clinical course than histopathologic results. This can have an impact on resource utilization planning.

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It has been generally accepted that appendicitis is a progressive disease that starts with appendiceal obstruction and inflammation, ultimately leading to necrosis and perforation [1–3]. This concept is the foundation for the surgical management of appendicitis. Post-operative management following appendectomy is dependent upon intra-operative determination of the degree of appendicitis [2,4,5]. While there are reports in the literature that have attempted to define the varying degrees of appendicitis [2,6–8], there remains no generalized agreement for intra-operative classification of the disease. This subsequently results in a number of differing treatment and management pathways among institutions, ultimately affecting hospital resource utilization.

Acute appendicitis and perforated appendicitis are generally less difficult diagnoses to make intra-operatively, and their post-operative management and course tend to be more predictable. Patients with acute or simple appendicitis are found to have inflammation and erythema of the appendix without further spread of infection. Our group has shown that patients with acute appendicitis may be safely

discharged the day of surgery. The introduction of a fast track pathway has led to a decrease in the use of inpatient resources resulting in a savings of more than \$750,000 over one year in our institution [9]. Patients with perforated or complex appendicitis are noted to have either a hole in the appendix, diffuse peritonitis, or an appendiceal abscess. These patients require inpatient admission for intravenous antibiotic treatment as they present with a more advanced disease process. Therefore, intra-operative assessment and prediction of the severity of appendicitis has the potential to impact clinical pathways.

The definition and diagnosis of suppurative and gangrenous appendicitis, however, remains controversial. While some institutions include gangrenous appendicitis in the complicated appendicitis group [7], others have argued the lower incidence of complications seen with gangrenous appendicitis should prompt its classification into the simple appendicitis category [2,6]. We have found in our institutional analysis that patients with suppurative appendicitis have complication rates higher than that of acute appendicitis. Our institutional classification includes suppurative and gangrenous appendicitis in the complicated group as these patients are treated with admission and intravenous antibiotics post-operatively, similar to those found to have perforated appendicitis. Again, this definition of simple or complicated appendicitis ultimately dictates the patient's post-operative management.

Without defined intra-operative definitions of the severity of appendicitis, appropriate treatment protocols and outcome measures may be misleading. This may be especially evident when histopathologic

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findings differ from those made on gross inspection in the operating room. The variability in treatment may lead to over treatment or under treatment of these patients which ultimately affects outcomes such as infection rates, hospital length of stay, treatment cost, antibiotic selection, and length of treatment. Our aim was to determine concordance between surgical findings and histopathologic diagnosis to better predict resource utilization in pediatric patients undergoing appendectomy.

## 1. Material and methods

After Institutional Review Board approval (IRB # 13–0601), a retrospective analysis of a prospectively collected database of 326 patients who underwent appendectomy at a free-standing, tertiary children's hospital from July 2012 to July 2013 was performed. One of four attending pediatric surgeons performed all appendectomies on a rotating basis determined by call schedule with the aid of a pediatric surgery fellow or mid-level provider. All patients received preoperative antibiotics. Appendectomy was performed by an open, multi-port laparoscopic, or single-incision laparoscopic technique based on surgeon preference. Pre-operative, peri-operative, and post-operative care are standardized at our institution regardless of the operative technique utilized for appendectomy.

Patients were grouped into simple appendicitis (SA) and complex appendicitis (CA) based on intra-operative findings determined by the attending surgeon. The decision to separate intra-operative findings into two groups (simple versus complex) was based on the post-operative management for simple and complex appendicitis designations at our institution. The classification of appendicitis is based on strict intra-operative findings regardless of pre-operative factors. Simple appendicitis was characterized by inflammation and erythema limited to the appendix. These patients follow a fast track protocol and are discharged from the post anesthesia recovery unit once strict criteria are met without further antibiotic treatment. Our fast track protocol for patients undergoing appendectomy for acute appendicitis has been previously described [9]. Complex appendicitis included suppurative, gangrenous, and perforated appendicitis as these intra-operative findings are managed similarly post-operatively. Patients found to have complex appendicitis are admitted to the inpatient unit for further treatment with intravenous antibiotics. They are subsequently discharged once criteria are met. This includes remaining afebrile for 24 hours, tolerating a regular diet, maintaining adequate pain control, and exhibiting a decrease in white blood cell count or C - reactive protein when appropriate.

Histopathologic diagnosis was determined for each patient. Appendix specimens are typically processed by pathology within 24 hours from receipt of the specimen. Those received by 1600 hours on weekdays are processed the same day, while specimens with incidental findings may take up to 48 hours. Simple appendicitis constituted pathologic findings of acute appendicitis, subacute appendicitis, or lymphoid hyperplasia. Histologically, this finding includes the presence of inflammatory infiltrate which permeates the smooth muscle wall and extends into the serosa and surrounding periappendiceal fibrofatty tissue. Complex appendicitis constituted pathologic findings of suppurative, gangrenous, or perforated appendicitis. Histologically, this finding is represented by necrosis of the wall with inflammation and ulceration of the mucosa and often the presence of crypt abscesses or microabscesses, extensive mucosal necrosis, and perforation. Histopathologic diagnosis was then compared to the degree of appendicitis determined by the surgeon intra-operatively.

