Original Article

Ideal Timing of Surgery for Acute Uncomplicated Appendicitis

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Abstract

Background: Early surgery for appendicitis is thought to avoid complications associated with appendiceal rupture. **Aims:** This study was to evaluate the effect of timing of surgery on complications, length of stay (LOS) and cost in patients undergoing appendectomy. **Materials and Methods:** Retrospective review of 396 patients with appendectomies from January 1, 2005 to December 31, 2007 was performed. Demographic data, time of presentation, physical findings, diagnostic data, operating room times, LOS, cost and complications were collected. Patients were divided into 4 groups based on time from presentation to appendectomy. **Results:** Pathology confirmed appendicitis in 354 (89%) patients. Most patients (90%) had surgery within 18 h of presentation. Timing of surgery did not affect the incidence of purulent peritonitis ($P = 0.883$), abscess ($P = 0.841$) or perforation ($P = 0.464$). LOS was significantly shorter for patients with emergency department registration to operating room times less than 18 h ($P < 0.0001$). Costs were significantly higher for patients with times to operating room greater than 18 h ($P < 0.001$). **Conclusion:** Timing of surgery did not affect the incidence of complications or perforated appendicitis. However, delay in surgical consultation and surgery are associated with increased LOS and increased hospital costs. The optimal timing of appendectomy for uncomplicated acute appendicitis appears to be within 18 h of emergency department presentation.

Keywords: Appendectomy, Delayed surgery, Hospital costs, Length of stay

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Introduction

Historically, acute appendicitis has been considered a condition that required urgent surgical treatment. From Fitz's historic description of acute appendicitis in the 1800's to the late 20th century, the notion that this disease constituted a surgical emergency was not questioned.[1] Despite the absence of objective data, it was generally accepted that the best treatment was emergent appendectomy. Studies in children have confirmed that acute appendicitis can be managed with intravenous antibiotics and operated on hours later without increased morbidity or mortality.[2-4] The timing of appendectomy has also been examined in adults, however, no definite conclusion on the timing of surgery.[5-8]

At our hospital, as in many others, there is no standardized approach to the management of acute uncomplicated appendicitis. Our objective was to evaluate the effect of timing of appendectomy on outcomes and cost at our institution.

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Materials and Methods

After obtaining approval from our institutional

review board, a retrospective review of the records of all patients undergoing appendectomy at our community teaching hospital over a two-year period was performed. All patients with an ICD-9 code of 47.01 and 47.09 (appendectomy) from January 1, 2005 to December 31 2007 were included. Patients with incidental appendectomy, those with known perforated appendicitis after full diagnostic workup, and patients undergoing interval appendectomy were excluded.

Patient records were reviewed for demographic data, signs and symptoms, laboratory and imaging results, intraoperative findings, pathology and antibiotic(s) administered. Outpatient records were reviewed for post-operative complications. Length of stay (LOS) and total hospital costs were also analyzed.

Our facility is a teaching hospital with operating rooms available 24 h a day and surgery residents supervised by attending surgeons. Appendectomies were performed by 11 surgeons with 5 surgeons performing 95% of the cases. Patients were initially evaluated by an emergency department physician. Imaging studies (abdominal X-rays, ultrasound or CT-scan) were obtained at the discretion of that physician. A surgical consultation was triggered by a workup suspicious for appendicitis. A laparoscopic approach was attempted with every patient. All patients received antibiotics prior to surgery. Patients with intraoperative findings of appendiceal abscess, perforated or gangrenous appendix were given an extended course of intravenous antibiotics post-operatively.

Time of emergency department registration (EDR), time of surgery consultation and time of skin incision were gathered from patient charts. Patients were then divided into four groups. The first group consisted of patients with appendectomy less than or equal to 6 h after EDR. Group 2 included patients with appendectomy 6-12 h after EDR. Group 3 patients had appendectomy 12-18 h after ED registration. Group 4 patients had appendectomy more than 18 h after EDR.

Statistical analysis

Statistical analyses for differences among the 4 EDR to OR groups were controlled for gender. For analyses of differences in means of continuous variables we used 2-way analysis of variance (time to OR and gender), followed by Tukey's studentized range post-hoc tests to investigate statistically significant results. For analyses of categorical variables with time to OR groups, we used Cochran-Mantel-Haenszel Chi-square tests, stratifying by gender. A P value of <0.05 was considered statistically significant. The data analysis for this paper was generated using SAS software, Version 9.1 of the SAS System for Windows. Copyright, SAS Institute Inc. SAS and all other SAS Institute Inc. product or service names are registered trademarks or trademarks of SAS Institute Inc., Cary, NC, USA.

