PAPER

# Outcome of Elderly Patients With Appendicitis

## *Effect of Computed Tomography and Laparoscopy*

*Thomas T. Hui, MD; Kevin M. Major, MD; Itzhak Avital, MD; Jonathan R. Hiatt, MD; Daniel R. Margulies, MD*

**Hypothesis:** Elderly patients who have appendicitis have a greater morbidity and mortality rate when compared with younger patients. We hypothesized that recent changes in the diagnosis and management of appendicitis in elderly patients might affect the outcome.

**Design:** Retrospective review.

**Setting:** Large metropolitan teaching hospital.

**Patients:** All patients aged 70 years and older who underwent appendectomy for appendicitis between January 1, 1991, and December 31, 2000, were divided into groups 1 (those treated from January 1, 1991, through December 31, 1995) and 2 (those treated from January 1, 1996, through December 31, 2000).

**Main Outcome Measures:** Age, sex, preoperative evaluation, operative duration and findings, postoperative course, duration of hospital stay, and mortality rate. Continuous and categorical variables were analyzed using $t$ and $\chi^2$ tests, respectively.

**Results:** Ninety-five patients met inclusionary criteria. The mean age (78 years), sex, preoperative suggestion of appendicitis (group 1, 39 [83%] of 47 patients; group 2, 45 [94%] of 48 patients), and duration of the preoperative hospitalization over 24 hours (group 1, 11 patients [23%]; group 2, 9 patients [19%]) were similar in both groups. There was an increasing use of diagnostic computed tomography (group 1, 13 patients [28%]; group 2, 32 patients [67%]; $P<.001$) and laparoscopy (group 1, 14 patients [30%]; group 2, 23 patients [48%]; $P=.02$) between the 2 study periods associated with no significant difference in the duration of hospitalization, frequency of appendiceal perforation or abscess, occurrence of complications, or mortality. The length of operating time increased in the second period (ie, January 1, 1996, through December 31, 2000).

**Conclusions:** Appendicitis in elderly patients continues to be a challenging surgical problem. While computed tomography may represent a useful diagnostic tool and laparoscopic appendectomy may be appropriate therapy for selected patients, neither has affected outcome when measured for morbidity and mortality rates. Overall results might improve with earlier consideration of the diagnosis in elderly patients with abdominal pain, followed by prompt surgical consultation and operation.

*Arch Surg. 2002;137:995-1000*

*From the Departments of Surgery, Trauma Services, Cedars-Sinai Medical Center (Drs Hui, Major, Avital, Hiatt, and Margulies), and University of California, Los Angeles, the UCLA School of Medicine (Dr Margulies), Los Angeles.*

WHILE ACUTE appendicitis is primarily a disease of the younger population, with only 5% to 10% of cases occurring in elderly persons, the incidence of appendicitis in older patients seems to be increasing with an increase in life expectancy.[1,2] Morbidity and mortality rates are greater in older patients who often have delayed and atypical presentations, leading to increased frequency of perforation and intra-abdominal infection.[3] Diagnostic studies may cause further delays in definitive management, and associated illnesses increase operative risks.[1,3]

The past decade has produced 2 major advances in the diagnosis and treatment of appendicitis. Contrast-enhanced computed tomography (CT) has been shown to be both sensitive and specific in diagnosis.[4-6] Laparoscopic appendectomy has been shown in some series to offer more rapid recovery and less postoperative pain compared with the open approach.[7,8] However, these benefits were not demonstrated in all studies and several studies have shown an increased risk of postoperative abscess formation in patients who have perforated appendicitis treated laparoscopically. Laparoscopy has the potential advantage of aiding in diagnosis as well as providing an opportunity for treatment, but it has not been evaluated in older patients. This study was undertaken to evaluate the changes in diag-

