The Sustained Impact of an Evidenced-Based Clinical Pathway for Acute Appendicitis

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Appendicitis is a frequent pediatric surgical condition for which there is great variability among practitioners regarding diagnosis and postoperative management. With this in mind, the authors designed and implemented an evidence-based appendicitis clinical pathway at their institution. Establishment of the pathway resulted in decreased hospital cost, reduced hospital stay, and fewer unnecessary laboratory tests. The purpose of the current study was to determine the sustainability of the pathway beyond its initial implementation phase. The authors showed that several, but not all, favorable outcomes of the pathway were sustained. These data suggest that a clinical pathway for appendicitis at the authors' institution results in sustained beneficial effects in some but not all outcome parameters. Ongoing monitoring of pathway compliance, continued education of practitioners and nursing personnel, and identification of key pathway team member(s) responsible for the pathway system might result in a greater long-term impact of these guidelines.

APPENDICITIS represents the most common surgical emergency of childhood and one of the major causes of hospitalization among children between 1 and 14 years of age.[1] At our institution (Children's Hospital Medical Center, Cincinnati, OH), there are multiple attending surgeons with varied training backgrounds. This was a major factor contributing to a significant variability in the diagnostic approach and management of patients presenting with acute appendicitis. Factors such as length of postoperative stay, type of antibiotic utilized, response time for surgical consultation, and overall patient time spent in the emergency department (ED) were unpredictable. Furthermore, most patients with perforated appendicitis often were kept in the hospital for the duration of their antibiotic regimen.

In 1998, we reported preliminary data regarding the implementation of an evidence-based clinical pathway for appendicitis at our institution.[2] The purpose of this pathway was to minimize the variability in diagnosis and treatment of patients that present with acute appendicitis. We also sought to identify opportunities to reduce the overall cost for this familiar pediatric surgical condition. We showed that establishment of the pathway resulted in a significant decline in the duration of hospitalization and cost for patients with both perforated and nonperforated appendicitis. In addition, patients were seen in the emergency room by consulting surgeons more rapidly, fewer laboratory and radiographic tests were ordered to establish the correct diagnosis of appendicitis, and preoperative antibiotics were given more frequently. These improvements occurred without adversely affecting diagnostic accuracy or perioperative complications.

During the study period (early implementation phase), compliance with the pathway was insured by repeated assessment of outcome parameters by the pathway leaders, ongoing orientation of the rotating surgical house officers to the pathway, frequent in-services to nursing and emergency room personnel, and regular discussions of the pathway during faculty meetings of surgical attendings. After the study period (late implementation phase) and once the pathway was running smoothly, it was felt that the need for active compliance monitoring was no longer necessary. The pathway simply was incorporated into the service resident handbook. The purpose of this study, therefore, was to determine the impact of a clinical pathway for acute appendicitis at a major pediatric medical center. We sought specifically to determine the impact of this pathway over a prolonged period—without active compliance enforcement.

METHODS

Protocol Development

The evidence-based clinical pathway for appendicitis was developed by a multidisciplinary team, and specific details already have been published.[2] During the pathway implementation phase, compliance was closely monitored by a research assistant and a clinical nurse specialist assigned to the Division of Pediatric Surgery. These personnel made daily rounds, identified appropriate patients, and monitored pathway use. Key areas of focus for the pathway included early involvement and clinical education of the surgical teams, decreasing routine use of laboratory and radiologic testing for patients with suspected appendicitis, routine use of home antibiotics for patients with perforated appendicitis, and preoperative use of antibiotics for all patients. All patients were scheduled for outpatient follow-up examinations within 2 weeks of hospital discharge.

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Pathway Components

The clinical pathway was initiated in all patients at the time of the initial surgical evaluation in the ED. Patients were excluded from the pathway using criteria cited in Table 1. Guidelines for radiologic and laboratory studies are shown in Table 2 and Table 3. In patients whose symptom duration was relatively brief (<24 to 48 hour) and if the abdominal tenderness was localized to the right lower quadrant, the nonperforated pathway was begun. In these patients, preprinted standing orders were utilized and included establishment of intravenous access, a bolus of intravenous fluids (10 to 15 mL/kg normal saline), and a second-generation cephalosporin (Cefotetan; Zeneca Pharmaceuticals, Wilmington, DE). No laboratory or radiographic testing was done before surgery except for a urinary β–human chorionic gonadotropin (HCG) in a girl older than 11 years. Preprinted standing postoperative orders assured proper continuation of antibiotics for one additional dose, initiation of diet within 6 to 8 hours, and advancement of activity as tolerated. To assure timely discharge, nursing personnel were directed to page the surgical house officer for discharge orders if the patient was afebrile, tolerating clear liquids, and able to ambulate with assistance.

