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Appendicitis in preschool aged children: Regression analysis of factors associated with perforation outcome☆,☆☆,★

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ABSTRACT

Objectives: Apply multivariate regression analysis to determine the significance of clinical variables for perforation outcome of a large series of preschool aged children with appendicitis.
Methods: Retrospective case review of 180 consecutive children <5 years of age diagnosed with appendicitis during an 8-year period.
Results: This age group accounted for only 9% of all cases of pediatric appendicitis at our institution during the study period. Perforation rate was inversely proportional to patient age, occurring in 100% aged <1 year, 91% ages 1–2 years, 76% ages 2–3 years, 73% ages 3–4 years, and 57% ages 4–5 years. Risk for perforation increased proportionately with duration of symptoms, ranging from 48% when <1 day vs 84% when >1 day; and 93% when >2 days. One-quarter with perforation had a prior recent medical evaluation with an alternative diagnosis rendered preappendicitis diagnosis. The mean duration of hospitalization was four times longer in those with perforation [8 days] vs no perforation [2 days]. Univariate analysis showed each of the following factors was significantly associated with perforation outcome: younger patient age, female gender, prior medical visit <48 hours of appendicitis diagnosis, symptom duration, presence of fever, and presence of appendicolith. Multivariate logistic regression combining all significant univariate predictors showed only duration of symptoms and presence of appendicolith were significantly associated with perforation outcome; receiver-operating characteristic curves are generated to evaluate the predictive accuracy of these two factors, both individually and when combined.
Conclusions: Although relatively uncommon in this age group, appendicitis is frequently associated with delayed diagnosis and perforation outcome. Risk for perforation is directly proportional to increasing duration of symptoms. Clinicians must maintain a high index of suspicion for this condition in these younger children, as early diagnosis is essential to maximizing outcome.

Appendicitis is the most common pediatric abdominal surgical emergency condition, accounting for more than 80,000 surgical procedures each year in the US. It is relatively rare in younger-aged children [1–4]. Although generally accepted that youngest children with appendicitis experience relatively higher rates of appendiceal perforation, most prior studies [1–18] utilized simple parametric statistical testing to determine the significance of associated clinical factors for this outcome. Specifically, two prior reports [4,5] examining preschool aged children with appendicitis lacked performance of multivariate logistic regression to eliminate potential confounding and accurately determine factor significance for perforation outcome.

To more accurately define this group, the present study will apply multivariate regression analysis to precisely correlate clinical characteristics and outcomes of a large series of consecutive preschool aged children with appendicitis.

1. Methods

A retrospective case review was conducted of consecutive children aged ≤5 years with a discharge diagnosis of appendicitis at Maimonides Medical Center, Brooklyn, NY, from 2006 to 2014. Information gathered was: patient age, gender, type and date of onset of symptoms [abdominal pain, vomiting, and fever], date of and diagnosis rendered at any recent prior medical visit, ED-measured body temperature, duration of fever [≥38.0 °C] during hospitalization, duration of antibiotic therapy during hospitalization, ED-measured CBC WBC count, duration of hospitalization [days], total number of radiologic imaging studies during hospitalization, and whether subsequent ED visits occurred for those with appendix perforation solely managed medically after hospital discharge prior to interval appendectomy. Also gathered from each case was information from dictated preoperative radiology reports [attending-level

Abbreviations: CT, computerized tomography scan; US, ultrasound; ED, emergency department; OR, odds ratio; CBC, complete blood count; ROC, receiver-operating characteristic; AUC, area under curve; CI, confidence interval; LOS, length of stay.

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radiologist], postoperative surgical report [attending-level surgeon] and pathology histologic report [attending-level pathologist].

Appendiceal perforation was considered present if on CT imaging the radiologist identified a collection of "free" intraperitoneal fluid; if either surgeon/pathologist noted gross perforation [i.e., visual evidence of appendiceal tissue perforation]; or if at laparoscopy the surgeon identified purulent contaminated intraperitoneal "free" fluid; whereas a small volume of clear intraperitoneal "free" fluid was considered consistent with the appendicitis inflammatory process, and not indicative of perforation. All US and CT scan results were interpreted by an attending-level pediatric radiologist according to the following criteria: 1] US positive = visualization of noncompressible appendix measuring >6 mm in diameter [other signs include presence of appendicolith, periappendiceal fluid, increased flow in the appendiceal wall with color Doppler]; US negative = complete visualization of a compressible appendix measuring <6 mm in diameter; and US equivocal/inconclusive = nonvisualization of appendix; 2] CT positive = visualization of an enlarged appendix measuring >7 mm in diameter in addition to inflammatory signs including hyperemia in the wall, periappendiceal fat stranding, or appendicolith; and CT negative = complete visualization of a normal appendix. Patients were considered to have had a recent prior medical visit if they were evaluated by a physician and given an alternative diagnosis <48 hours of the ultimate diagnosis of appendicitis.

The study was approved by our IRB.