Results

Three hundred ninety six patients were included in the analysis. Of these, 56% were male. Ninety percent of our patients were Caucasian. The mean age was 36 years (range: 3-86 years). The mean admission white blood cell count (WBC) was 14.7 thousand/mL (range: 4-32 thousand/mL). Eighty-five percent of patients had CT-scans performed, 9% had abdominal X-rays and 8% had pelvic ultrasounds. Time to surgical consult was documented in 87% patients. Ninety-two percent underwent laparoscopic appendectomy. The average operating room time was 82.8 min. Pathology confirmed appendicitis in 89% patients; the remaining 11% of patients had negative appendectomies. Mean hospital stay was 2.3 days and average hospital cost was $15,488.

The majority of our patients (73%) underwent appendectomy within 12 h of EDR (Group 1, ≤6 hrs, $n = 124$; Group 2, 6-12 h, $n = 165$). Sixty nine patients (17%) had surgery 12-18 h after EDR (Group 3) and 38 patients (10%) had their appendectomies more than 18 h after EDR [Table 1].

Four percent of patients had additional abdominal procedures performed. One percent of patients had documented postoperative wound complications and 1% required reoperation. Two (0.5%) patients were pregnant at the time of appendectomy.

The association of demographics and diagnostic presentation with time to surgery is presented in Table 1. Overall, age and gender had no significant relationship to time of surgery. Among males, however, those younger than 50 years were more likely to undergo surgery within 6 h when compared to men over 50 years (38% vs. 23%, $P = 0.04$).

Comorbid conditions were rare in our patient population. There was no significant relationship between their and timing of surgery. Prior abdominal surgery was not statistically different among the four time to OR groups, however, those with prior abdominal surgery were more likely to undergo surgery after 18 h than at 18 h or less (22% vs. 8%, $P = 0.01$). Initial temperature over 100.4 F was significantly associated with timing of surgery for males, with 35% of men with surgery after 18 h of EDR having temperatures over 100.4, compared to 0-8% for the other three groups ($P = 0.001$). Patients with localized abdominal tenderness were more likely to undergo appendectomy earlier than those with diffuse

Table 1: Patient differences by time to OR groups

Patient characteristics	≤6 h *N*=124	6-12 h *N*=165	12-18 h *N*=69	>18 h *N*=38	*P* value[a]
Average time to OR (hours)	4.0	8.6	14.8	26.7	
Age ≥50 (%)	23	26	33	29	
Female	35	28	26	35	0.747
Male	16	25	41	22	0.043
Mean age (years)	33.3	36.8	38.9	36.6	0.38
Male (%)	61	56	49	47	0.334
Prior abdominal surgery (%)	8	7	9	21	0.100
Mean temperature (°F)	98.7	98.5	98.4	99.1	0.0032
Temp >100.4°F (%)	8	5	3	19	
Female	8	3	6	5	0.614
Male	8	7	0	35	<0.001
Mean WBC (count)	15.0	14.7	15.2	12.3	0.02
WBC ≤10 (%)	19	13	10	39	0.001
Localized abdominal tenderness (%)	89	85	81	74	0.164
Abdominal ultrasound (%)	9	7	9	8	0.879
Abdominal X-ray (%)	3	12	13	13	0.031
CT-scan performed (%)	65	92	97	100	<.001
Positive CT-scan (%)[b]	80	89	85	66	0.005
Average time to surgical consult (hours)	1.5	3.8	4.0	7.4	<.0001
Comorbidities (%)	10	9	17	24	0.081

[a]*P* values based on 2-way analysis of variance for continuous variables, Cochran-Mantel-Haenszel Chi-square tests stratified on gender for overall tables of categorical variables, and Pearson Chi-square tests for gender-specific tables of categorical variables, [b]CT scans only performed in 336 patients, 154 females and 182 males

abdominal tenderness, although this association was not statistically significant.

Average WBC was significantly different for the 4 groups ($P = 0.02$). Post-hoc tests indicated significantly lower WBC for those operated on after 18 h than for any other time group ($P < 0.05$). Surgery performed 18 h or more after EDR occurred more frequently among those with a normal WBC of 10,000/mL or less than those with higher WBC (39% for those with at least 18 h to surgery vs. 10-19% for the other three groups, $P < 0.001$). Performance of KUBs was less common among those that had surgery within 6 h of EDR ($P = 0.031$).

