Application of Pediatric Appendicitis Score on the Emergency Department of a Secondary Level Hospital

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Background: Acute appendicitis is the most common surgical emergency during childhood. Accurate early diagnosis is important to avoid complications and unnecessary interventions. In 2002, Samuel developed the Pediatric Appendicitis Score (PAS) based on a series of data obtained from anamnesis, physical examination, and laboratory tests. The main purpose of this study was to check the validity of PAS and its applicability to our population.

Methods: Prospective observational study, carried out at Hospital Río Hortega (Valladolid, Spain), between June 2009 and May 2010. Data from 101 patients who presented to the emergency department experiencing abdominal pains were recovered.

Results: A total of 101 patients were included in the study: 55 were boys and 46 girls. The mean age was 9.51 (2.76) years. Diagnosis was acute appendicitis in 28 patients, adenitis in 8 patients, nonspecific abdominal pain in 51 patients, and other diagnoses in 14 patients. The mean (SD) PAS for children with and without appendicitis was 7.43 (1.79) and 4.97 (1.67), respectively ($P < 0.001$).

Conclusions: With a cutoff PAS of 3 or lower, there were no patients diagnosed with acute appendicitis; hence, these patients could be discharged without any image studies. If all the patients with a PAS of 8 or higher undergo surgery, we would find in our sample a 4.95% rate of negative appendicectomy, less than other studies have shown. The application of this score in the emergency department could help in the decision making process, aiding in the identification of patients with a low risk of having appendicitis and enabling a better use of resources by avoiding unnecessary diagnostic tests.

Key Words: appendicitis, score, abdominal pain

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Acute appendicitis is the most frequent surgical emergency in childhood.[1] An early diagnosis decreases the rate of complication. The most frequent among them is the appendicular perforation.[2–5] It is also important to establish the most accurate diagnosis to avoid unnecessary interventions. The rate of nonpathologic appendix, in histological postappendicectomy studies, is between 10% and 23%.[5,6]

One of the main problems in dealing with this pathologic finding at the emergency department (ED) is that diagnosis depends strongly on the pediatrician's suspicion.

There have been several trials to create a clinical score system, as a base to establish a selective use of image diagnosis according to the likelihood of appendicitis.[6] Many diagnostic scores have been proposed, with the one created by Alvarado[7] as the most used. Its main inconvenience is that it is applied on the adult population. In 2002, Samuel developed the Pediatric Appendicitis Score (PAS).[8] Based on a cohort of patients from 4 to 15 years, it values the presence of 8 items obtained from anamnesis, physical examination, and laboratory tests, scoring them with 1 or 2 points (Table 1).

OBJECTIVES

The main objective of our study was to test the validity of PAS and its implementation in our population. As secondary objectives, we aimed to establish the demographic characteristics of appendicitis in our area and the correlation within the score and the clinical characteristics and to establish a guideline in performing imaging tests on suspicious cases.

METHODS

A prospective observational study, at the Teaching Hospital Rio Hortega, Valladolid, Spain, has been done between June 1, 2009, and May 30, 2010, collecting data from patients younger of 14 years who presented with suspicion of acute appendicitis at our ED.

Every year, more than 24,000 requests are attended at our ED. On a 24-hour daily basis, there are a pediatrician and 1 or 2 residents at all times. There is no pediatric surgery department at our hospital; thus, patients younger than 10 years who need surgery are sent to our reference center in pediatric surgery located within the same city, unless their clinical situation establishes the transfer as unadvisable. Patients older than 10 years and those who cannot be transferred are sent to the general surgery department at our center.

Patients with long-lasting abdominal pain (>7 days), those who underwent appendicectomy, and those to whom no analytical test was performed were all excluded from the study.

Parents were informed and asked for verbal consent before data were collected. Data of patients referred to physical examination were collected by a pediatrician before having the analytical test done. The rest of the data was collected by the main investigator by consulting the hospital database. Histological study of the surgical piece was performed in every case of surgical intervention to confirm the diagnosis. In those patients who were transferred to another center, telephone contact was made to confirm histological diagnosis.

Patients were classified in 2 groups, namely, study (appendicitis confirmed) and control groups (no appendicitis), according to the results of the histological study.

