To identify differences between correctly diagnosed appendicitis and misdiagnosed cases that resulted in litigation between 1982 and 1989 retrospective review of malpractice claims was conducted. A total of emergency department (ED) charts at the time of the initial ED visit were reviewed and compared with 86 concurrent controls. Missed cases appeared less acutely ill, had fewer complaints of right lower quadrant pain, received fewer rectal examinations, received intramuscular (IM) narcotic pain medication for undiagnosed abdominal pain or symptoms, and more often received an ED discharge diagnosis of gastroenteritis. Misdiagnosed patients had a 91% incidence of ruptured appendix, more extensive surgical procedures, and more postoperative complications. Data were analyzed using the Pearson's χ² test, Mann-Whitney U test, and stepwise discriminant analysis. Significance was defined as P ≤ .05. Misdiagnosis of acute appendicitis is more likely to occur with patients who present atypically, are not thoroughly examined (as indexed by documentation of a rectal examination), are given IM narcotic pain medication and then discharged from the ED, are diagnosed as having gastroenteritis (despite the absence of the typical diagnostic criteria), and with patients who do not receive appropriate discharge or follow-up instructions. (Am J Emerg Med 1994;12:397-402. Copyright © 1994 by W.B. Saunders Company)

A patient with abdominal pain represents a dilemma for the emergency physician, who must decide whether the patient requires immediate surgery (or surgical consultation), should only be observed, or can be sent home. Even when the patient is admitted to the hospital, the diagnostic challenge remains: one prospective study found that only 44% of patients admitted to the hospital with abdominal pain had a discharge diagnosis identical to their initial diagnosis.1

In patients seeking treatment for abdominal pain, the incidence of appendicitis varies between 0.14% and 0.25%.2,3 Although the incidence of nonperforative appendicitis is decreasing,4 appendicitis is still one of the most common surgical diseases5 and also the most common condition requiring emergency surgery in infants, children, and pregnant women.6,7

The classic appendicitis is easy to diagnose, but in some cases, eg, children, women of childbearing age, patients older than 60 years of age, diagnosis can be difficult, and the perforation rate can be as high as 59%.8 Because the misdiagnosis of acute appendicitis is among the five leading causes of litigation against emergency physicians, accounting for 5% of the total dollars lost by insurers of emergency physicians,9 the differences between cases of misdiagnosed and correctly diagnosed appendicitis in terms of emergency department (ED) presentation and subsequent course were investigated. The goals were to identify any differences and to formulate quality assurance recommendations that might decrease the risk of misdiagnosis and the likelihood of subsequent malpractice claims. By investigating such claims, this article was written to decrease individual behaviors or practices shown to be associated with malpractice or poor outcomes and not as a cause celebre for malpractice attorneys.

METHODS

Closed medical malpractice claims against the St. Paul Fire and Marine Insurance Company and Spectrum Emergency Care, Inc, were examined from 1984 to 1989. Cases were included in the study if acute appendicitis was confirmed by pathological analysis, and the correct or misdiagnosed occurred in an ED, as opposed to an urgent care center, a private office, or with hospitalized patients. One study using malpractice claims records as its data source and basis for quality assurance recommendations demonstrated that this method can identify problem behaviors.10

The St. Paul Fire and Marine Insurance Company maintains an electronic database that was searched for cases meeting any of the following criteria: claims with an indemnity payment, claims in which at least $1,000 was spent on legal fees, claims whose description of loss was the failure to diagnose or the improper treatment of acute appendicitis, claims that resulted from treatment in an ED, and claims that were reported by either physicians or hospitals. Individual files were then reviewed, and data from claims meeting the study inclusion criteria were abstracted and analyzed using a standard form.