There was a statistically significant relationship between positive initial CT-scan diagnosis of appendicitis and time to surgery. CT scans were performed for 336 patients. Surgery was more likely to be delayed past 18 h in patients with negative CT scans compared to patients found to have CT findings consistent with appendicitis (34% in Group 4 vs. 11-20% in Groups 1-3; $P < 0.001$). The overall sensitivity of our CT-scans in diagnosing acute appendicitis as confirmed by pathology was 87.1% with a specificity of 50.0%.

Table 2 shows different outcome measures by the time to OR groups. A laparoscopic procedure was more common in male patients operated on within 18 h of EDR ($P = 0.003$). There was no difference in rates of laparoscopy by time to OR in females ($P = 0.675$). While the average operating room time was longer for those operated in the later time to OR groups this difference is of no statistical or clinical significance. While negative appendectomy rates were higher among men undergoing surgery after 18 h (33% vs. 3-15% for the other three groups, $P = 0.001$), there was no association between timing of surgery and negative appendectomy in women. Rates of purulent appendicitis, perforation, peritonitis, and surgical wound complications were not associated with timing of surgery [Table 2].

Average LOS was significantly different for the 4 groups ($P < 0.0001$) with significantly longer average LOS for patients operated after 18 h (4.0 days) when compared to patients operated on ≤6 and 6-12 h from EDR (1.92 days and 2.07 days respectively, $P < 0.01$) and compared to patients operated on at 12-18 h after EDR (2.49 days, $P < 0.05$). Similarly, hospital costs differed significantly for the four groups at $P < 0.0001$). Patients with time to surgery greater than 18 h had significantly higher average hospital costs ($19,374) than those operated on ≤6 and 6-12 h from EDR at $P < 0.01$ and those operated on 12-18 h after EDR at $P < 0.05$ ($14,076, $15,414 and $16,061 respectively) [Table 2, Figure 1].

Discussion

From Fitz's historic description of acute appendicitis in the 1800's to the late 20th century, the notion that this disease constituted a surgical emergency was not questioned.[1] Despite the absence of objective data, it was generally accepted that the best treatment was emergent appendectomy. In the last two decades, debates have emerged over the diagnosis and management of acute appendicitis. As Meeks points out in a recent review of the current controversies on appendicitis, little level 1 evidence exists on any aspects of this debate.[8]

Our study focuses on delays in time to surgical

Table 2: Outcomes by time to OR groups

Patient outcomes	≤6 h *N*=124	6-12 h *N*=165	12-18 h *N*=69	>18 h *N*=38	*P* value[a]
Laparoscopic appendectomy (%)	92	95	93	79	
Female	92	94	97	90	0.675
Male	92	95	88	67	0.003
Average OR time (min)	82.2	80.8	86.8	86.6	0.21
Pathology-confirmed appendicitis (%)	86	93	93	79	
Female	88	89	89	90	0.994
Male	85	96	97	67	<0.001
Wound complications (%)	1	0	3	0	0.115
Purulent appendicitis (%)	14	16	12	13	0.883
Peritonitis (%)	0	1	1	0	0.565
Abscess (%)	11	12	7	11	0.841
Perforation (%)	15	13	7	16	0.464
Additional procedures (%)	3	4	3	5	0.934
Average length of stay (Days)	1.9	2.1	2.5	4.0	<0.0001
Average hospital cost ($)	14,076	15,414	16,061	19,374	<0.0001

[a]*P* values based on 2-way analysis of variance for continuous variables, Cochran-Mantel-Haenszel Chi-square tests stratified on gender for overall tables of categorical variables, and Pearson Chi-square tests for gender-specific tables of categorical variables

consultation and surgery; however, there are several other factors also responsible for these delays including delays in presentation and diagnosis.[5,8-12] Given the difficulty in controlling for and documenting onset and duration of symptoms prior to presentation, we used time of EDR as our starting point. Like many emergency departments in the United States, patients may experience delays in our emergency department waiting room prior to being registered and seen by a physician.