If patients had a relatively prolonged duration of symptoms (>48 hours) or if the physical examination suggested diffuse peritonitis or an abdominal mass, the perforated appendicitis pathway was initiated. An intravenous line was begun; the patient was resuscitated with crystalloid fluids, and laboratory and radiographic studies were performed as outlined above. Broad-spectrum antibiotics were administered (gentamicin with ampicillin sodium/sulbactam sodium). In the postoperative period, preprinted orders directed early consultation with home care services to begin teaching of the patient and family. Antibiotics were continued for a minimum of 7 postoperative days. Laboratory testing was kept to a minimum and included a renal profile and gentamicin levels on the first postoperative day. Additional renal profiles were suggested if an underlying electrolyte imbalance was present or if a nasogastric tube was required. A complete blood count was not repeated until the seventh postoperative day unless directed by persistent pyrexia. Patients were discharged with the antibiotic course to be completed at home if the home environment was favorable, the parents and patient were willing, and if the patient was afebrile, tolerating regular diet, and pain control was satisfactory with orally administered medications.

Table 1. Exclusion Criteria for Pathway

• Age ≤ 3 years
• Previous appendectomy
• History of ovarian cyst
• History of bloody stools
• History consistent with pelvic inflammatory disease or pregnancy
• Chronic past history
Cystic fibrosis
Crohn's disease
Organ transplant
Malignancy
• Suspected diagnosis not appendicitis

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Table 2. Guidelines for Radiologic Studies

• Plain radiographs (3 view)
• Suspected free air
• Diffuse peritonitis
• Suspected small bowel obstruction
• Palpable mass
• Past history or suspected gallbladder/renal stones
• Right lower quadrant/pelvis ultrasound scan
• Pelvic pain in female patient
• Palpable mass by transrectal, transvaginal, or transabdominal examination
• Past history or suspected gallbladder/renal stones

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Patient Population

The patient population included all patients with a principal procedure of appendectomy that linked to the appendectomy diagnosis–related group (DRG) between June 1994 and March 2001. The patient were was captured from the hospital data system where clinical data were linked to financial information. This review encompassed 4 study periods: period 1, control period, June 1994 through March 1995 (n = 236 patients); period 2, pathway development phase, April 1995 through May 1996 (n = 330 patients); period 3, immediate postimplementation phase, June 1996 through April 1998 (n = 565

Table 3. Guidelines for Laboratory Studies

Complete blood count
Peritonitis
Suspected perforated appendix
Toxic appearance
Renal profile
<10% clinical dehydration
Significant history of vomiting/diarrhea
Liver profile/amylase
Right upper quadrant/epigastric pain
Suspected gallstones
Blood Culture
Toxic appearing child
Temperature >103°F
Urinalysis
History of dysuria/hematuria
Costovertebral angle tenderness

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patients); period 4, late postimplementation phase, May 1998 through March 2001 (n = 867 patients).

Analysis

Data were stratified by perforated or nonperforated appendicitis for each of the 4 study periods. Comparisons were made for the outcomes of interest between the 4 study periods.

The rate of change for length of hospital stay (LOS) and hospital costs were determined by performing a linear regression with time in years as the independent variable and LOS in days or hospital costs in dollars as the dependent variables. Individual visits (stays) were used for analysis. Each time period was analyzed separately. The resulting time coefficient (slope) was the average change per year for a visit in the specified time period.

The difference between the time trends in periods 3 and 4 was tested by using a linear regression model. The dependent variable was LOS in days or cost in dollars. The independent variables were time in years and an indicator for period 4 (1 = period 4, 0 = period 3). An interaction variable (time x period 4 indicator) also was included in the model. The parameter value of the interaction variable provided an estimate of the difference in slope between the trends of periods 3 and 4. Individual visits for periods 3 and 4 were analyzed. The trends in resource utilization (laboratory and radiologic testing) were analyzed over the 4 time intervals using a Mantel-Haenszel χ^2 test for trends.