**Table 1. Presentation and Preoperative Evaluation***

| Variable | Total (N = 95) | Group 1 (n = 47)† | Group 2 (n = 48)† | *P* Value |
|---|---|---|---|---|
| Age, mean (SD), y | 78 (5.6) | 78 (6.4) | 78 (4.9) | .87 |
| Female | **49** (52) | 23 (49) | 26 (54) | .76 |
| Symptoms >48 h | **52** (55) | 21 (45) | 31 (65) | .08 |
| No. of associated illnesses, mean (SD) | 2.3 (1.4) | 2.5 (1.4) | 2.0 (1.4) | .09 |
| Appendicitis suspected | **70** (73) | 34 (72) | 36 (75) | .95 |
| Type of diagnostic study | | | | |
| Computed tomography | **45** (47) | 13 (28) | 32 (67) | <.001 |
| Contrast enema | **31** (33) | 23 (43) | 8 (17) | .002 |
| Ultrasonography | **16** (17) | 9 (19) | 7 (15) | .75 |
| None | **20** (21) | 14 (30) | 6 (13) | .04 |
| Operated on within 24 h | **75** (79) | 36 (77) | 39 (81) | .82 |

*Data are given as the number (percentage) of elderly patients unless otherwise indicated.

†Patients who were aged 70 years and older and who underwent appendectomy for appendicitis were divided into the following groups: group 1, those treated between January 1, 1991, and December 31, 1995; group 2, those treated between January 1, 1996, and December 31, 2000.

nostic and treatment methods in elderly patients with acute appendicitis over the past decade.

## PATIENTS, MATERIALS, AND METHODS

We reviewed the medical records of elderly patients (aged ≥70 years) who underwent appendectomy for acute appendicitis at Cedars-Sinai Medical Center, Los Angeles, Calif, a large, private teaching hospital, between January 1, 1991, and December 31, 2000. Variables selected for analysis included age, sex, number of associated illnesses, presenting symptoms, diagnostic studies, operative approach, operative findings, need for postoperative admission to the intensive care unit, duration of hospitalization (total and postoperative), and morbidity and mortality rates. The following definitions were used: fever, a temperature higher than 37.8°C; hypothermia, a temperature lower than 35.6°C; leukocytosis, a white blood cell count higher than $10 \times 10^3/\mu L$; and/or leukopenia, a white blood cell count lower than $4 \times 10^3/\mu L$.

Patients were divided into 2 groups for comparison (group 1, those patients admitted to the hospital from January 1, 1991, through December 31, 1995; group 2, those patients admitted to the hospital from January 1, 1996, through December 31, 2000). Further analysis was performed by comparing those patients in whom acute appendicitis was suspected after the initial evaluation with those in whom the diagnosis was unsuspected. Patients undergoing laparoscopy were also compared with those treated with open operation.

Sixty-eight patients (72%) were admitted from the emergency department after evaluation by an emergency medicine physician. The remainder were admitted directly to the hospital by an internist or general surgeon. Operative approach was chosen by the attending surgeon. All patients received parenteral antibiotics preoperatively. Cefotetan disodium was the most common antibiotic used. Antibiotics were administered postoperatively for at least 5 days for patients with perforated appendicitis.

Computed tomographic scanning of the abdomen and pelvis was performed using 1 of 2 scanners (either the Somatom; Siemens Analytical X-Ray Instruments, Madison, Wis, or the LightSpeed; General Electric, Waukesha, Wis). All patients received oral and intravenous contrast-enhanced medium; 92 patients (97%) received rectal contrast-enhanced medium. A technician using an ultrasonograph (model HDI 5000; Advanced Technology Laboratory, Best, the Netherlands) performed abdominal ultrasonography. Computed tomographic scans and sonograms were interpreted by a staff radiologist. Enema studies using contrast media were performed by a staff radiologist using water-soluble contrast material under fluoroscopic guidance.

All data were entered into a relational database program. Statistical analyses were performed using the *t* test for continuous variables and $\chi^2$ test with the Yate correction for categorical variables. $P<.05$ was considered statistically significant.

## RESULTS

During the study period, 95 elderly patients underwent appendectomy for acute appendicitis (**Table 1**). Their mean age was 78 years; the sex distribution was nearly equal.

