Effects of Delaying Appendectomy for Acute Appendicitis for 12 to 24 Hours

Fadi Abou-Nukta, MD; Charles Bakhos, MD; Kervin Arroyo, MD; Young Koo, DDS; Jeremiah Martin, MD; Randolph Reinhold, MD; Kenneth Ciardiello, MD

Objective: To determine whether delaying appendectomy for 12 hours to avoid disturbing the operating room schedule and to minimize the number of operations during the night negatively affects the outcome of patients with acute appendicitis.

Design: Retrospective study.

Setting: Large teaching community hospital.

Patients: The medical records of 380 patients who underwent appendectomies between January 1, 2002, and December 31, 2004, were reviewed. Patients proven to have an inflamed appendix on the pathological report were divided into 2 groups. The early group comprised patients who had undergone appendectomies within 12 hours of presentation to the emergency department, including patients with generalized sepsis. The late group comprised patients who had undergone appendectomies more than 12 to 24 hours after presentation.

Main Outcome Measures: Length of stay, operative time, and the rate of perforations and complications.

Interventions: Laparoscopic or open appendectomies.

Results: There were 309 patients included in our study. There were no statistically significant differences between the early and late groups in the length of stay, operative time, the percentage of advanced appendicitis, or the rate of complications.

Conclusions: In selected patients, delaying appendectomies for acute appendicitis for 12 to 24 hours after presentation does not significantly increase the rate of perforations, operative time, or length of stay. It decreases the use of the nursing staff, anesthesia team, and surgical house staff during the night shifts, and it decreases the interruption of the regular operating room schedule.

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APPENDECTOMY FOR ACUTE appendicitis is the most common nonelective procedure performed by general surgeons. It has generally been accepted that an appendectomy should be performed within a few hours of diagnosis and that a delay in the operation may lead to an increase in the morbidity. Recent articles on the negative impact of sleep deprivation on clinical performance suggest the value of limiting operations and procedures during the night and early morning hours to absolute emergencies. In this study, we assess whether appendectomy for acute appendicitis can be safely delayed for 12 to 24 hours to be performed during the day shift.

Between January 1, 2002, and December 31, 2004, 380 appendectomies were performed in our hospital. We included patients who underwent appendectomies after a preoperative diagnosis of acute appendicitis that was confirmed by pathological examination. We excluded patients who were younger than 18 years, patients who underwent negative appendectomies, incidental appendectomies, or interval appendectomies, and patients who had errors or delays of more than 24 hours in the diagnosis (Table 1).

Patients included in the study were divided into 2 groups. The early group comprised patients who underwent appendectomies within 12 hours after presentation to the emergency department. The late group comprised patients who underwent appendectomies between 12 and 24 hours after presentation. There were several reasons for the delay in the operation: the time between admission to the emergency department and surgical consultation, the lack of operating room availability, a delay in the diagnosis owing to an atypical presentation, and the surgeon’s decision to delay the surgical procedure. Oral intake was stopped for patients in both groups. Intrave-
nous hydration using crystalloid fluids and intravenous antibiotics were administered at the time of diagnosis. The medical records of patients from both groups were compared for age, white blood cell counts, and temperature on presentation as well as length of stay, operative time, and pathological diagnosis. We differentiated between nonadvanced appendicitis and advanced appendicitis (gangrenous or perforated). The rate of complications was also recorded.

Our hospital is a teaching community hospital with residents of all levels on call in house and supervised by attending surgeons who are either in house or on call. At all times, our operating rooms are staffed and readily available for emergency operations.

The t test and Fisher exact test were used to analyze the statistical difference between the 2 groups. We calculated a sample size of 152 patients in each group to detect an increase of 10% in the rate of advanced appendicitis, with a power of 80%. A P value of less than .05 was considered significant.

### RESULTS

Three hundred nine patients were included in the study. There were 165 men and 144 women. The average age was 40 years (age range, 18-90 years). There were 233 patients in the early group and 76 patients in the late group. The mean ± SD time between presenting to the emergency department and surgery was 6.7 ± 2.7 hours for the early group and 16.7 ± 3.6 hours for the late group. Both groups were comparable with respect to age, sex, white blood cell count, and temperature (Table 2).

