Appendicitis versus non-specific acute abdominal pain: Paediatric Appendicitis Score evaluation

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KEYWORDS
Appendicitis; Non-specific acute abdominal pain; Diagnosis; Clinical prediction rule; C-reactive protein; Child

Abstract
Introduction: Non-specific acute abdominal pain is the most common process requiring differential diagnosis with appendicitis in clinical practice. The aim of this study was to assess the Paediatric Appendicitis Score in differentiating between these two entities.

Material and methods: All patients admitted due to suspicion of appendicitis were prospectively evaluated in our hospital over a two-year period. Cases of non-specific acute abdominal pain and appendicitis were enrolled in the study. Several variables were collected, including Score variables and C-reactive protein levels. Descriptive, univariate and multivariate analyses and diagnostic accuracy studies (ROC curves) were performed.

Results: A total of 275 patients were studied, in which there were 143 cases of non-specific acute abdominal pain and 132 cases of appendicitis. Temperature and right iliac fossa tenderness on palpation were the variables without statistically significant differences, and with no discrimination power between groups. Pain on coughing, hopping, and/or percussion tenderness in the right lower quadrant was the variable with greater association with appendicitis.

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Appendicitis versus non-specific acute abdominal pain

The Score correctly stratified the patients into risk groups. Substitution of temperature for C-reactive protein in the Score increased diagnostic accuracy, although with no statistically significant differences.

**Conclusions:** The Paediatric Appendicitis Score helps in differential diagnosis between appendicitis and non-specific acute abdominal pain. It would be advisable to replace the temperature in the Score, since it has no discrimination power between these groups. C-reactive protein at a cut-off value of 25.5 mg/L value could be used instead.

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**Table 1** Paediatric Appendicitis Score (clinical prediction rule for paediatric appendicitis).

<table>
<thead>
<tr>
<th>Variables</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pain in RIF on palpation</td>
<td>2</td>
</tr>
<tr>
<td>Tenderness in RIF with coughing, hopping and/or</td>
<td>2</td>
</tr>
<tr>
<td>percussion</td>
<td></td>
</tr>
<tr>
<td>Migration of pain toward RIF</td>
<td>1</td>
</tr>
<tr>
<td>Anorexia</td>
<td>1</td>
</tr>
<tr>
<td>Nausea/vomiting</td>
<td>1</td>
</tr>
<tr>
<td>Temperature &gt;37.3 °C</td>
<td>1</td>
</tr>
<tr>
<td>Leukocytes &gt;10.0 × 10⁹/L</td>
<td>1</td>
</tr>
<tr>
<td>Neutrophils &gt;7.5 × 10⁹/L</td>
<td>1</td>
</tr>
<tr>
<td>RIF, right iliac fossa</td>
<td>1</td>
</tr>
</tbody>
</table>

in the diagnosis of appendicitis. Since nonspecific abdominal pain (NSAP) is the most frequent diagnosis at discharge from the emergency department in cases of acute abdominal

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**PALABRAS CLAVE**

Appendicitis; Dolor abdominal agudo inespecífico; Diagnóstico; Regla de predicción clínica; Proteína C reactiva; Niño

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**Appendicitis versus dolor abdominal agudo inespecífico: evaluación del Paediatric Appendicitis Score**

**Resumen**

*Introducción:* El dolor abdominal agudo inespecífico es el principal proceso que requiere diagnóstico diferencial con la appendicitis en la práctica clínica. El objetivo de este estudio es evaluar la utilidad del Paediatric Appendicitis Score (Regla de predicciación clínica de appendicitis pediátrica) para diferenciar estas 2 entidades.

*Material y métodos:* Se evaluó prospectivamente a los pacientes atendidos por sospecha de appendicitis en nuestro centro durante 2 años, incorporando al estudio casos de dolor abdominal agudo inespecífico y appendicitis. Se recogieron diferentes variables, incluyendo las que conforman el Score y la proteína C reactiva, que se analizaron estadísticamente de manera descriptiva, univariante y multivariante, y mediante pruebas de rendimiento diagnóstico (curvas ROC).

*Resultados:* Se estudiaron 275 casos; 143 casos de dolor abdominal agudo inespecífico y 132 casos de appendicitis. La temperatura y el dolor a palpación en fosa ilíaca derecha fueron las únicas variables que no mostraron diferencias significativas entre los grupos, careciendo de poder de discriminación. El dolor con la tos, el salto y/o la percusión fue la variable con mayor asociación a appendicitis. El Score estratificó correctamente a los pacientes en grupos de riesgo. La sustitución de la temperatura por la proteína C reactiva en el Score aumentaba su rendimiento diagnóstico, aunque sin diferencias significativas.

*Conclusiones:* El Paediatric Appendicitis Score ayuda en el diagnóstico diferencial entre appendicitis y dolor abdominal agudo inespecífico. Sería recomendable la sustitución de la temperatura en el Score, pues carece de poder de discriminación entre estos grupos. La proteína C reactiva, categorizada en el valor 25,5 mg/L, podría ser utilizada en su lugar.

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pain, and this is the process that most frequently requires differential diagnosis with appendicitis. The objective of this study was to assess the usefulness of the PAS in the differential diagnosis of appendicitis and NSAP.