Associated illness occurred in 71 patients (75%). The average number of associated illnesses was 2.3 per patient and was similar in both groups. Hypertension was present in 42 patients (44%), cardiac disease in 30 patients (32%), diabetes mellitus in 13 patients (14%), chronic obstructive lung disease in 7 patients (7%), renal insufficiency in 3 patients (3%), and myeloma in 1 patient (1%). The mean duration of symptoms was 4 days. More than half of the patients were initially seen with longer than 2 days of symptoms before hospital admission. Symptoms included abdominal pain in 90 patients (95%), nausea in 41 patients (43%), and emesis in 19 patients (20%). Signs included right lower quadrant tenderness in 79 patients (83%), leukocytosis in 68 patients (72%), fever in 29 patients (31%), and leukopenia in 1 patient (1%). No patients had hypothermia. There were no statistically significant differences for any of the presenting signs or symptoms between the 2 groups.

After completion of the medical history and physical examination, appendicitis was suggested in only 70 patients (74%). Admission diagnoses in the 25 patients not initially suspected of having appendicitis included small-bowel obstruction (6 patients); nonspecific abdominal pain (6 patients); diverticulitis (3 patients); cholecystitis (2 patients); chest pain (2 patients); and thigh abscess, incarcerated ventral hernia, incarcerated femoral hernia, gastrointestinal hemorrhage, pneumonia, and multiple myeloma (1 patient each).

Most (75) patients (79%) underwent diagnostic studies. Contrast enema was the most frequent diagnostic test in the first period (ie, January 1, 1991, through December 31, 1995), while CT was most frequent in the second period (ie, January 1, 1996, through December 31, 2000); use of ultrasonography was similar in both periods. Computed tomography was the most sensitive for the diagnosis of acute appendicitis (91% sensitivity), while ultrasonography was the least sensitive (53%). Contrast enema had a sensitivity of 81%. After testing, suspicion of appendicitis increased to 39 patients (83%) in group 1 and 45 (94%) in group 2 ($P=.19$). The time from hospital admission to operation was less than 24 hours in 75 patients (79%) and was not significantly different between the 2 groups.

Operative therapy is summarized in **Table 2**. Use of laparoscopy increased significantly in the second period, and the number of open procedures declined cor-

**Table 2. Operative Approach and Findings***

| Variable | Total (N = 95) | Group 1 (n = 47)† | Group 2 (n = 48)† | *P* Value |
|---|---|---|---|---|
| Attempted laparoscopic appendectomy | **41** (43) | 14 (30) | 27 (48) | .02 |
| Completed laparoscopically | 33 (35) | 12 (26) | 21 (44) | .09 |
| Converted to open approach | 8 (8) | 2 (4) | 6 (13) | .28 |
| Open appendectomy | 54 (57) | 33 (70) | 21 (44) | .02 |
| Duration of operation, min | | | | |
| All patients, mean (SD) | 89 (52.0) | 78 (43.0) | 100 (57.0) | .03 |
| Laparoscopic appendectomy | 93 | 95 | 91 | .83 |
| Converted to open approach | 128 | 125 | 129 | .94 |
| Open appendectomy | 80 | 68 | 99 | .05 |
| Perforated appendicitis | 65 (68) | 32 (68) | 33 (69) | .93 |
| Abscess present at operation | 36 (38) | 19 (40) | 17 (35) | .61 |

*Data are given as the number (percentage) of elderly patients unless otherwise indicated.
†Patients who were aged 70 years and older and who underwent appendectomy for appendicitis were divided into the following groups: group 1, those treated between January 1, 1991, and December 31, 1995; group 2, those treated between January 1, 1996, and December 31, 2000.

respondingly. Despite the more frequent use of laparoscopy, operative durations were longer in group 2. Most cases were found to be perforated at the time of operation in both groups, and abscesses were present in more than one third of the patients.