Spectrum Emergency Care, Inc, maintains its data in a file system. Claims filed against physicians insured by Spectrum were indexed according to the following allegations: failure to diagnose, failure to admit, or failure to properly treat acute appendicitis. Claims were received that met the same criteria as those noted above for the St. Paul Fire and Marine Insurance Company.
Sixty-six claims meeting the study inclusion criteria, 33 from each source, were reviewed. The records reviewed included ED charts handwritten at the time of initial diagnosis; inpatient charts; operative reports; pathology reports; insurance adjuster’s reports; correspondence between insurance companies and defendants; depositions of physicians, nurses, plaintiffs, and expert witnesses; physicians’ curricula vitae; and settlement amounts (indemnity payments and legal fees). Data gathered from the ED records of the visit with an adverse outcome included historical factors bearing on the presenting complaint; the general appearance component of the physical examination that describes patients as being in no, mild, moderate, or severe distress; the physical examination; diagnostic tests ordered in the ED and, if recorded, the results of those tests; treatment rendered in the ED; discharge diagnosis; and patient disposition. Medical records of any subsequent hospitalization were used to confirm the presence and nature of complications. Results of the single court trial were also noted.

The gathered data provided descriptions of cases for which there was a malpractice loss. However, these descriptions might not differ from the descriptions of cases in which a patient’s acute appendicitis was correctly diagnosed (Our null hypothesis was that there would be no difference in the patient profiles between suspected and/or correctly diagnosed appendicitis and profiles that resulted in poor outcome or litigation). An ideal control group would consist of correctly diagnosed patients seen at the same time and in the same EDs, but such cases were unavailable. To construct a control group demographically similar to the experimental group, a cohort of patients correctly diagnosed during the same period (1984-1989) in hospital EDs similar to those that generated the experimental cases was assembled.

To ensure that the control group reflected the same mix of hospitals existing in the experimental group, a convenience group of US hospitals with full-time ED service and an ED medical director was selected. This group of hospitals was subgrouped according to the number of yearly ED visits: fewer than 5,000; 5,000 to 20,000; and more than 20,000. Each hospital was numbered and then fed into a computer program that generated random numbers and then selected five hospitals from each subgroup. The ED medical director at each of the selected hospitals was asked to arbitrarily choose and forward the charts of five cases of correctly diagnosed appendicitis. The first 66 charts to arrive, the same number as study cases identified as the experimental group, a cohort of patients correctly diagnosed during the same period (1984-1989) in hospital EDs similar to those that generated the experimental cases was assembled.

The charts in the experimental group were reviewed in a nonblinded fashion, as were the charts in the experimental group. Clinical and outcome data for cases in both study groups were abstracted using the same standard form. Because the data were collected retrospectively, it was impossible to determine whether symptoms or signs not recorded on the ED charts were present in the patients during their ED evaluations. However, it is commonly assumed and supported in a textbook of emergency medicine that only a positive sign or symptom, is significant in an ED record, especially in cases of missed diagnosis. Pearson’s χ² test or Fisher’s exact test were used to analyze univariate differences for categorical outcome between the two groups. The Mann-Whitney U test was used to analyze continuous variables, whereas stepwise discriminant analysis determined whether and how the two groups differed on a given set of variables present during the initial ED encounter. These variables included all parameters except disposition and chest x-ray data. Stepwise discriminant analysis was chosen because the stepwise approach selects the best subset of variables to explain the differences between the groups being compared. In addition, studies comparing discriminant analysis with regression analysis have shown that discriminant analysis performed as well as regression analysis in classifying an individual case into one of two or more groups. Data were analyzed on a Digital Equipment Corporation, (Digital Equipment Corp. Maynard, MA) VAX computer running statistical package for the social sciences (SPSS-Inc, Chicago, Il.). Significance was defined as P < .05.

RESULTS

Throughout this article, the experimental group will mean those patients in whom the diagnosis of acute appendicitis was missed by the emergency physician during the initial ED visit and that resulted in litigation, and control patient will mean those patients correctly diagnosed at the time of their initial ED presentation. The experimental and control groups were not significantly different in terms of age (experimental: mean, 24.6 years; median, 24 years; range, 1 to 66 years; control: mean, 23.0 years; median, 18 years; range, 3 to 75 years). In the experimental group there were 30 women and 35 men (one data point missing), and in the control group there were 28 women and 38 men. One experimental group patient had previous abdominal surgery and 2 control group patients had similar histories.

Of the patients in the control group 29% had right lower quadrant pain as their presenting complaint, whereas only 15% of the patients in the experimental group had the same complaint. Control patients also had a greater incidence of associated nausea and vomiting, more frequently reported anorexia, and a shorter duration of pain than experimental group patients. All these factors were statistically significant (Table 1). Tables 1 and 2 summarize some clinical and outcome characteristics of control patients and patients who sued for missed diagnosis of acute appendicitis. There were important differences between the groups in terms of presentation, atypical or classical: thoroughness of physical examination, as indexed by rectal examination; treatment in the ED: discharge diagnosis; and patient disposition.