It was also checked if any discharged patient requested medical attention in the next 7 days for the same clinical semiology.

Data were entered on an Excel table (Microsoft Corp, Redmond, Wash), and PAS was calculated for each patient.

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TABLE 1. Items of PAS

	Diagnostic Items	PAS
Anamnesis	Tenderness in the right lower quadrant	2
	Migration of pain	1
	Anorexia	1
	Nausea/emesis	1
Physical examination	Fever/temperature >37.3°C	1
	Cough/percussion tenderness	2
Laboratory tests	Leukocytosis $>10 \times 10^9$/L	1
	Polymorphonuclear neutrophils $>7.5 \times 10^9$/L	1

Statistical analysis was made with SPSS 14 program (SPSS, Inc, Chicago, Ill). Quantitative variables are described as mean (SD), and normality is established with the Kolmogorov-Smirnov test. Qualitative variables are described as absolute frequency and percentages. The χ^2 test was used to study the association between qualitative variables. To study differences between means, Student *t* test or Mann-Whitney test was used, depending on application conditions. Significance level was considered for $P < 0.05$.

Considering histological diagnosis of appendicitis as the criterion standard, a receiver operating characteristic curve was made to determinate score diagnostic characteristics and optimal PAS cutoff points.

A logistic regression analysis was made, with appendicitis diagnosis as the dependent variable and score items plus sex as the independents variables.

RESULTS

During the study, 909 patients with complaints of abdominal pain were attended. In 163 patients, acute appendicitis was suspected by the attending pediatrician, and in 101 of them, data were collected and patients were included in the study. Of them, 55 (54.5%) were boys and 46 (45.5%) were girls. Mean (SD) age was 9.51 (2.76) years.

Thirty patients (29.7%) underwent surgery, and result of the histological study of the appendix was normal in 2 (1.98%) of them. Of these 2 patients, a Meckel diverticulum was removed in one and a diagnosis of acute mesenteric lymphadenitis was made on the other. These 2 patients were finally included in the control group.

Final diagnoses were acute appendicitis in 28 patients (27.7%), acute mesenteric lymphadenitis in 8 patients (7.9%), nonspecific abdominal pain in 51 patients (50.5%), and others in 14 patients (13.9%). Sample final diagnosis is shown in Table 2. Histological findings in surgical pieces are also shown in Table 3.

TABLE 2. Sample Final Diagnosis

Diagnosis	No. Patients (%)
Appendicitis	28 (27.7)
Acute mesenteric lymphadenitis	8 (7.9)
Nonspecific abdominal pain	51 (50.5)
Meckel diverticulum	1 (1)
Viral infection	4 (4)
Gastritis	5 (4.9)
Acute gastroenteritis	1 (1)
Ileitis	1 (1)
Bowel intussusception	1 (1)
Urinary tract infection	1 (1)

TABLE 3. Histological Findings in Surgical Pieces

Histological Diagnosis	No. Patients (%)
Phlegmonous appendicitis	16 (57.1)
Gangrenous appendicitis	7 (25)
Perforated appendicitis	4 (14.3)
Peritonitis	1 (3.6)
Normal	2 (7.2)

The study group (appendicitis) had a mean PAS of 7.43 (1.79), whereas the control group (not appendicitis) had a mean PAS of 4.97 (1.67) ($P < 0.001$). Blumberg sign is positive more frequently in the study group than in the control group (50% vs 28.8%, $P = 0.045$). Comparison between the study group and the control group is shown in Table 4.

Table 5 shows measured temperature values at the ED. Patients with complicated appendicitis, such as gangrenous or perforated appendicitis, or peritonitis had higher temperatures than the other patients. Also, 11 patients with no complicated appendicitis (including simple or phlegmonous appendicitis) had no fever at the moment of diagnosis ($P = 0.01$).

Area under the receiver operating characteristic curve was 0.832 (95% confidence interval [CI], 0.741–0.923; Fig. 1). If the PAS cutoff point is 3 or lower, there were no patients diagnosed with acute appendicitis. Tests would have a negative predictive value of 100% (95% CI, 96.4%–100%) and a sensitivity of 100% (95% CI, 98.2%–100%). If a cutoff point of 8 or higher is set, only in 5 patients with 8 points or higher in score that the result of the histological study of the appendix was normal; hence, the specificity is 93.1% (95% CI, 86.7%–99.6%) and the positive predictive value is 76.2% (95% CI, 55.6%–96.8%).