Duration of total hospitalization (group 1 vs group 2, 8.3 vs 11.0 days, $P=.15$) and postoperative hospitalization (group 1 vs group 2, 7.6 vs 9.4 days, $P=.26$), intensive care unit admission rate (group 1 vs group 2, 26% vs 21%, $P=.76$), morbidity rate (group 1 vs group 2, 28% vs 33%, $P=.71$), and mortality rate (group 1 vs group 2, 2% vs 4%, $P=.51$) were similar in both groups. Seven patients developed surgical complications (wound infection in 4 patients and intra-abdominal abscess in 3 patients). Other complications in 29 patients included ileus and/or small-bowel obstruction in 9 patients, arrhythmias in 6 patients, pneumonia or respiratory tract failure in 5 patients, urinary retention in 3 patients, generalized sepsis in 2 patients, and acute renal failure in 1 patient. The 3 deaths were due to sepsis syndrome in 2 patients and cardiopulmonary arrest in 1 patient.

In 25 (26%) of the 95 patients in this series, appendicitis was not suggested before diagnostic testing (**Table 3**). Abdominal pain was less frequent in these patients; therefore, operations were delayed, intensive care unit admissions were more frequent, durations of total and postoperative hospitalization were prolonged, and mortality was increased. Twenty-one (22%) of the patients underwent at least 1 diagnostic imaging procedure. A CT scan performed in 16 patients (64%) and contrast enema performed in 9 patients (36%) showed appendicitis in 14 patients (87%) and 4 patients (44%), respectively ($P=.04$). Only 5 (20%) of these 25 patients underwent a laparoscopic procedure.

Comparing patients only by operative approach, those who underwent open appendectomy were older (group 1 vs group 2 mean age, 79 vs 76 years, $P=.01$) with a higher rate of perforation (group 1 vs group 2, 76% vs 48%, $P=.02$) and abscess (group 1 vs group 2, 50% vs 15%, $P=.002$), and duration of postoperative hospitalization was longer (group 1 vs group 2, 9.9 vs 5.0 days, $P=.01$). Complication and mortality rates were similar between the open and laparoscopic groups.

**Table 3. Comparison of Patients by Initial Diagnosis***

| | Those With Suspected Appendicitis (n = 70) | Those With Unsuspected Appendicitis (n = 25) | *P* Value |
|---|---|---|---|
| Age, mean (SD), y | 77 (6.0) | 80 (5.0) | .03 |
| Abdominal pain | 70 (100) | 20 (80) | <.001 |
| Diagnostic study | 54 (77) | 21 (84) | .66 |
| Operated on within 24 h | 61 (87) | 9 (36) | <.001 |
| Laparoscopic appendectomy | 28 (40) | 5 (20) | .12 |
| Duration of hospitalization, mean (SD), d | | | |
| Total | 7.6 (5.7) | 15.3 (13.4) | .01 |
| Postoperative | 7.1 (5.8) | 12.4 (10.9) | .03 |
| ICU admission | 11 (16) | 11 (44) | .009 |
| Complications | 18 (26) | 11 (44) | .15 |
| Deaths | 0 | 3 | .02 |

*Data are given as the number (percentage) of elderly patients unless otherwise indicated. ICU indicates intensive care unit.

## COMMENT

This study was performed to evaluate the changes in the management of 95 elderly patients with acute appendicitis following the introduction of CT for diagnosis and laparoscopy for therapy. The presentation of these patients differs from that of younger patients. The classic triad of right lower quadrant pain of short duration, fever, and leukocytosis was infrequently observed, and more than half of the patients presented with symptoms of longer than 2 days' duration. Despite the report of abdominal pain in 90 (95%) of the 95 patients on presentation, the admitting physician suspected appendicitis in only 70 patients (74%) after the patients' provided a medical history and underwent a physical examination. Imaging tests were helpful in establishing the diagnosis, as the suspicion increased to 88% (84 patients) after testing but prior to operation.

The disease process is consistently more advanced in elderly persons. Although most patients underwent operation within 24 hours of hospital admission, the frequency of appendiceal perforation (65 patients [68%])

and intra-abdominal abscess (36 patients [38%]) remained high, similar to observations of other authors.[3] The reasons for delay in presentation may include problems of access to medical care, communication, or fear of hospitalization. Some believe that the physiology differs in the elderly and that the progression to perforation is more rapid owing to decreased lymphoid tissue or blood supply.[9]

The wider application of CT for patients with suspected appendicitis has been shown to improve diagnostic accuracy and decrease the negative appendectomy rate,[4-6] although one study has shown that routine use of CT may lead to delay in definitive management.