Compared with control patients, patients with misdiagnosed acute appendicitis seemed to be in less severe distress; had less abdominal tenderness, rebound, and guarding; and received fewer rectal examinations. There were no differences between the groups in heart rate, blood pressure, respiratory rate, temperature, time of day of presentation, or total white blood cell count (analyzed both as group means and within the following groups: 5,000 to 10,000, 10,000 to 15,000, >15,000). No discharged patient in the experimental group had surgical consultation during the initial ED encounter.

Experimental group patients were discharged with the following diagnoses (a patient could have more than one discharge diagnosis): 33 with gastroenteritis; 10 with abdominal pain; 8 with urinary tract infection; 5 with pelvic inflammatory disease; 5 with constipation; 3 with peptic ulcer disease; 3 with dehydration; I each with suspected appendicitis, genitourinary tract disease, and gastrointestinal bleeding; and 12 with an ED diagnosis of “other.”

Experimental group patients less often had a simple appendectomy; more often required an exploratory laparotomy, abscess drainage, and/or laparoscopy; and experienced significantly more postoperative complications than control group patients (Table 3). Most misdiagnosed patients were subsequently found to have a ruptured appendix (Table 3). There was no significant difference between the groups in the retrocecal location of the appendix.

Of the 66 misdiagnosed patients, 33 (50%) were sent home
TABLE 1. Historical and Physical Examination Factors

<table>
<thead>
<tr>
<th>Historical factors</th>
<th>Experimental Group</th>
<th>Control Group</th>
<th>Significance*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right lower quadrant pain</td>
<td>23/53 (43.4)</td>
<td>38/60 (63.3)</td>
<td>.034</td>
</tr>
<tr>
<td>Associated nausea and vomiting</td>
<td>24/66 (36.4)</td>
<td>47/66 (71.2)</td>
<td>.00006</td>
</tr>
<tr>
<td>Anorexia</td>
<td>2/66 (3.0)</td>
<td>14/66 (21.2)</td>
<td>.0014</td>
</tr>
<tr>
<td>Duration of pain &lt; 12 hours</td>
<td>11/41 (26.8)</td>
<td>26/53 (49.1)</td>
<td>.0287</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Physical examination factors</th>
<th>Experimental Group</th>
<th>Control Group</th>
<th>Significance*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appearance of severe distress</td>
<td>0/66</td>
<td>11/66 (16.7)</td>
<td>.00053</td>
</tr>
<tr>
<td>Tenderness present</td>
<td>47/56 (83.9)</td>
<td>63/66 (95.4)</td>
<td>.0332</td>
</tr>
<tr>
<td>Rebound present</td>
<td>1/66 (1.5)</td>
<td>21/66 (31.8)</td>
<td>&lt; .00001</td>
</tr>
<tr>
<td>Guarding present</td>
<td>7/66 (10.6)</td>
<td>28/66 (42.4)</td>
<td>.00073</td>
</tr>
<tr>
<td>Rectal examination performed</td>
<td>12/66 (18.1)</td>
<td>26/66 (39.4)</td>
<td>.0071</td>
</tr>
</tbody>
</table>

Note: n = 66, not all cases had complete data files.

* Pearson’s χ².

from the ED with a discharge diagnosis of gastroenteritis after their initial visit. Of these 33 patients, pathological examination ultimately showed that 11 had a perforated appendix, 9 had a gangrenous appendix, and 5 had suppurative appendicitis. Therefore, these patients represent a group of true misses. The average time to correct diagnosis after the initial ED visit was 39 hours.

A stepwise discriminant analysis showed seven factors present during the ED encounter explaining 60.5% of the difference that discriminated between the experimental and control groups. The factors, with their unstandardized weights, and the equation used are listed in Table 4. This function correctly classified 84.9% of the observations.