There were no statistically significant differences between the 2 groups in the length of stay (P = .17), operative time (P = .93 for laparoscopic surgery; P = .14 for open surgery), rate of advanced appendicitis (P = .56), and complication rate (P = .74) (Table 3).

In reviewing the time of presentation to the emergency department and the time of operation, 54% of patients were admitted to the emergency department during the day hours (7 AM–7 PM) vs 46% during the evening and night hours (7 PM–7 AM). This percentage was slightly reversed when noting the time of operation: 57% during the evening and night hours vs 43% during the day hours.

### COMMENT

Acute appendicitis, the term we use today and the pathological abnormality we understand in the 21st century, is attributed to Reginald H. Fitz, the Shattuck Professor of Pathological Anatomy from Harvard University, Boston, Mass, who presented a paper in 1886 describing the natural history and progression of the disease. He also recognized the vital importance of early diagnosis and immediate surgical intervention.

The adoption of his conclusions by surgeons in North America in the following 15 years led to a decrease in the mortality of acute appendicitis from 50% to 15%. Today, appendectomy for acute appendicitis is the most common nonelective surgical procedure performed in the Western world. It is typically done within hours of diagnosis to prevent the complications of gangrene and perforation. However, medicine and surgery have witnessed tremendous improvements in the last few decades, with dramatic improvement in the quality of antibiotics. The use of antibiotics has become standard in the treatment of surgical infections, changing what otherwise would have needed an emergent operation to that with the option of an elective operation. The last 2 decades have also seen historic improvement in the quality of radiological studies available. Computed tomographic scans and ultrasonography are readily available in most US hospitals, and we are more able today than ever in the past to achieve a more accurate preoperative diagnosis of several surgical entities, including appendicitis.

One of the most prominent changes that marked the last few years has been the emphasis on the potential nega-

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**Table 1. Exclusion Criteria**

<table>
<thead>
<tr>
<th>Exclusion Criteria</th>
<th>Early Group (n = 233)</th>
<th>Late Group (n = 76)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age &lt; 18 years</td>
<td>3 (1)</td>
<td>1 (1)</td>
<td>.30</td>
</tr>
<tr>
<td>Negative appendectomy</td>
<td>122 (52)</td>
<td>21 (28)</td>
<td>.17</td>
</tr>
<tr>
<td>Incidental appendectomy</td>
<td>58 (25)</td>
<td>55 (73)</td>
<td>.14</td>
</tr>
<tr>
<td>Interval appendectomy</td>
<td>15 (6)</td>
<td>1 (1)</td>
<td>.74</td>
</tr>
<tr>
<td>Error or delay &gt; 24 h in the diagnosis</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 2. Comparisons in Age, Sex, White Blood Cell Count, and Temperature**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Early Group (n = 233)</th>
<th>Late Group (n = 76)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, mean ± SD, y</td>
<td>41.0 ± 16.9</td>
<td>39.6 ± 15.9</td>
<td>.85</td>
</tr>
<tr>
<td>Sex, No.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>129</td>
<td>36</td>
<td>.20</td>
</tr>
<tr>
<td>Female</td>
<td>104</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>WBC count, mean ± SD, µL</td>
<td>13.6 ± 3.9</td>
<td>14.1 ± 3.8</td>
<td>.30</td>
</tr>
<tr>
<td>Temperature, mean ± SD, °C</td>
<td>37.3 ± 0.5</td>
<td>37.4 ± 0.6</td>
<td>.78</td>
</tr>
</tbody>
</table>

