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Factors predictive of complicated appendicitis in children



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ABSTRACT

Background: The ability to predict whether a child has complicated appendicitis at initial presentation may influence clinical management. However, whether complicated appendicitis is associated with prehospital or in-hospital factors is not clear. We also investigate whether hyponatremia may be a novel prehospital factor associated with complicated appendicitis.

Materials and methods: A retrospective review of all pediatric patients (≤ 12 y) with appendicitis treated with appendectomy from 2000 to 2013 was performed. The main outcome measure was intraoperative confirmation of gangrenous or perforated appendicitis. A multivariable analysis was performed, and the main predictors of interest were age < 5 y, symptom duration > 24 h, leukocytosis (white blood cell count $> 12 \times 10^3/\text{mL}$), hyponatremia (sodium ≤ 135 mEq/L), and time from admission to appendectomy.

Results: Of 392 patients, 179 (46%) had complicated appendicitis at the time of operation. Univariate analysis demonstrated that patients with complicated appendicitis were younger, had a longer duration of symptoms, higher white blood cell count, and lower sodium levels than patients with noncomplicated appendicitis. Multivariable analysis confirmed that symptom duration > 24 h (odds ratio [OR] = 5.5, 95% confidence interval [CI] = 3.5–8.9, $P < 0.01$), hyponatremia (OR = 3.1, 95% CI = 2.0–4.9, $P < 0.01$), age < 5 y (OR = 2.3, 95% CI = 1.3–4.0, $P < 0.01$), and leukocytosis (OR = 1.9, 95% CI = 1.0–3.5, $P = 0.04$) were independent predictors of complicated appendicitis. Increased time from admission to appendectomy was not a predictor of complicated appendicitis (OR = 0.8, 95% CI = 0.5–1.2, $P = 0.2$).

Conclusions: Prehospital factors can predict complicated appendicitis in children with suspected appendicitis. Hyponatremia is a novel marker associated with complicated appendicitis. Delaying appendectomy does not increase the risk of complicated appendicitis once intravenous antibiotics are administered. This information may help guide resource/personnel allocation, timing of appendectomy, and decision for nonoperative management of appendicitis in children.

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Introduction

In children, acute appendicitis was responsible for more than 70,000 hospital admissions in 2012.¹ Appendicitis is classified as complicated when there is evidence of a perforated or gangrenous appendix, an intra-abdominal abscess, or fecal peritonitis often resulting in a longer length of stay and greater rates of morbidity and mortality. Overall, complicated appendicitis is more common in children, with rates as high as 30%.² The ability to identify children at risk for complicated appendicitis is important, as it dictates decisions regarding further workup and management. Specifically, patients with noncomplicated appendicitis may be amenable to nonoperative management with antibiotics alone.

The management of patients with complicated appendicitis differs greatly from that of acute appendicitis. The urgency of operative intervention is dependent on whether in-hospital progression of disease can convert acute appendicitis to complicated appendicitis. Previous studies have suggested age <5 y, duration of symptoms >24 h, white blood cell (WBC) count $>12 \times 10^3/\text{mL}$, C-reactive protein $>10 \text{ mg/L}$, and radiographic findings as possible predictors for complicated appendicitis.^{3,4} Despite these studies, it is still controversial as to whether complicated appendicitis is a prehospital event or due to in-hospital progression of acute appendicitis to complicated appendicitis.^{5,6} Thus, the purpose of this study is to investigate whether prehospital factors (age, symptom duration, and WBC count) or in-hospital factors (time from admission to appendectomy) are associated with complicated appendicitis. We will also investigate another prehospital factor, serum sodium level, to see if hyponatremia is associated with complicated appendicitis. We hypothesize that complicated appendicitis is a prehospital event and that hyponatremia will be predictive of complicated appendicitis in children.

Materials and methods

Study design

The study was approved by the Harbor-UCLA Medical Center Institutional Review Board. This study is a retrospective review of all consecutive pediatric patients (≤ 12 y) with appendicitis treated with appendectomy from 2000 to 2013. Patients with incomplete records were excluded from this study. Recorded values included patient admission characteristics such as age, gender, race/ethnicity, insurance status, comorbidities, duration of symptoms, laboratory values, imaging findings, and time to surgery. The primary outcome was the presence of complicated appendicitis.

Definitions

Duration of symptoms was taken from the patient's objective history of present illness and was dichotomized as to whether a patient had symptoms for 24 h or less. At our institution, hyponatremia is defined as a serum $\leq 135 \text{ mEq/L}$ and leukocytosis as a WBC count $>12 \times 10^3/\text{mL}$. If a patient was

transferred from an outside facility, their laboratory workup from that facility was used as their admission laboratory values in the database. Time to surgery was defined as the time from first evaluation by the emergency department to time of incision and was measured in hours. We used intraoperative findings of a perforated or gangrenous appendix, an intra-abdominal abscess, or fecal peritonitis as our definitive diagnosis of complicated appendicitis.

Statistics and data management

All data were recorded in Excel 2010 (Microsoft, Redmond, WA). Statistical analysis was performed using both SAS v9.3 (SAS Institute, Cary, NC) and Epi Info 7 v7.1.5.2 (CDC, Atlanta, GA) software. Continuous variables were analyzed using the Student's t-test, but in the presence of significant variance, the Kruskal–Wallis test was used instead. Categorical variables were analyzed using the chi-square test if all cells had expected values greater than five and a Fisher's exact test if any expected values were less than five. Statistical significance was set at a P value of less than 0.05. Clinically relevant variables and variables found to be statistically significant were included in a multivariable logistic regression for the outcome of complicated appendicitis. The multivariable model was assessed for goodness of fit using the Hosmer–Lemeshow test statistics and the area under the curve.

Results

Patient characteristics

A total of 503 patients were identified, but only 392 children had complete records and were included in this study. Of the 392 patients, 179 (46%) were found to have complicated appendicitis at time of surgery. Patient characteristics are summarized in Table 1. Patients with complicated appendicitis were slightly younger (8 versus 9 y, $P < 0.01$). There were no significant differences with respect to gender, body mass index, race/ethnicity, comorbidities, transfer status, or type of insurance. The median duration of symptoms was longer in patients with complicated appendicitis (2 versus 1 d, $P < 0.01$). There were no differences with respect to time from admission to surgery. The median serum sodium level in patients with complicated appendicitis was lower than that in patients with noncomplicated appendicitis (134 versus 137 mEq/L, $P < 0.01$). There was a statistically significant difference with respect to WBC count, although the clinical value was minimal (17 versus $16 \times 10^3/\text{mL}$, $P < 0.01$).

Relevant clinical cutoffs

Patients with complicated appendicitis were more likely to be aged younger than 5 y (18% versus 7.5%, $P = 0.01$), have symptoms for longer than 24 h (75% versus 36%, $P < 0.01$), and have a sodium $\leq 135 \text{ mEq/L}$ (63% versus 33%, $P < 0.01$). There were no significant differences with respect to leukocytosis. Univariate analysis of these relevant clinical cutoffs is summarized in Table 2.

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