All statistical analyses were performed using PC-SAS software (Release 8.0, SAS Institute, Cary, NC). Statistical significance was set at a P value less than .05.

RESULTS

Overall, administrative data for 1998 patients for the 4 study periods were analyzed, and the demographic characteristics are shown in Table 4. The incidence of perforation was 20% over all time intervals. However, a trend of decreasing incidence of perforation over the 4 periods was significant (25.8% during period 1, 22.1% for period 2, 15.9% during period 3, and 17.2% for period 4; $P < .001$). There were no differences with regard to patient age or sex distribution when comparing any time periods.

With regard to length of postoperative hospital stay (LOS) for the entire group, the regression model did not show any significant differences between the immediate and late postimplementation period (Fig 1). Thus, this outcome parameter for the clinical pathway was sustained despite the lack of active enforcement during period 4. The same held true for total hospital costs (adjusted to 2001 dollars; Fig 2) because there were no differences between the 2 postimplementation periods. When analyzed further, the greatest impact on hospital costs appeared to be caused by the reduced LOS in both nonperforated and perforated groups (Fig 3A & B). The reduced LOS was a direct result of the pathway-initiated guidelines for discharge within 24 hours in the nonperforated group and early home care involvement with completion of intravenous antibiotics at home in the perforated group. Again, the effect of the pathway was sustained throughout the early and late postimplementation phases.

The impact of the pathway over time was less sustained for utilization of specific resources. In the nonperforated group, implementation of the pathway resulted in a significant reduction in the ordering of preoperative complete blood count (CBC), renal panel (serum electrolytes, blood urea nitrogen, creatinine), and urinalysis (UA). However, when comparing the immediate and late postimplementation phases, we noted that performance of a CBC and UA was significantly more frequent in the later time periods (Fig 4A). In the perforated group, the renal panel was ordered less frequently in the later time period, and there were no significant differences with regard to CBC or UA (Fig 4B). In both perforated and nonperforated groups, there was a significantly greater use of preoperative plain abdominal radiographs studies in the late postimplementation phase of the pathway when compared with the early phase. Finally, utilization of home health care services in the perforated patients to provide home intravenous antibiotics was significantly greater in the later postimplementation phases of the pathway when compared with the early period.

Table 4. Patient Demographics

	Period 1	Period 2	Period 3	Period 4	Overall
Average age (yr ± SD)					
Acute, nonperforated	11.3 ± 3.5	11.2 ± 3.5	11.8 ± 3.3	11.6 ± 3.5	11.6 ± 3.5
No.	175	257	475	718	1625
Perforated	9.8 ± 3.7	9.0 ± 4.2	9.6 ± 3.6	9.6 ± 3.9	9.5 ± 3.8
No.	61	73	90	149	373
Sex					
Acute, nonperforated (% M/F)	50.9/49.1	68.5/31.5	54.8/45.2	53.3/46.7	55.9/44.1
Perforated (% M/F)	50.8/49.2	56.2/43.8	57.6/42.4	61.8/38.2	58.0/42.0