**Table 3. Endpoints Between the Early and Late Groups**

<table>
<thead>
<tr>
<th>End point</th>
<th>Early Group (n = 233)</th>
<th>Late Group (n = 76)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time to surgery, mean ± SD, h</td>
<td>6.7 ± 2.7</td>
<td>16.7 ± 3.6</td>
<td>NA</td>
</tr>
<tr>
<td>Length of stay, mean ± SD, d</td>
<td>2.5 ± 2.3</td>
<td>2.9 ± 1.8</td>
<td>.17</td>
</tr>
<tr>
<td>Advanced appendicitis, No. (%)</td>
<td>75 (32)</td>
<td>28 (37)</td>
<td>.56</td>
</tr>
<tr>
<td>Operative time, mean ± SD, min</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laparoscopic surgery</td>
<td>81.0 ± 31.0</td>
<td>81.5 ± 31.0</td>
<td>.93</td>
</tr>
<tr>
<td>Open surgery</td>
<td>77.0 ± 31.0</td>
<td>86.0 ± 33.0</td>
<td>.14</td>
</tr>
<tr>
<td>Complications, No. (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abscess</td>
<td>6 (2)</td>
<td>1 (1)</td>
<td>.74</td>
</tr>
<tr>
<td>Wound infection</td>
<td>2 (&lt;1)</td>
<td>1 (1)</td>
<td></td>
</tr>
</tbody>
</table>

Abbreviation: WBC, white blood cell.

*Early group indicates patients who underwent surgical procedures less than 12 hours after presentation to the emergency department. Late group indicates patients who underwent surgical procedures between 12 and 24 hours after presentation to the emergency department.

Abbreviation: NA, not applicable.

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tive impact of prolonged work hours for residents.5,6 Several studies have shown the negative effects of sleep deprivation on clinical performance, mood, and cognitive abilities.11 These changes suggest the need to limit operations and procedures performed during the night hours to absolute emergencies that cannot be safely delayed until the morning hours, when a well-rested surgeon and surgical team are available.

Surana et al14 studied the effects of delaying an appendectomy for acute appendicitis. They found no statistical difference in the rate of complications between children who underwent appendectomies within 6 hours of diagnosis and those who underwent appendectomies between 6 and 18 hours of diagnosis (2.3% vs 4.2%, respectively; P = .28). A similar study by Yardeni et al2 on the effects of delaying appendectomies by 6 to 24 hours in children showed no significant increase in the rate perforation, operative time, or complications when compared with children who underwent the appendectomies within 6 hours. Furthermore, some studies suggest that the rate of perforation is due to a delay in patient presentation rather than to a delay in treatment.12,13 In our study, the early and late groups had similar clinical outcomes. The late group had a slightly longer length of stay than the early group (2.9 days vs 2.5 days, respectively), but that included the average delay of 10 hours (0.4 day). The difference in the rate of advanced appendicitis was not statistically significant in the late group compared with the early group (37% vs 32%, respectively). Both groups had a similar rate of complications, including intra-abdominal abscesses and wound infections ranging from less than 1% to 2%.

Our study was underpowered when considering an increase of 10% in the rate of advanced appendicitis. However, on a post hoc analysis, our sample sizes were enough to detect an increase of 10% in the rate of complications, with a study power of 80%.

An approach to the treatment of acute appendicitis that includes the early administration of intravenous antibiotics and fluid hydration followed by the performance of appendectomy during the day hours does not increase the rate of complications, and it does not significantly increase the length of stay or rate of advanced appendicitis. In addition, this practice pattern decreases the effects of delaying appendectomies by 6 to 24 hours in children showed no significant increase in the rate perforation, operative time, or complications when compared with children who underwent the appendectomies within 6 hours. Furthermore, some studies suggest that the rate of perforation is due to a delay in patient presentation rather than to a delay in treatment.12,13 In our study, the early and late groups had similar clinical outcomes. The late group had a slightly longer length of stay than the early group (2.9 days vs 2.5 days, respectively), but that included the average delay of 10 hours (0.4 day). The difference in the rate of advanced appendicitis was not statistically significant in the late group compared with the early group (37% vs 32%, respectively). Both groups had a similar rate of complications, including intra-abdominal abscesses and wound infections ranging from less than 1% to 2%.

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shame on you. I am concerned that the publication of this material in the proceedings of this distinguished surgical society sends a very wrong message that was alluded to by the previous questioner.