TABLE 4. Comparison Between the Study and Control Groups

Diagnostic Item	Study Group (Appendicitis), n = 28	Control Group (Not Appendicitis), n = 73	*P*
Tenderness in the right lower quadrant	25 (89.3)	49 (67.1)	0.024
Cough/percussion tenderness	20 (71.4)	38 (52.1)	0.078
Migration of pain	13 (46.4)	17 (23.3)	0.023
Anorexia	25 (89.3)	49 (67.1)	0.024
Nausea/emesis	22 (78.6)	41 (56.2)	0.037
Fever/temperature >37.3°C	13 (46.4)	23 (31.5)	0.161
Leukocytosis $>10 \times 10^9$/L	26 (92.9)	37 (51.4)	<0.001
Polymorphonuclear neutrophils $>7.5 \times 10^9$/L	27 (96.4)	32 (44.4)	<0.001
Blumberg +	14 (50)	21 (28.8)	0.045

Values are n (%).

TABLE 5. Temperature Depending on Histological Diagnosis

Temperature at ED, °C	Not Complicated Appendicitis (Simple, Phlegmonous)	Complicated Appendicitis (Gangrenous, Perforated, Peritonitis)	Normal Histological Finding
≤37.3	11 (73.3)	3 (25)	51 (68.9)
37.4–38	4 (26.7)	4 (33.3)	9 (12.2)
≥38.1	0 (0)	5 (41.7)	14 (18.9)

Values are n (%).

The most powerful variables in the logistic regression are pain located at the lower right quadrant and leukocytosis. Results from the logistic regression are shown in Table 6.

TABLE 6. Results of Logistic Regression

Item	Odds Ratio	95% CI	*P*
Tenderness in the right lower quadrant	12.514	2.303–67.983	**0.003**
Cough/percussion tenderness	1.732	0.489–6.134	0.395
Migration of pain	1.544	0.357–6.670	0.561
Anorexia	4.700	0.708–31.212	0.109
Nausea/emesis	1.060	0.227–4.960	0.941
Fever/temperature >37.3°C	3.381	0.399–28.679	0.264
Leukocytosis $>10 \times 10^9$/L	26.680	2.468–288.410	**0.007**
Polymorphonuclear neutrophils $>7.5 \times 10^9$/L	2.267	0.615–8.361	0.219

Values in bold font indicate statistical significance.

DISCUSSION AND CONCLUSIONS

Several studies have tried to validate an appropriate score for the pediatric population, most of them resulting to be barely successful. The Alvarado score showed usefulness in males, but its sensitivity decreased within the female population of the sample.[6]

Samuel's study proposed a PAS cutoff point of 6, recommending surgery on those patients with a PAS of 6 or higher, with a sensitivity of 100% and a specificity of 92%. However, the study of Goldman et al,[1] which included every abdominal pain lasting less than 7 days, established a cutoff point of 7, with a low false-positive rate of 4%.

Later, other authors like Schneider and Bhatt showed different values, but their studies included only cases of suspected appendicitis. These studies had an appendicitis rate of 34% versus 14.5% from Goldman et al.[6] Other studies like that of Kharbanda et al[4] show a different score with the purpose of identifying those patients at low risk of appendicitis and avoiding the performance of unnecessary tests. This is important because, at the ED, there are only 2 image tests available: ultrasound (US) and abdominal computed tomography (CT). Ultrasound is safe, fast, and economic, but its sensitivity and specificity depend on the experience of the radiologist who performs it. Computed tomography, however, has sensitivity and specificity values higher than those of US and a better cost-benefit and risk-benefit value. Nevertheless, we must consider the patient's exposure to radiation because some works have demonstrated that, for each 600,000 CT performed in children per year, 500 of these children will develop cancer as a consequence of this radiation.[7]