Several studies have confirmed that patients who have appendectomy performed on a non-emergent basis are not at higher risk of complications, perforation or lengthened hospital stay. Abou-Nukta's study of 309 patients showed that delaying appendectomy by 12-24 h after presentation did not significantly increase the rate of perforations, operative times, or LOS.[7] Partelli, *et al*. found in a prospective study that changing operative priorities to delay surgery in uncomplicated appendicitis until normal business hours did not affect outcomes.[13] Papziagas also found in his study that there was no increase in complications if patients were operated on within 24 h.[14]

Similar results have been found in studies of children with appendicitis. Surana reported no statistically significant difference in the complication rate between children who underwent appendectomy within 6 h of diagnosis when compared with those operated on 6-18 h after diagnosis.[2] In Yardeni's study, he showed that delaying appendectomies by 6-24 h in children did not cause an increase in perforations, operative times or complications when compared with children operated on within 6 h.[4]

There are, however, also multiple studies which show that delaying appendectomy is associated with an increased risk of advanced pathology and post-operative complications. Ditilo's review of over 1,000 patients with acute appendicitis concluded that delaying appendectomy was unsafe due to adverse intraoperative findings and increased complication rates. In fact, the risk of advanced pathology was found to be increased 13-fold when time from symptom onset to appendectomy was greater than 71 h.[6] However, Ditilo only included patients with pathology-confirmed appendicitis. In separate studies, Von Titte and Chung studied delays at various stages of the appendicitis workup. Von Titte reported that the incidence of perforation increased when appendectomy was delayed by 72 h or more while Chung found a significant relationship between ED physician delays and post-operative complications.[11,15]

Our study suggests that the optimal timing of surgery in acute uncomplicated appendicitis is within 18 h of EDR. In addition, optimal timing of surgical consultation appears to be within 6 h of EDR. Within these time frames, the probability of a successful laparoscopic procedure is higher and both LOS and hospital costs are lower.[16-18] Delays beyond 18 h do not appear to increase the incidence of surgical site infections or other complications, but are costly and increase the patient's LOS. It is unclear why there was delay in surgery for patients in this group (Group 4) of patients. This is likely a multifactorial issue. One reason may be that these patients did not present with the "classic" story for appendicitis, requiring a more extensive workup before the emergency room physician felt the need to consult the surgical team, thus increasing the EDR to OR time.[19-22] The time of the patient's arrival to the ED may have played a role, although this aspect was

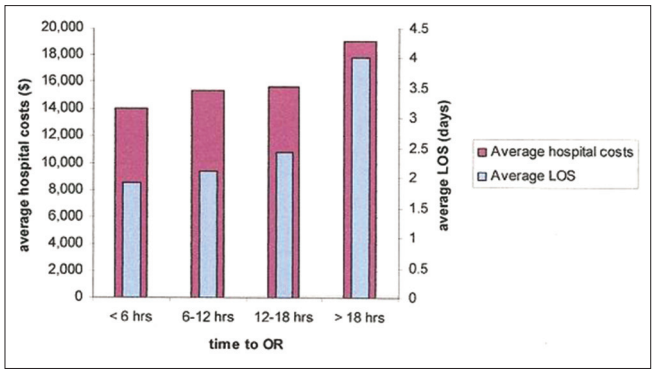

Figure 1: Average hospital costs and length of stay

not examined in our study. If a patient presents late at night in our institution with appendicitis, their surgery is often held over to the next day while they are treated with antibiotics.

The increase in hospital stay may be due to waiting until the following business day to operate on a patient who presented in the middle of the night with acute appendicitis. In our institution, as in many others, these "add-on" cases must usually wait until all the elective surgeries of the day have been completed. This typically leads to a late afternoon or early evening appendectomy. The patient then cannot be discharged, at the earliest, until the next morning.

The major limitations of our study are its retrospective design and the predominantly white demographic of our local population which may not be representative of larger medical centers. Another limitation is that the diagnostic workup of patients presenting to our emergency department with abdominal pain was at the discretion of the emergency department physician. While in some cases a surgical consult was requested based on clinical findings alone, some patients had a positive abdominal imaging study prior to surgical consult.

Our findings are especially relevant in the current era of healthcare reform and the need to properly manage limited medical resources. While we do not advocate delays in appendectomy for uncomplicated acute appendicitis, we propose it is not necessary to mobilize the entire surgical staff in the middle of the night since appendectomy may be performed safely and economically within 18 h of emergency department presentation

Conclusion

Timing of surgery does not affect the incidence of complications or adverse intraoperative findings. Delays in surgical consultation and surgery are associated with increased lengths of stay and increased hospital costs. We have shown that delay in appendectomy is safe but does increase total hospital costs. The optimal timing of appendectomy for uncomplicated acute appendicitis appears to be within 18 h of emergency department presentation.

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