**Dr Abou-Nukta:** I'm sorry that you were disturbed, but I assure you, nothing was personal. The title of my paper is merely a question. Asking questions is the basis for starting any scientific project. This is not the first paper to ask this. In 1993, Surana published a paper in the *British Medical Journal* which had the same idea. They compared 6 hours vs 6 to 18 hours and found no increase in the rate of complications. Yardeni published a paper in the *Journal of Pediatric Surgery* in 2004 which asked the same question with a very similar title. I disagree with you that the primary reason appendectomy is an emergent operation is to relieve pain and suffering. If that is the case, then we should perform emergency cholecystectomies on patients with acute cholecystitis. Now, about the pain and suffering. In 2000, I was diagnosed with appendicitis in the middle of the night. The surgeon was called. They told him the results of the CT [computed tomography] scan and it was now 2 o'clock in the morning, and they said that the surgeon would be here first thing in the morning to do your appendectomy. I said, “Okay, can I have some morphine and go to sleep?” The day after, I woke up and I was taken to surgery. I don't think it prolonged my pain and suffering, and I'm glad that it actually did not increase my risk of complications.

**Orlando Kirton, MD, Hartford, Conn:** To follow up on the first 2 discussants, looking at what is written in our meeting booklet, it says:

**Objective:** To determine if delaying appendectomy for 12 hours to avoid disturbing the operating room schedule and to minimize the number of operations during the night negatively affects the outcome of patients with acute appendicitis.

Seventy-seven percent of your patient cohort actually had their operation early and the remainder late. Was this due to unavailable OR time or unavailable surgeon?

My second observation which would have helped us was if all the patients had an abnormal CAT [computed axial tomography] scan. You alluded that CAT scans have changed your overall approach to the diagnosis of appendicitis. If that was the case, you can better triage which patients you may want to delay vs not. Did every patient in this review receive a CAT scan?

**Dr Abou-Nukta:** The reason in the delay was, first of all, we chose T0 as the time of admission to a room in the emergency department, so sometimes it is a few hours before the surgeon is called because the emergency department attending sees the patient first, gets some laboratories, and then a surgeon is called. Some of the other delay was having an OR available, and in only a few cases it had to do with reversal of Coumadin and the patient had to be reversed. Now the thing about the use of CT scans. In my conclusions, I say in selected patients. Actually, I wanted to reiterate that in our conclusion, we say, "in selected patients." We are not saying if someone is having severe pain or in generalized peritonitis or the patient is very ill to delay until the morning. This should be elected in someone who is having right lower-quadrant pain and mildly elevated white count, having some tenderness in the right lower quadrant, with findings of early appendicitis on CT. I think that is a very different decision than in someone with signs of perforation.

**Robert Touloukian, MD, New Haven, Conn:** Simple question. Is this an affirmation for the referring physician to delay referral until the morning?

**Dr Abou-Nukta:** No. It has to be after the patient has been evaluated and the diagnosis is confirmed, then to selectively choose patients to wait until the morning.

**Richard Barth, MD, Hanover, NH:** Did you find that there were any more complications in the patients that were operated on at night?

**Dr Abou-Nukta:** No.

**Dr Barth:** So isn't that one of the reasons why you are trying to avoid surgery at night?

**Dr Abou-Nukta:** Oh, I'm sorry. You meant the patients who had surgery at night?

**Dr Barth:** Yes.

**Dr Abou-Nukta:** No, we didn't look at that. We looked only at the time between the presentation and the surgery, but not who was operated on at night vs who was operated on during the day.

**Dr Barth:** Did you find that surgery at night wasn't safe for these patients?

**Dr Abou-Nukta:** We did not look at the rate of complications in patients operated upon at night vs during the day.

**A. Ronald Grimm, MD, Canaan, NH:** In 1984, I was called in at 2 o'clock in the morning to help someone with an appendectomy. It was a 12-year-old girl. The anesthetist was tired, had a long day, and didn't notice when she stopped breathing and died.