Insurance losses for the experimental group averaged $21,347 ± $46,265 standard deviation (SD), (range $0 to $252,182). The amount actually received by patients or their families was frequently much higher than the settlement amount because annuity policies were often purchased with a portion of the total indemnity payment. Attorneys’ fees averaged $7,623 ± $12,862 SD (median $3,148). Two of the 66 patients in the experimental group died. In the single case in which litigation ended in a jury trial, the jury found on behalf of the defendant physician.

DISCUSSION

The classical presentation of acute appendicitis only occurs in approximately 55% of nonpregnant patients with pathologically confirmed appendicitis. With careful, complete histories and thorough physical examinations, a diagnostic accuracy of ≤80% can be achieved; in fact, most misdiagnoses result from careless history-taking and physical examination.

How can physicians recognize atypical cases of acute appendicitis? Are there factors that allow distinction between appendicitis and common conditions not requiring surgery? Our study sought to identify differences in the presentation of atypical presenters and patients who were correctly diagnosed during the initial ED visit. We found important differences between these two groups of patients in the following areas: initial appearance of the patient, presenting complaint, thoroughness of the physical examination, therapeutic management in the ED, disposition and discharge diagnosis, type of operation performed, number of operative complications, and pathologic determination of the severity of appendiceal inflammation.

Fifty percent of patients with acute appendicitis are 10 to 29 years old. Our study was, therefore, a representative sample of patients with acute appendicitis, because the mean ages in the experimental and control groups were quite similar (24.6 years v 23.0 years, respectively). Moreover, the age range was also typical of the patient population presenting to most full-service EDs.

Even though anorexia is a good symptom of appendicitis

TABLE 2. Diagnosis, Management, and Disposition

<table>
<thead>
<tr>
<th>ED diagnosis</th>
<th>Experimental Group</th>
<th>Control Group</th>
<th>Significance*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suspected appendicitis</td>
<td>1/66</td>
<td>51/66</td>
<td>&lt; .00001</td>
</tr>
<tr>
<td>Abdominal pain</td>
<td>10/66</td>
<td>20/66</td>
<td>.038</td>
</tr>
<tr>
<td>Gastroenteritis</td>
<td>33/66</td>
<td>3/66</td>
<td>&lt; .00001</td>
</tr>
<tr>
<td>Narcotic pain medication given in the ED</td>
<td>37/66</td>
<td>15/66</td>
<td>&lt; .00009</td>
</tr>
<tr>
<td>Sent home</td>
<td>65/66</td>
<td>0/66</td>
<td>&lt; .00001</td>
</tr>
</tbody>
</table>

Note: n = 66.

* Pearson’s χ².

TABLE 3. Operative and Pathological Findings

<table>
<thead>
<tr>
<th>Operation performed</th>
<th>Experimental Group</th>
<th>Control Group</th>
<th>Significance*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appendectomy and abscess drainage or exploratory laparotomy or laparoscopy</td>
<td>31/65</td>
<td>10/66</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Complications experienced</td>
<td>37/66</td>
<td>13/66</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Pathological and operative findings</td>
<td>63/66</td>
<td>13/66</td>
<td>&lt; .00001</td>
</tr>
<tr>
<td>Retrocecal location</td>
<td>9/66</td>
<td>15/66</td>
<td>NS</td>
</tr>
</tbody>
</table>

Note: n = 66.

ABBREVIATION: NS, not significant.

* Pearson’s χ².
TABLE 4. Factors That Correctly Classified 84.9% of Misdia gnosed Cases Based on Stepwise Discriminant Analysis

<table>
<thead>
<tr>
<th>Factors</th>
<th>Unstandardized Weight</th>
<th>Cumulative Wilk's Lambda</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>ED diagnosis of gastroenteritis</td>
<td>-1.227</td>
<td>.7396</td>
<td>&lt;.00005</td>
</tr>
<tr>
<td>Rebound absent</td>
<td>1.0665</td>
<td>.6626</td>
<td>&lt;.00005</td>
</tr>
<tr>
<td>Received narcotic pain medication in the ED</td>
<td>-0.6966</td>
<td>.6056</td>
<td>&lt;.00005</td>
</tr>
<tr>
<td>No associated nausea and/or vomiting</td>
<td>1.0013</td>
<td>.5635</td>
<td>&lt;.00005</td>
</tr>
<tr>
<td>Lacked appearance of severe distress</td>
<td>1.0874</td>
<td>.5384</td>
<td>&lt;.00005</td>
</tr>
<tr>
<td>Guarding absent</td>
<td>0.6951</td>
<td>.5160</td>
<td>&lt;.00005</td>
</tr>
<tr>
<td>No rectal examination performed or documented</td>
<td>0.6455</td>
<td>.4958</td>
<td>&lt;.00005</td>
</tr>
</tbody>
</table>

Note: n = 66.