Demographic data was obtained on age, weight, gender, category of appendicitis, surgical procedure utilized, and time of arrival to our emergency center (EC). Quality and outcome measures including time from EC diagnosis to operating room arrival, post-operative length of stay, and 30-day complications were analyzed. Descriptive data is reported as mean  $\pm$  standard deviation and range where appropriate. Statistical analysis was performed using Student's t-test for continuous

variables, Fisher's exact test for categorical variables, and the concordance correlation coefficient (Kappa) for comparison of agreement between operative findings and histologic diagnosis. Statistical significance was set at  $p < 0.05$ .

As this data was prospectively collected and retrospectively reviewed, this allowed for strict monitoring of complications among the study cohort both prospectively during collection and retrospectively with electronic medical record review. Complications that were considered included intra-abdominal abscess, surgical site infection, post-operative ileus or obstruction, and any re-admissions within 30 days. There were two complications in the SA group that were excluded as these were felt to be unrelated to the appendectomy. One patient presented with Henoch-Schönlein purpura with hematochezia, nephritis, and *Clostridium difficile* infection five days following surgery and one patient was re-admitted for orthostatic hypotension and headache two weeks following surgery.

## 2. Results

During the study period, a total of 326 patients underwent appendectomy. One hundred ninety four (59.5%) patients were found to have intra-operative findings of simple appendicitis while 132 (40.5%) patients had findings of complex appendicitis. Those in the CA group included 58 patients with suppurative, 22 patients with gangrenous, and 52 patients with perforated appendicitis. Demographic, quality, and outcome measures are described in detail in Table 1. We found no significant difference in age, weight, or gender between the two groups. We noted significant differences between the SA and CA groups for WBC ( $13.9 \pm 4.9$  vs.  $16.5 \pm 4.7$ ,  $p < 0.05$ ), CRP ( $2.7 \pm 3.3$  vs.  $8.3 \pm 8$ ,  $p < 0.05$ ), operative time ( $23.3 \pm 7.7$  vs.  $26.9 \pm 11.8$  minutes,  $p < 0.05$ ), length of stay ( $13.5 \pm 10.8$  vs.  $82 \pm 92.3$  hours,  $p < 0.05$ ) and 30-day complications (3.1% vs. 10.6%,  $p < 0.05$ ).

Complications for the SA group (3.1%) included four surgical site infections treated with outpatient oral antibiotics, one post-operative ileus, and one patient presenting with intra-abdominal hematoma. Complications for the CA group (10.6%) included six intra-abdominal abscesses, four surgical site infections, and four patients with post-operative ileus. When complications were evaluated by degree of appendicitis it was noted that the complication rate for perforated appendicitis was 13.5%, suppurative appendicitis was 10.3%, gangrenous appendicitis was 4.5%, and acute appendicitis was 3.1%. When re-admissions were evaluated by degree of appendicitis it was noted that the re-admission rate for perforated appendicitis was 3.8%, suppurative appendicitis was 1.7%, acute appendicitis was 1%, and gangrenous appendicitis had none. While the complication rate for suppurative appendicitis appears high, the re-admission rate of 1.7% is low, as the majority of these patients presented with uncomplicated surgical site infections that were managed with outpatient antibiotic treatment.

The same analysis was performed based on histopathologic findings (Table 2). Of the 326 patients who underwent appendectomy, 73 (22.4%) were found to have findings of SA, while 253 (77.6%) were found to have findings of CA. Those in the CA group included 154 patients with suppurative appendicitis, 80 with perforated appendicitis, and 19 with gangrenous appendicitis. Again, there was no significant difference in age, weight, or gender between the two groups. We noted significant differences between the SA and CA groups for WBC ( $13.3 \pm 4.7$  vs.  $15.5 \pm 4.9$ ,  $p < 0.05$ ), CRP ( $2.99 \pm 3.9$  vs.  $5.7 \pm 6.9$ ,  $p < 0.05$ ), and length of stay ( $24.7 \pm 28.2$  vs.  $46 \pm 75.2$  hours,  $p < 0.05$ ). Unlike the intra-operative findings group, there was no significant difference in operative time or 30-day complications.

Complications for the SA group (6.8%) included two superficial wound infections, one hematoma, one post-operative ileus, and one fluid collection treated with intravenous antibiotics. Complications for the CA group (5.9%) included six wound infections, five intra-abdominal abscesses, and four ileus. When complications were evaluated by degree of appendicitis it was noted that the complication rate for

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