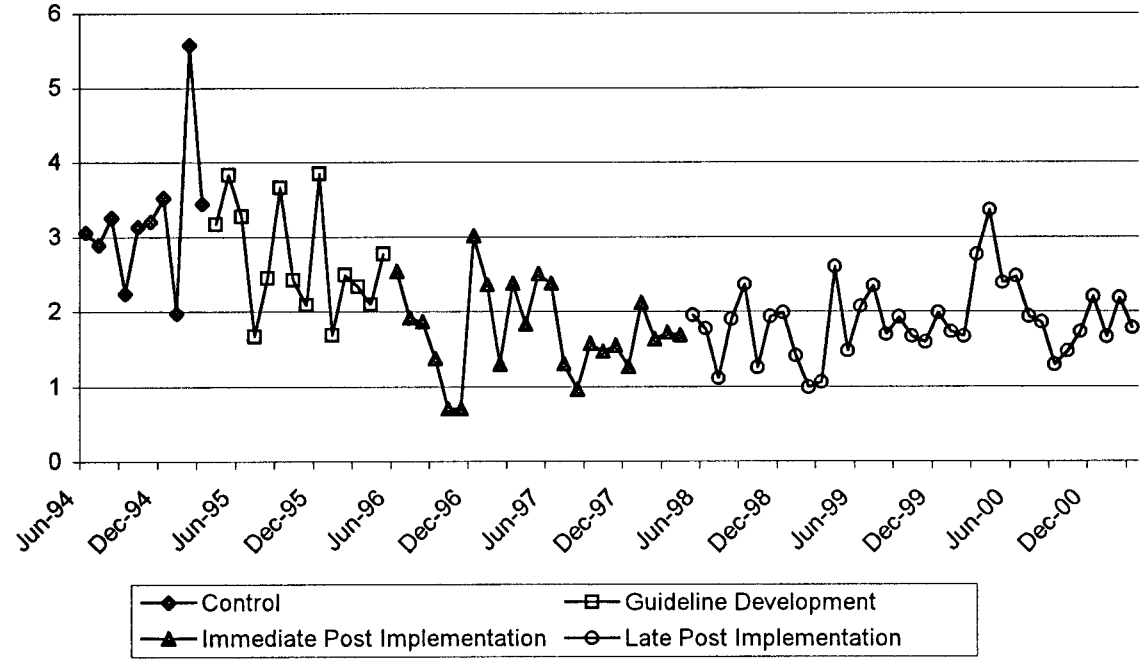

Fig 1. Mean length of stay in days for all patients with either perforated or nonperforated appendicitis. Patients are grouped into intervals of time in relationship to the initiation of the appendicitis clinical pathway. The control period is from June 1994 through March 1995 (n = 236 patients) and represents the period before the pathway. The Guideline development phase ranges from April 1995 through May 1996 (n = 330 patients). The immediate postimplementation phase, June 1996 through April 1998 (n = 565 patients) includes the early phase of pathway, whereas the late postimplementation phase, May 1998 through March 2001 (n = 867 patients) corresponds with the late phase of the pathway.

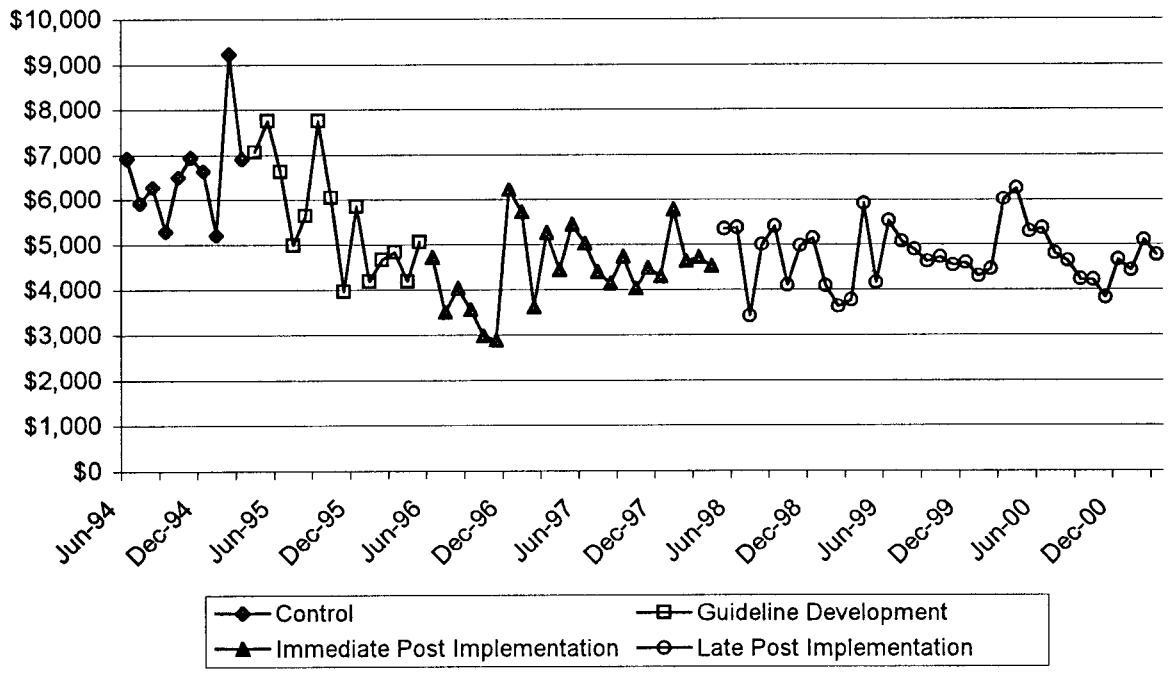

Fig 2. Mean hospital costs (normalized to 2001 dollars) for all patients with either perforated or nonperforated appendicitis. Patients are grouped into intervals of time in relationship to the initiation of the appendicitis clinical pathway. The control period is from June 1994 through March 1995 (n = 236 patients) and represents the period before the pathway. The Guideline development phase ranges from April 1995 through May 1996 (n = 330 patients). The immediate postimplementation phase, June 1996 through April 1998 (n = 565 patients) includes the early phase of pathway, whereas the late postimplementation phase, May 1998 through March 2001 (n = 867 patients) corresponds with the late phase of the pathway.