Wilk's Lambda is the proportion of the variance between groups not explained by the factor noted and those above it in the table. The unstandardized weight is the coefficient by which the variable must be multiplied to maximize discrimination between the groups.

The equation used was:
\[ D = -568 - 1.227 (ED diagnosis of gastroenteritis) + 1.066 (rebound) - 0.697 (narcotic pain medication in the ED) + 1.001 (nausea or vomiting) + 1.087 (severe distress) + 0.695 (guarding) + 0.646 (rectal examination) \]

in patients who complain of abdominal pain, very few experimental cases contained a record of this symptom, and less than 10% of the control cases noted its presence. Therefore, reliance on anorexia alone would not have significantly decreased the number of missed cases. Perhaps patients who are otherwise candidates for discharge, but who are anorexic, should be kept for observation longer or should be scheduled for an early follow-up examination within 12 hours. In one study of patients presenting with complaints of abdominal pain who were subsequently diagnosed as having appendicitis, 69% complained of pain that originated in and remained confined to the right lower quadrant; only 43% had nausea or vomiting.\(^1\) In our study, the duration of pain experienced by experimental group patients, i.e., patients with appendicitis misdiagnosed during their first ED presentation, was 50% longer than those diagnosed as having appendicitis during their initial ED evaluation. Previous studies\(^1\),\(^6\),\(^16\) have shown that patients who have symptoms for a longer period of time tend to have an increased rate of perforation. However, the observation that patients with acute appendicitis present earlier in their disease is not uniformly supported by the literature. Other reports\(^15\) indicate that the duration of symptoms in patients with abdominal pain with and without appendicitis is similar.\(^15\),\(^16\) Another study found that patients with appendicitis had a mean duration of symptoms of 24 hours; those with pelvic inflammatory disease, 60 hours; and those with no inflammation, fewer than 18 hours.\(^14\) One strategy for decreasing the number of misdiagnoses would be to schedule an early follow-up examination or surgical consultation for all patients who have a history of abdominal pain but are otherwise candidates for ED discharge.

In addition to historical factors, several physical examination factors distinguished the patient groups in our study. Experimental group patients appeared less severely ill than patients in the control group. Perhaps the misdiagnosed patients came to the ED in that interval between rupture and the development of unmistakable signs of peritonitis. One author has noted that patients with vague symptoms and signs more often have perforated appendicitis.\(^6\) This same finding was confirmed in our study: experimental group patients had a much higher perforation rate than control patients.

Forty-five experimental group patients had abdominal tenderness, the importance of which was apparently de-emphasized by the emergency physician. One study of acute appendicitis found that 43% of misdiagnosed cases had maximum tenderness in the right lower quadrant that was ignored by the physician\(^27\); another study found tenderness to be the most valuable sign.\(^8\) Our findings are consistent with the results of those studies.

Another important difference in the physical examination between the two groups is that fewer experimental group patients received a rectal examination. Besides the detection of lateralizing tenderness, other reasons for doing a rectal examination in patients with abdominal pain or symptoms of uncertain etiology are to determine whether a rectal mass or occult blood are present. The performance and documentation of a rectal examination may indicate a more thorough ED evaluation. Although one study has shown that the rectal examination has a low diagnostic weight,\(^21\) another found that in patients with appendicitis, even children younger than 6 years of age, 50% to 80% of patients have localizing tenderness and 25% have a palpable mass.\(^20\)

There are three major reasons for the diagnostic dilemmas in acute appendicitis: (1) the typical signs and symptoms of acute appendicitis are nonspecific and may be caused by a broad range of pelvic and abdominal disorders; (2) there is no good adjunctive diagnostic test for appendicitis; and (3) on the basis of a single physical examination, it is often impossible to diagnose appendicitis; indeed, most errors occur after only one examination.\(^23\)