2. Statistical analysis

Normally distributed data are described in terms of mean ± SD while skewed data are presented in terms of median [minimum, maximum]; and categorical data are described in terms of frequency [percent]. To assess interrater agreement in data recording, 35 cases [20% of total] were randomly selected and 9 variables [patient age/gender, fever, WBC count, appendicolith, perforation on pathology report, duration of symptoms [days], days in hospital, perforation on surgery report] were reexamined by 3 investigators. Continuous variables were compared using intraclass correlations while categorical variables were compared using kappa coefficients. The median coefficient of agreement was 1.0 [range 0.8–1.0], indicating excellent agreement.

Statistical comparisons between patients with and without perforation were performed using independent group Student t-tests for continuous predictor variables and with chi square tests for comparing categorical predictors. Logistic regression was used to perform multivariate analysis to test which factors were most strongly associated with perforation outcome. A receiver-operating characteristic curve was constructed to evaluate the predictive accuracy of the logistic regression results and to estimate cutoff points for continuous variables to maximize sensitivity and specificity. All tests were carried out using $p < 0.05$ as the significance level and were done using IBM SPSS Statistics for Windows [IBM Corp, Armonk, NY].

3. Results

Raw demographic data and characteristics percentages for patients distinguished by outcome are summarized in Table 1. Of 40 patients who had a prior medical visit <48 hours to appendicitis diagnosis, discharge diagnoses at that visit included viral syndrome [20], gastroenteritis [12], acute otitis media [4], UTI [2] and not specified [2].

Fig. 1 gives the breakdown of appendicitis cases at our institution during the 9-year study period. Of the total, 180 [9%] were aged ≤5 years; of these, 128 [71%] had a perforated appendix. The perforation rate was inversely proportional to patient age, occurring in 100% aged <1 year, 91% ages 1–2 years, 76% ages 2–3 years, 73% ages 3–4 years, and 57% ages 4–5 years. Fig. 2 shows perforation rate was directly proportional to symptom duration, ranging from 48% when <1 day vs 84% when >1 day; and increased to 93% when ≥2 days. All patients received parenteral antibiotic therapy initiated in the ED.

Table 1
Patient characteristics.

Clinical characteristic	Total #	Perforated appendix N = 128 [71%]	Nonperforated appendix N = 52 [29%]
Age [years]:			
≤1	5	5	0
1–2	22	20	2
2–3	37	28	9
3–4	55	40	15
4–5	61	35	26
Males	111	72	39
Prior medical visit <48 hours preappedicitis diagnosis	40	35	5
Symptom duration [days]:			
<1	64	31	33
1–2	61	46	15
2–3	27	24	3
≥4	28	27	1
Symptom duration [hours]:			
≤48	125	77	48
>48	55	51	4
CBC WBC [/mm^3]:			
≥15,000	116	71	45
≥20,000	52	29	23
Fever [temperature ≥38.0 °C]	143	112	31
Appendicolith	97	85	12
Hospitalization duration [days]:			
≤2	48	9	39
3–4	14	9	5
≥4	118	110	8

Laparoscopic appendectomy was performed in 133 cases [81 with perforation]; whereas 47 with CT evidence of perforation received nonsurgical management [29 solely received medical management with parenteral antibiotics; 18 had percutaneous drainage of intraabdominal abscess by interventional radiology]. In each case involving appendectomy, the attending-level surgeon's dictated report specified whether there was evidence of/the character of intraperitoneal "free" fluid. The mean length of hospitalization was 8 days in those with perforation vs 2 days in those without perforation; for all patients with perforated appendicitis, the mean length of hospitalization who solely received medical management was 8.8 days, vs 7.1 days when appendectomy was performed.

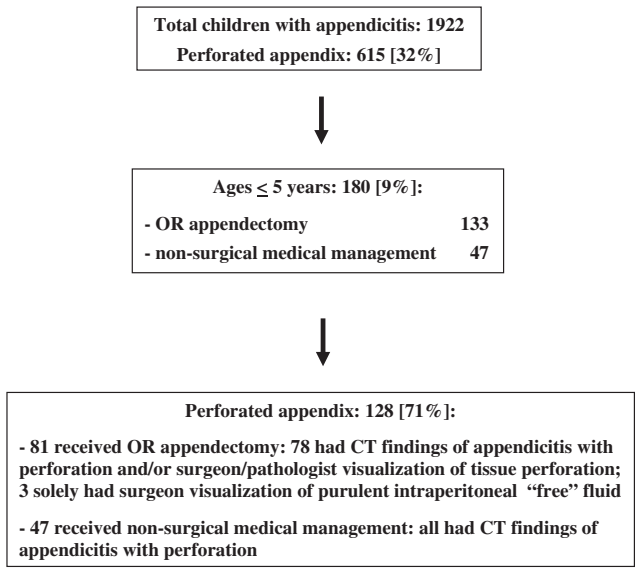

Fig. 1. Distribution of appendicitis cases and their characteristics during 9-year study period.