In the present series, we observed a clear increase in the use of diagnostic CT in the second study period when compared with the first. While we could not evaluate the specificity of CT in diagnosis of appendicitis, because only patients with acute appendicitis were included, the test had excellent sensitivity. There was only 1 false-negative result, and the scans identified the diagnosis in some patients in whom appendicitis had not been considered likely and confirmed the diagnosis in others.

Appendicitis was unsuspected after initial evaluation in one quarter of our patients, and the delay in correct diagnosis ultimately resulted in delayed operation and prolonged hospitalization. Abdominal pain was present in 76 (80%) of the 95 patients. While the differential diagnosis of abdominal pain in older patients is broad, these data demonstrate that appendicitis should always be considered, and early surgical consultation is advised.

The use of laparoscopic appendectomy also increased in the second study period. The benefit of the laparoscopic approach has not been clearly demonstrated. Several prospective randomized controlled trials have found more rapid recovery and less postoperative pain with the laparoscopic approach,[7,8] while others have not found a difference in these variables.[10-12]

In the present study, more frequent use of laparoscopic appendectomy was associated with an increase in operating time but no statistically significant difference in the duration of the hospitalization or complications. Patients whose appendectomy was completed laparoscopically were younger and less likely to have appendiceal perforation and abscess. The postoperative hospitalization of these patients was shorter, reflecting the selection of less complicated cases for this subgroup. Similar to our previous study of perforated appendicitis in younger patients,[13] no significant increase in the frequency of postoperative abscess was found in the laparoscopic compared with the open approach group.

Comparing the 2 study periods, no significant differences in the interval from presentation to operation, duration of hospitalization, frequency of appendiceal perforation and abscess, postoperative complications, or mortality were observed despite increase use of CT and laparoscopy. This implies that the cost of treating an elderly patient with acute appendicitis has increased without significant outcome improvement. The greatest value of CT is its specificity and its ability to reduce a negative appendectomy rate, which cannot be evaluated in the present series owing to design limitation. This benefit is likely less important in elderly patients because the incidence of acute appendicitis is relatively low. However, CT is much more useful in establishing a diagnosis of appendicitis in patients with atypical presentation if it is ordered in a timely fashion. In the present series, the symptoms of 25 patients were not suggestive of appendicitis after intake of an initial medical history and after undergoing a physical examination. Of these 25 patients, 14 had a CT scan performed demonstrating appendicitis longer than 24 hours after hospital admission.

## CONCLUSIONS

Appendicitis in the elderly continues to be a challenging surgical problem. Patients continued to present late with atypical presentations. The use of CT and laparoscopy has increased significantly but no differences in the frequency of complicated appendicitis, time from the hospital admission to operation, length of hospitalization, and morbidity and mortality rates were observed. Results might improve with earlier consideration of the diagnosis in elderly patients with abdominal pain, followed by prompt surgical consultation and operation.

*This paper was presented at the 73rd Annual Meeting of the Pacific Coast Surgical Association, Las Vegas, Nev, February 16, 2002, and is published after peer review and revision. The discussions are based on the originally submitted manuscript and not the revised manuscript.*

*Corresponding author and reprints: Daniel R. Margulies, MD, Suite 8215, Department of Surgery, Cedars-Sinai Medical Center, 8700 Beverly Blvd, Los Angeles, CA 90048 (e-mail: daniel.margulies@cshs.org).*