Clearly, there is a need to identify which patients are candidates for surgery and those patients that can be safely observed. Computer-aided diagnoses\(^1\),\(^24\) and scoring systems\(^24\) for evaluating the possibility of acute appendicitis can decrease the misdiagnosis rate. Computer-aided diagnosis has been shown to increase the diagnostic accuracy of both resident and senior physicians.\(^1\),\(^24\)-\(^27\) Decrease the negative laparotomy rate,\(^1\),\(^24\)-\(^26\) provide earlier surgical interventions,\(^25\) and decrease the number of perforations.\(^24\)-\(^26\) How can emergency physicians maximize the probability of correctly diagnosing appendicitis during the ED encounter of unselected patients with abdominal pain?\(^9\)

None of the patients in either the experimental or control group had a carefully documented history of abdominal pain that included all of the following historical points: location, duration, quality, radiation, increasing or decreasing factors, associated symptoms, and past medical history of similar abdominal pains. This fact is consistent with the findings of
another study that reported poor documentation of physical examination findings in cases of abdominal pain.20 Perhaps a system similar to that developed by the American College of Emergency Physicians for documenting the history and physical examination findings in cases of patients with chest pain needs to be developed for patients with acute abdominal symptoms. Such a system would ensure a more thorough examination of such patients. Use of this system in conjunction with a computer-based diagnostic aid or a system referring all patients with abdominal pain of uncertain etiology for surgical consultation or follow-up within 12 hours should decrease the number of missed diagnoses.

The discharge diagnosis, obviously, was a factor closely related to cases of missed appendicitis. Of the 66 patients in the experimental group, 33 (50%) were discharged from the ED with a diagnosis of gastroenteritis. This is consistent with the results of other studies that have found gastroenteritis to be the initial diagnosis in 42% to 50% of missed cases.3,14,20,21,28 Clearly, many of these patients had established appendiceal inflammation at the time of the initial ED presentation. Why were these patients missed? One possible explanation is that physicians misinterpreted the nausea and/or vomiting as gastroenteritis instead of as signs of early peritonitis. It is interesting to note that no patient with an ED diagnosis of gastroenteritis had the three cardinal signs of gastroenteritis: nausea, vomiting, and diarrhea, documented in the written ED record. Patients should only be discharged with this diagnosis if they meet the diagnostic criteria. In addition, physicians should avoid using the term “gastroenteritis” to label vague abdominal symptoms and should instead diagnose patients as having abdominal pain or symptoms of uncertain etiology. This strategy of sharing the uncertainty of the diagnosis with the patient will certainly increase the number of repeat examinations and could lead to fewer misdiagnoses.

An additional factor noted in the misdiagnosed group was the administration of narcotic pain medication for vague abdominal symptoms. Although 13 patients in the control group received narcotic pain medications in the ED, these patients already had a diagnosis of acute appendicitis and were scheduled for surgery. Thirty-three patients with vague abdominal symptoms or suspected gastroenteritis received IM narcotic pain medication before ED discharge. Had these patients been admitted to the hospital or had surgical consultation before ED discharge, almost half of the misdiagnoses might have been prevented. Therefore, it may be prudent to admit patients for observation or to obtain ED surgical consultation before ED discharge, if patients require narcotic pain medications to relieve or decrease undiagnosed abdominal symptoms.

After patients were discharged from the ED with an incorrect diagnosis, the average time to correct diagnosis was 39 hours. Previous studies14,24,28,29 have reported that delayed diagnosis increases the perforation rate. A consequence of delayed diagnosis in experimental group patients was an increased number of cases of perforated appendicitis found at surgery and on pathological examination (Table 3). These patients experienced an increased number of surgical procedures and a significantly increased number of complications (Table 3). However, it is noteworthy that 19.7% of correctly diagnosed patients had perforative appendicitis at their initial presentation, despite early correct diagnosis and prompt surgical intervention. Previous studies have reported perforation rates, at the time of the initial diagnosis, ranging from 10% to 15% in populations ranging from young children to the elderly.2,5,31 Our data are consistent with this range.