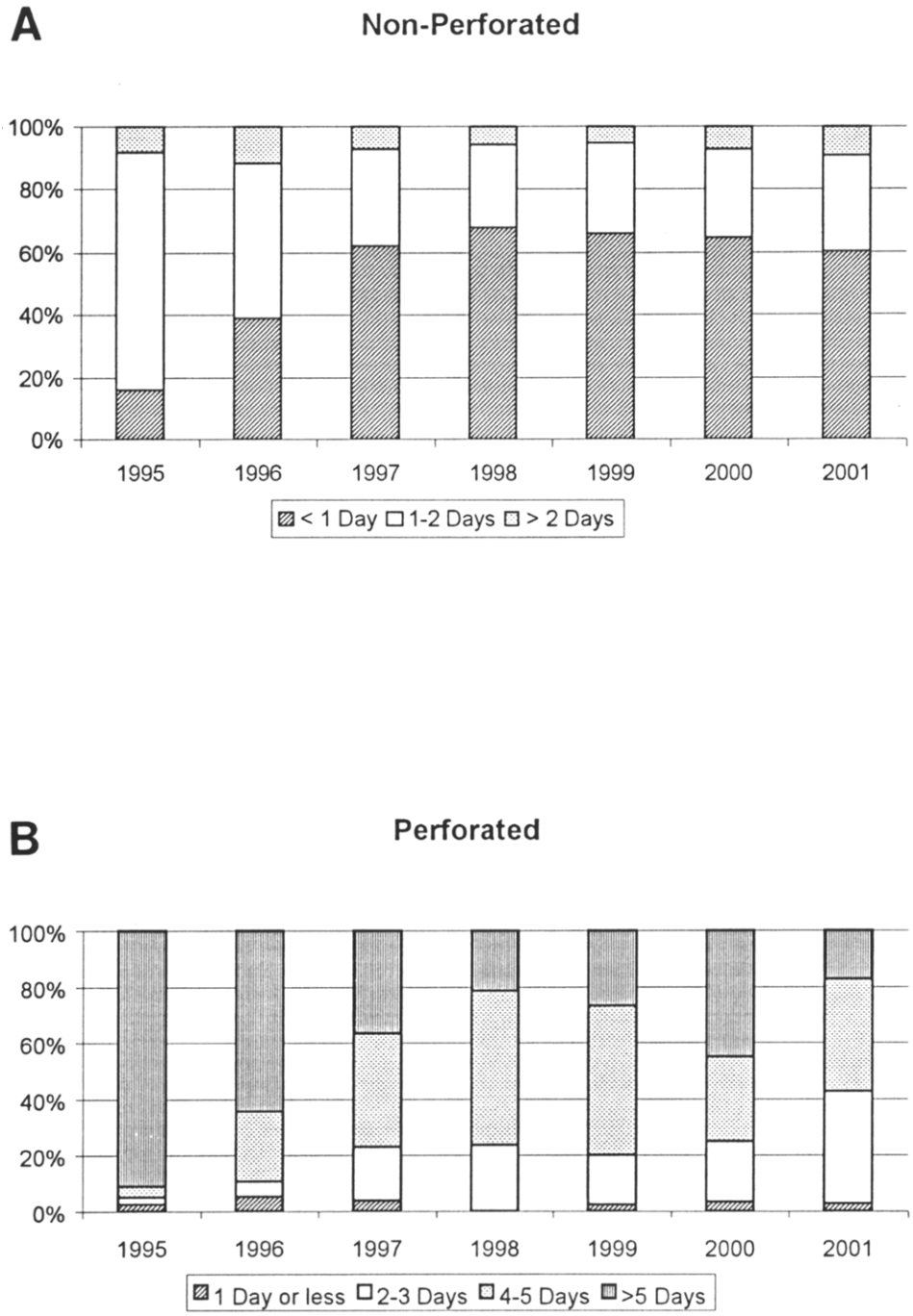

Fig 3. Length of hospital stay by fiscal discharge year for patients with nonperforated (A) or perforated (B) appendicitis. The percent of patients discharged within the time intervals as indicated in the figure legend is shown on the y axis.