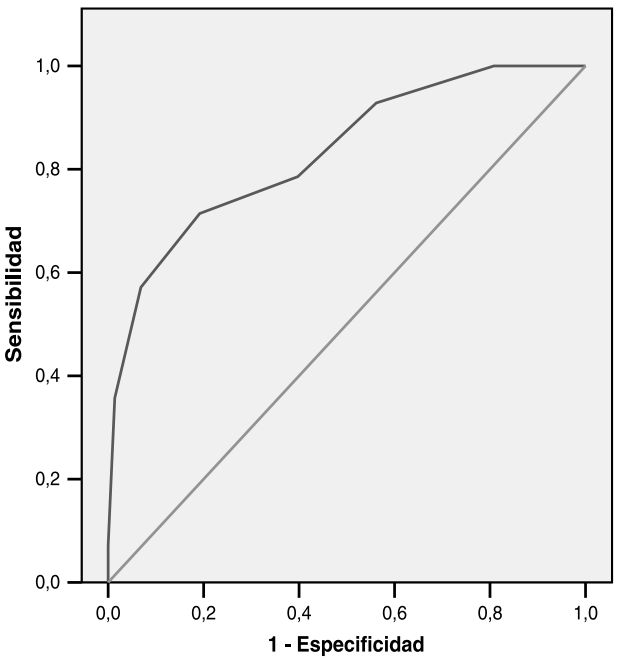

FIGURE 1. Receiver operating characteristic curve for Pediatric Appendicitis Score.

In our study, there were no patients diagnosed with appendicitis with a PAS of 3 or lower. Therefore, these patients could be discharged with no need for observation or image test performance. Before discharge, it is very important to explain to the parents about the need for requesting for medical attendance in the next 6 and 23 hours if the symptoms do not disappear because, once 23 hours have passed, the risk of perforation rises significantly.[9] Likewise, with a PAS of 8 or higher, there were only 5 patients in the control group. Therefore, if every patient with a PAS of 8 or higher would undergo surgery, without any imaging test performed, in our sample, the rate of blind appendicitis would only be 4.95% lower than that in previous studies.[8,9]

In patients with a PAS between 4 and 7, performing an image test would be recommended. Our approach includes US as the first test, and we performed CT only in rare cases. However, the approach might depend on the sensitivity and specificity of US in each center.

We have observed that, although the Blumberg sign is positive more frequently in the study group (statistically significant), this sign is positive only in 50% of the cases of real appendicitis. Thus, its absence should not reject the diagnosis. We explain this fact by the subjectivity of this test and the difficulty of a good exploration in children.

We have also observed that the less significant indicator is the temperature higher than 37.3°C. We think that this is explained by the fact that PAS points equal a temperature of 37.4 to 38°C and fever or a temperature higher than 38°C. In addition, most of the patients with no complicated appendicitis are without fever.

When analyzing patients with fever alone, there is a tendency to a statistical significance ($P = 0.073$). In fact, of the 5 patients with appendicitis and fever or a temperature higher than 38°C, 2 had perforated appendicitis and the other 3 had gangrenous appendicitis close to perforation. Because the objective of our score was to make an early diagnosis of appendicitis, it might be more accurate to consider as positive only the case with mild fever, although this matter should be researched further on future studies.

Our study has several limitations. First, our small sample size indicates that our results have to been interpreted with caution. We believe that it will be interesting to study a larger sample size, maybe from multiple centers, to have a varied sample.

Another limitation of our study is that we only included patients with a clinical suspicion of acute appendicitis not only with abdominal pain. Some items of the PAS were obtained from laboratory tests, and we considered it unethical to perform these tests to patients who do need them, at the discretion of the attending pediatrician. This makes our score applicable to patients with suspected appendicitis and not all patients with abdominal pain.

The fact that the exploration was collected only by 1 person from each patient, and not always the same person, is another limitation, making it impossible to obtain a κ value for determining interobserver agreement in collecting data. Otherwise, people who explore patients were pediatricians or residents, all of them with enough experience in this task.

Although studies such as that of Mandeville et al[3] prove that PAS has not enough prognostic value as to become the only diagnostic method, we believe that the application of this score at the ED might be helpful in making a decision and in better using resources, specially when identifying patients at low risk of appendicitis, hence avoiding the performance of unnecessary tests.

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