In our study, no difference was found between patients in the two groups regarding the anatomic position of the appendix. This finding is consistent with another study that reported that the retrocecal location did not increase the perforation rate.14,23 but contrasts another study that reported an increased frequency of delayed diagnosis in pediatric patients with a retrocecal location.25

The experimental group also differed from the control group in the type of operation performed once the diagnosis of appendicitis was finally suspected. Compared with control group patients, experimental group patients had fewer simple appendectomies, more often required exploratory laparotomies and drainage of abscesses, and had more postoperative complications (Table 3). Surgical complications are related to the extent of pathology found at operation.18 Patients with perforation and abscess formation have complication rates as high as 48.4%,24 a conclusion consistent with our data: 63 (95.45%) of 66 missed patients had a ruptured appendix, 31 (47%) required laparotomy and abscess drainage, and 37 (56%) experienced postoperative complications.

Mortality in cases of acute appendicitis has been reported to be 0.8% to 1.6% in a general population.33 The only two deaths in our study occurred in patients with misdiagnosis, for a mortality rate of 3%. This mortality rate contrasts sharply with the mortality rate of 0.04% when acute appendicitis is not associated with gangrenous changes or perforation on pathological examination.23 Consistent with our finding, another study reported that the only deaths occurred in misdiagnosed patients.20 Other reports state that morbidity and mortality in acute appendicitis are related almost entirely to ruptured appendicitis.2,8,28,29

**STUDY LIMITATIONS**

A criticism of this study could be that it lacked a study group composed of patients in whom the diagnosis of appendicitis was missed and that did not result in litigation. Without such a group, we could not determine differences that may be associated with misdiagnosis alone in the absence of litigation. However, we have compared the two most extreme cases: those in which acute appendicitis is correctly diagnosed or suspected during the initial ED encounter, and those instances in which misdiagnosis lead to untoward consequences for both patient and physician. If emergency physicians could reduce the incidence of misdiagnosis in our experimental group patients, then similar decreases in misdiagnosis would occur with patients who do not sue physicians.

A second criticism is that some of the variables included in the discriminant analysis model, final diagnosis and administrations of narcotics, are probably caused by the misdiagnosis. Because the ED encounter is an interaction between patient and physician behaviors, our discriminant analysis considered both patient and physician variables in the final model. If emergency physicians had shared the uncertainty of diagnosis with their patients, rather than labeling them as
having gastroenteritis (especially because all patients lacked documentation of that diagnosis), then perhaps repeat examinations or earlier follow-up might have prevented complications (especially because an average of 39 hours elapsed between the initial ED evaluation and the correct diagnosis). Another emergency physician behavior that certainly would have reduced the incidence of misdiagnosis was to have admitted for observation those patients that required narcotic pain medications to relieve abdominal symptoms or else to obtain surgical consultation in such patients before ED discharge. Because the above mentioned factors were part of the ED encounter, we believe they should be included as independent variables that could be fairly related to outcome. Other physician behaviors that might reduce misdiagnosis would be more thorough or structured histories and physical examination of patients with abdominal symptoms.

Although we collected and compared the physician years of training and experience between the experimental and control groups, physician data were too incomplete regarding these variables; therefore, we could not draw statistically significant conclusions regarding these characteristics, although this was one of our goals when we began this study.

CONCLUSIONS

Based on the results of stepwise discriminant analysis comparing the experimental (missed) and control (correctly diagnosed) groups, we believe the following profile represents the patient most likely to have a missed diagnosis of acute appendicitis on the initial ED visit: no “classic” signs and/or symptoms of acute appendicitis; pain but no nausea or vomiting; no rectal examination performed or documented; administration of IM narcotic pain medication followed by discharge from the ED; diagnosis of gastroenteritis, despite lack of documentation of the typical features of that disease; and no specific documentation on the ED chart to return for follow-up examination within 12 to 24 hours (Table 4). Accordingly, several quality assurance recommendations are in order. Emergency physicians should consider atypical presentations of acute appendicitis; perform complete physical examinations, including rectal examinations, on patients with gastrointestinal or abdominal symptoms; not administer IM narcotics for vague abdominal pain or symptoms unless the patient is to be admitted or has a surgical consultation before ED discharge; avoid a discharge diagnosis of gastroenteritis unless the patient meets strict diagnostic criteria for that condition; and arrange for follow-up examination within 12 hours for patients discharged with abdominal pain or symptoms of uncertain etiology.

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