## REFERENCES

1. Peltokallio P, Tykka H. Evolution of the age distribution and mortality of acute appendicitis. *Arch Surg.* 1981;116:153-156.
2. Lau WY, Fan ST, Yiu TF, Chu KW, Lee JM. Acute appendicitis in the elderly. *Surg Gynecol Obstet.* 1985;161:157-160.
3. Horattas MC, Guyton DP, Wu D. A reappraisal of appendicitis in the elderly. *Am J Surg.* 1990;160:291-293.
4. Stroman DL, Bayouth CV, Kuhn JA, et al. The role of the computed tomography in the diagnosis of acute appendicitis. *Am J Surg.* 1999;178:485-489.
5. Balthazar EJ, Megibow AJ, Siegel SE, Birnbaum BA. Appendicitis: prospective evaluation with high resolution CT. *Radiology.* 1991;180:21-24.
6. Rao PM, Rhea JT, Novelline RA, Mostafavi AA, McCabe CJ. Effect of computed tomography of the appendix on treatment of patients and use of hospital resources. *N Engl J Med.* 1998;338:141-146.
7. Frazee RC, Roberts JW, Symmonds RE, et al. A prospective randomized trial comparing open versus laparoscopic appendectomy. *Ann Surg.* 1994;219:725-731.
8. Golub R, Siddiqui F, Pohl D. Laparoscopic versus open appendectomy: a metaanalysis. *J Am Coll Surg.* 1998;186:545-553.
9. Freund HR, Rubinstein E. Appendicitis in the aged: is it really different? *Am Surg.* 1984;50:573-576.
10. Fallahzadeh H. Should a laparoscopic appendectomy be done? *Am Surg.* 1998; 64:231-233.
11. Martin LC, Puente I, Sosa JL, et al. Open versus laparoscopic appendectomy: a prospective randomized comparison. *Ann Surg.* 1995;222:256-262.
12. Bonanni F, Reed J III, Hartzell G, et al. Laparoscopic versus conventional appendectomy. *J Am Coll Surg.* 1994;179:273-278.
13. Khalili TM, Hiatt JR, Savar A, Lau C, Phillips EH, Margulies DR. Perforated appendicitis is not a contraindication to laparoscopy. *Am Surg.* 1999;65:965-967.

## DISCUSSION

**Kenneth Waxman, MD, Santa Barbara, Calif:** This interesting study raises important issues. We all hope and believe that we are progressively improving the care that we provide, but we do not often look at this critically. The authors of this study asked whether outcomes of their elderly patients who had appendicitis improved over time. To answer this question, they retrospectively compared 47 elderly patients with appendicitis treated in the first half of the 1990s with 48 patients treated in the second half of the decade.

The authors focused on 2 changes in diagnosis and treatment over this period, CT scanning and laparoscopy. Two thirds (32) of the 48 patients had CT scans in the second half of the decade vs only 13 patients (28%) in the first half. Laparoscopy was also more common in the later period, with 23 (48%) of 48 patients having an attempted laparoscopic approach vs 14 (30%) of the 47 patients in the earlier period.

The results of the study are interesting: there was no improvement in outcome. Specifically, the death rate was not different, the complication rate was not lower, and the duration of hospitalization was not shorter. Therefore, the answer to the authors' question is that there was no improvement in outcome over this period despite increased use of CT and laparoscopic scanning. The authors conclude that neither CT nor laparoscopy improved outcome. In fact, this conclusion is the title of the paper. However, I believe that this conclusion may be invalid, because of the design of the study.

This study is retrospective, and the results must be interpreted carefully because of this. Any outcome difference or lack of difference may be a result of CT or laparoscopy, because there may well have been other changes in treatment that occurred over this period, and these other treatments may have independently affected outcome. For example, was the emergency department busier, resulting in longer time delays? Did more patients in the later period have managed care insurance, and might their insurance status have resulted in delays in treatment? It is theoretically possible that CT and laparoscopy were in fact helpful, but this benefit was offset by other changes. This possibility cannot be excluded from this retrospective study design.

In fact, data from this study regarding both CT and laparoscopy suggest possible benefit. Computed tomography correctly diagnosed appendicitis in 86 (91%) of of the 95 cases, with only 2 false-negative results (2%). In contrast, ultrasound was nearly useless, with only 53% (9/17) diagnostic accuracy, and 29% (5/17) false-negative results. Contrast enema fell in between these extremes. We do not have data from this study regarding how many patients with suspected appendicitis had other diagnoses made on CT such as diverticulitis or cancer. (This is an additional value of CT, not addressed by this study.)

Laparoscopy was attempted in 41 patients and could be completed in 33. Successful laparoscopic procedures were associated with shorter hospitalizations, although this may well have been influenced by the severity of disease. There were no differences in complications, suggesting that these complications were a result of underlying disease rather than operative approach.