DISCUSSION

In this study, we have shown a sustained effect of a clinical pathway for pediatric patients with appendicitis in several parameters. We showed a persistently lowered hospital cost as well as duration of hospitalization. These benefits continued despite the lack of active enforcement of the guidelines. However, a greater trend toward ordering more preoperative laboratory and radiographic studies in patients with nonperforated appendicitis has developed without ongoing supervision of pathway compliance. These results support the fact that implementation of an appendicitis clinical pathway has longstanding beneficial effects on major clinical outcomes but not all outcome parameters. A program of ongoing monitoring

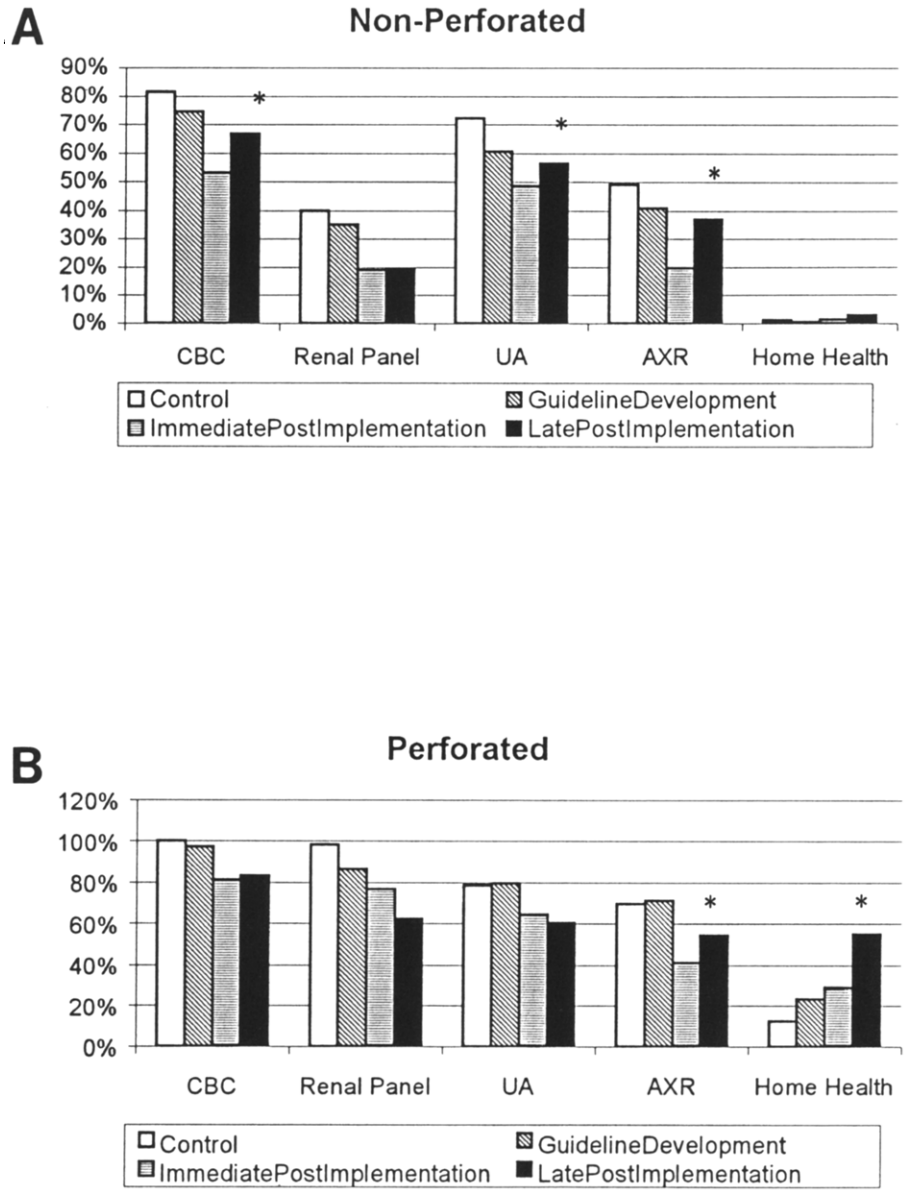

Fig 4. Utilization of hospital resources. The percentage of patients in whom a preoperative complete blood count (CBC), serum electrolytes, blood urea nitrogen, and creatinine (renal panel), urinalysis (UA), and plain abdominal radiographs (AXR) was ordered in patients with either nonperforated (A) or perforated (B) appendicitis. In addition, the percentage of patients that home health care was utilized for home intravenous antibiotic administration is shown. The control period was from June 1994 through March 1995 and represents the period before the pathway. The Guideline development phase ranges from April 1995 through May 1996. The immediate postimplementation phase, June 1996 through April 1998 includes the early phase of pathway, whereas the late postimplementation phase, May 1998 through March 2001 corresponds with the late phase of the pathway. In the nonperforated group, the trend for increased ordering of CBC, UA, and AXR in the late postimplementation phase was significant (*$P<.01$ using the Mantel-Haenszel χ^2 test for trends). In the perforated group, the increased use of preoperative AXR in the late postimplementation phase also was significant (*$P<.01$ using the Mantel-Haenszel χ^2 test for trends).

therefore is likely to be an important component of the uniform success of this pathway.

We acknowledge that, coincident with implementation of the appendicitis pathway, other changes in hospital practices and organization occurred that might have affected the reduced length of hospital stay and cost. Ongoing pressure from third party payers, reduced charges associated with hospitalization and specific resources, and the substantial growth and popularity of our home care department are important factors that warrant consideration. Length of stay and charges associated with hospitalization were likely to be much more influential on costs than the contributions of specific preoperative laboratory or radiographic testing. However, we did

identify several quality of care factors that occurred coincident with the start of the pathway including quicker consultation time for surgeons to see the patient in the emergency room, sooner arrival in the operating room, and higher likelihood of having received appropriate preoperative antibiotics.