As in previous studies of appendicitis in the elderly, the diagnosis of appendicitis in this series was late. Over half the patients had symptoms for longer than 48 hours. In fact, delays in presentation tended to increase over the second half of the decade. Over two thirds of the patients had perforation at the time of operation, and an abscess was present in almost 19 patients (40%). Fifteen (31%) of the 48 patients had complications and 1 patient (3%) died. Hospitalization averaged almost 10 days. From my perspective, the major problem with caring for these patients was their late presentation and their advanced appendicitis at the time of treatment. These issues did not improve over time.

I have 3 questions for the authors: First, did the frequency of patients with managed care insurance increase during this study period? Could their insurance plans have affected treatment? Second, has this review influenced your practice; that is, do you now do fewer CT scans or less laparoscopy? Finally, what can you recommend to us and to your own medical community to effect earlier diagnosis and treatment, as these seem to be the critical factors related to outcome?

**Joshua D. I. Ellenhorn, MD, Duarte, Calif:** With the greater advent of the use of CT scanning, there may have been diagnosis of appendicitis in patients in the later years of your study who might have just died septic deaths without ever having a diagnosis of appendicitis had they presented in earlier years. Is the absence of that denominator hiding an actual benefit to CT scanning?

**John T. Owings, MD, Sacramento, Calif:** I enjoyed this study very much. Whenever you ascribe no difference between 2 groups after a statistical analysis, rather than the absence of being able to identify that difference, a type II error is problematic. With this particular study I have this question. Did the authors look, given the very low incidence of mortality in appendicitis, through a power analysis at how many patients they would have expected to need to enroll to demonstrate that truly no difference existed between groups and, thus, avoid a type II error. The same question exists for the relatively low complication rate that is normally seen.

**Bruce Wolfe, MD, Sacramento:** Dr Waxman raised the issue that owing to the methodology, patients with an alternate diagnosis to appendicitis identified by CT scan are excluded from this analysis. The same can be said for laparoscopy. Laparoscopy is used by many of us in patients who have an uncertain diagnosis, and we believe that complete examination of the abdominal cavity is facilitated by laparoscopy as opposed to a small muscle-splitting incision in the right lower quadrant. The patients in whom an alternate diagnosis was established by laparoscopy I presume are also excluded from this study, thereby perhaps omitting a group in which a benefit from this technique may have been missed.

**Steven C. Stain, MD, Nashville, Tenn:** Actually I agree with the authors' conclusion that newer technology probably does not affect outcome. Their study risks omitting patients who had CT scans that were excluded from having appendicitis and never went to operation. My question to the authors is: how did they account for those patients who never had operation and the diagnosis of appendicitis was excluded by CT scan?

**James J. Peck, MD, Portland, Ore:** We recently studied 443 patients who had right lower quadrant pain over an 18-month period. There were 19 patients that were 70 years old or older. Eighteen of 19 patients had a CT scan with a zero percent negative appendectomy rate. One of the important advantages of CT scanning in the older aged group is an alternative diagnosis. In our study of 443 patients, there were 11 patients who had diverticulitis that presented as midline or right-sided abdominal pain. Ten of 11 did not require surgery and, therefore, avoided operative intervention.

Your conclusions that older patients need an aggressive approach and early operation supports CT. Only 67% of these patients had a CT scan. If you had done your CT earlier, you may have had a different result. There is no question that the incidence of perforation in this study is related to the delay in presentation rather than in the delay in diagnosis. Sixty-five percent presented longer than 48 hours after their symptoms began. What was your technique of CT scanning? Did you use intravenous and/or oral contrast media? In our study, 57% of the patients had small appendicaliths that can be obscured by a contrast medium.

**Michael J. Hart, MD, Seattle, Wash** It is pretty clear in this group of patients that the delay in initiating therapy is the major issue in their morbidity and mortality rates. One issue is unclear; is this a delay in patient presentation or is this a delay in diagnosis? If it is a delay in diagnosis, is that a delay that occurs on the surgical service or prior to surgical evaluation when patients remain in the emergency department for prolonged observation or are admitted by hospitalists or a nonsurgical service? Where were these patients found? Was the surgeon called when the patient was seen in the emergency room with abdominal pain, or did the patient finally have the surgeon stumble on to him or her several days into the course of things?

**Ronald G. Latimer, MD, Santa Barbara:** Since abscesses were present in 38 (40%) of these 95 patients, how many of the patients did have percutaneous drainage before they underwent their appendectomies?

**Theodore O'Connell, MD, Los Angeles:** I have 1 question also for the authors. I was a little fascinated by the mortality rate which was 2% (1 patient) in the first group and 4% (2 patients) in the second group—3 deaths. I almost cannot remember a death from appendicitis in any age range for about the last 20 years because of the use of modern antibiotics, CT catheter drainage, etc. What were the circumstances of the death in those patients?

**Dr Margulies:** Thank you, Dr Waxman and all the discussants for their questions. Addressing Dr Waxman's questions regarding managed care: most of these patients were covered by Medicare and so I do not think that managed care played a large role in their selection. Similarly, managed care patients in our population had increased in the early 1990s and persisted throughout the later 1990s. Regarding the point that perhaps there are other changes in care that may have contributed, this is possible. However, because there were no statistically significant differences in outcome between the 2 periods, unless these other factors counterbalanced one another, it would be unlikely that they had any significant effect. We chose 2 periods close together to maximize the effect of CT and laparoscopy, which did change, and to minimize effects of other changes.

Several questions addressed the use of CT. We believe that the CT scan was useful. Because contrast enema was also sensitive, replacing it with CT did not alter the outcome. Many other questions brought out how it was really the delay in presentation from these patients that established the rate of perforation, the high rate of complications, and their ultimate outcome, and, therefore, very little could be done, even if the diagnosis had been made initially. This is true, is one of the main findings, and points to an area for improvement.

Regarding the comment for a type II error, yes, certainly this is possible, but because there was not even a trend toward a difference in outcome between the 2 periods, I do not think that this possibility played a significant role, even if we had had a larger number of patients. Regarding Dr Wolfe's question on the laparoscopic benefits of the diagnosis, actually I agree. There are patients that laparoscopy can benefit and, in fact, the ones in our study who underwent a completely laparoscopic approach had a shorter hospital stay and faired well. Still this was a selected group. There are the additional benefits that alternate diagnoses can be made and treated. We did not find that laparoscopy was a detriment certainly, and in some patients, I think it can be a benefit.

Dr Stain, CT scanning certainly could have excluded the diagnosis in certain patients. However, these patients were excluded from our study as all of the patients in this study did have appendicitis. Overall the CT scan was useful and, yes, oral (and rectal) contrast medium were used. Many of these patients certainly did present late. Eighty percent (76/95) were operated on within the first 24 hours, so for most the delay occurred prior to their arrival at the hospital. We did analyze those patients who had a delay in the diagnosis after the hospitalization, and these 25 patients did less well. These patients had alternate diagnoses. For instance, patients with a small-bowel obstruction were treated without the confirming evidence of a CT scan initially and then, when their conditions did not improve, a workup and a CT scan revealed an appendicitis resulting in their being operated on. Therefore, we actually agree that a CT scan was useful and would recommend it even earlier in the course of these patients. As mentioned also, it could result in other diagnoses, for example, diverticulitis and others. So we encourage the use of CT scanning. Still, despite the benefits of both CT and laparoscopy, overall outcomes were not improved between periods in the way we use CT.

We did not have any of the patients in this group who had percutaneous drainage prior to the operation. Regarding the question of the deaths, there were 3 in this series. One was an interesting patient who had a presentation with a thigh abscess from necrotizing infection with purulence throughout the muscles of the entire thigh. To exclude a diagnosis of appendicitis as the cause at the time of drainage at his initial operation, a laparotomy was performed and he did have a ruptured retroperitoneal appendicitis that had drained down into the leg. He eventually had a septic course in the intensive care unit with multisystem failure. The other 2 patients were actually initially recovering well and suffered cardiac events that occurred in the postoperative recovery period.