For guidelines to be effective, they must affect physician behavior and show some type of measurable improvement in patient outcomes. Although most physicians recognize the potential benefits of practice guidelines, some concerns remain about the potential adverse legal ramifications, the tone of "cookbook medicine," and the opinion that guidelines may be too cumbersome and time-consuming.[3,4]

Therefore, simply developing and disseminating practice guidelines do not guarantee subsequent changes in medical practice. Multimodal support is needed to sustain behavior changes.

Locally generated and site-specific guidelines are more likely to be implemented successfully.[5] It has been shown previously that practitioners who contribute to the development of the guidelines use them more frequently than those who are uninvolved.[6] Informing practitioners of guideline availability and content, using reminder strategies, sending physician-specific report cards, and informing physicians of the applicability of a specific guideline in the care of a specific patient all have been reported in some settings to influence the incorporation of guidelines in care.[7-9]

A clinical pathway development team interviewed multiple members of various departments throughout our institution with the goal of identifying potential barriers and solutions to enhance successful impact of pathways. Incomplete or complete lack of education about the pathway led to confusion, noncompliance, and clinician resistance. The multidisciplinary nature of this pathway requires that active, ongoing education be provided. The need for an identified pathway caretaker/manager was raised. This person would have the sole responsibility to coordinate, educate, and monitor utilization, implementation, outcomes, and staff responses regarding the pathway. Having a singular person capable of influencing various departments and patient care areas was considered important. Finally, a system needed to be developed to ensure that the pathway was accessible and initiated for every patient. We frequently observed that even when a clinician was aware and informed about the pathway, the supply of preprinted orders or guidelines could not be located within the emergency department or operating room. Often, this resulted in a lack of compliance with specific postoperative orders and care plan. Along these lines, continued discussion of the guidelines with colleagues, reminder notes or stickers on the front of patient chart, and verbal reminders from informed nursing personnel may be the most effective means to encourage utilization.[10]

Appendicitis is a common pediatric surgical condition for which there is much variability in terms of preoperative evaluation and postoperative management. For purposes of minimizing this variability, the development of an effective pathway must be based on solid evidence. The best quality evidence is derived from randomized, prospective clinical trials involving large numbers of patients. Unfortunately, in pediatric surgery, these types of randomized trials are infrequent.[11] However, this trend seems to be improving as a greater number of prospective clinical trials are being published in the pediatric surgical literature. Information from multicenter clinical trials with large cohorts of patients are paramount to base recommendations for best clinical practice.

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