Materials and methods

We conducted a prospective study of all patients aged less than 15 years assessed in the emergency department of our hospital (Complexo Hospitalario Universitario de Vigo) for suspected appendicitis between 2013 and 2014, selecting cases of appendicitis and NSAP. The inclusion criteria were: clinical suspicion of appendicitis; documentation of the variables included in the PAS (pain in the right iliac fossa [RIF] on palpation, tenderness in the RIF with coughing, hopping and/or percussion; history of pain migration toward the RIF; anorexia; nausea and/or vomiting; body temperature; total leukocyte count and total neutrophil count); serum CRP level; consent given by a parent or legal guardian of the patient to access patient data for the purpose of research. The exclusion criteria were: age less than 5 years (the PAS is difficult to obtain and has not been validated for this age group); abdominal pain lasting more than 72 h (differential diagnosis of appendicitis and NSAP is rarely needed in such cases) or less than 6 h (diagnostic tests are not usually performed at this point); history of disorder of blood or blood-forming organs, malignancy, liver disease or inflammatory disease, current or diagnosed in the month preceding onset, or antibiotic or anti-inflammatory treatment in the month preceding onset (they could alter the levels of inflammatory markers); interval of more than 12 h between collection of blood sample for analysis and appendectomy (for the adequate correlation between inflammatory markers and the type of appendicitis). The diagnosis of NSAP was made by exclusion when disease was not detected, with nonspecific findings of abdominal ultrasound in all cases, and absence of antibiotic treatment in the month following the diagnosis (to avoid including cases of appendicitis or infectious disease that had not been detected and resolved with treatment). The study was approved by the Clinical Research Ethics Committee of Galicia (2013/361).

Variables under study

We collected data for the following variables: age, sex, time elapsed between onset of abdominal pain and performance of blood tests, PAS variables, serum CRP levels and type of appendicitis (suppurative, gangrenous or perforated). Suppurative appendicitis was defined by the presence of neutrophilic infiltrate in the muscularis propria and gangrenous appendicitis by the presence of necrosis in the appendiceal wall. Perforated appendicitis was diagnosed based on the presence of a hole in the appendiceal wall or of a free appendicolith in the peritoneal cavity. We considered suppurative appendicitis uncomplicated appendicitis, and gangrenous and perforated appendicitis complicated appendicitis. We followed up cases of NSAP through outpatient visits or by phone in the first month from the diagnosis with the purpose of assessing the exclusion criteria.

All laboratory tests were performed in the haematology emergency laboratory (total leukocyte and neutrophil count) and clinical analysis laboratory (CRP) of our hospital, following routine procedure and always using the same method for each variable.

Statistical analysis

We conducted the statistical analysis with the package SPSS 19.0 for Windows (SPSS Inc; Chicago, IL, USA; 2010). We performed a descriptive analysis of all the variables under study, univariate analyses of quantitative variables with the Student t test and of qualitative variables with the 2 test, and multivariate logistic regression to detect the variables most strongly correlated with appendicitis. We also assessed the diagnostic yield of different quantitative variables and the PAS by measuring the area under the ROC curve (AUC), identifying the cut-off points with the highest discriminatory power for the diagnosis of appendicitis. Lastly, we developed a modified PAS by adding the CRP level, categorised based on the cut-off point, to the original score. We defined statistical significance as a P-value of less than .05 for all tests.

Results

During the period under study, 764 patients underwent evaluation for suspected appendicitis, and the most frequent diagnoses were NSAP, with 327 cases (42%), and appendicitis, with 273 (36%) (Table 2). The total number of patients included after applying the inclusion and exclusion criteria were 275, of who 143 were in the NSAP group and 132 in the appendicitis group (100 cases of uncomplicated appendicitis and 32 of complicated appendicitis [9 gangrenous and 23 perforated]).

Table 3 shows the descriptive analysis of the variables under study. The univariate analysis showed statistically significant differences between the NSAP and appendicitis groups in sex, but not in age or duration of symptoms. We ended up removing the variable of pain in the RIF on palpation from the analysis because it was present in all cases. There were statistically significant differences in the rest of the qualitative variables included in the PAS between the NSAP and the appendicitis groups (Table 3). The analysis of these qualitative variables by type of appendicitis also found statistically significant differences in every instance, except for nausea and/or vomiting between the NSAP and uncomplicated appendicitis groups (P = .830) (Table 4).

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Cases of suspected appendicitis (2013–2014).</th>
</tr>
</thead>
<tbody>
<tr>
<td>NSAP</td>
<td>327 (42.8%)</td>
</tr>
<tr>
<td>Appendicitis</td>
<td>273 (35.7%)</td>
</tr>
<tr>
<td>Mesenteric lymphadenitis</td>
<td>35 (4.5%)</td>
</tr>
<tr>
<td>Acute gastroenteritis</td>
<td>24 (3.1%)</td>
</tr>
<tr>
<td>Urinary tract infection</td>
<td>17 (2.2%)</td>
</tr>
<tr>
<td>Ovarian cyst</td>
<td>14 (1.8%)</td>
</tr>
<tr>
<td>Respiratory tract infection</td>
<td>11 (1.4%)</td>
</tr>
<tr>
<td>Other</td>
<td>63 (8.2%)</td>
</tr>
<tr>
<td>Total</td>
<td>764 (100%)</td>
</tr>
</tbody>
</table>

NSAP: nonspecific abdominal pain.
Table 3 Descriptive and univariate analysis of NSAP and appendicitis groups.

<table>
<thead>
<tr>
<th>Variable</th>
<th>NSAP</th>
<th>Appendicitis</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex, male/female (ratio)</td>
<td>60/83</td>
<td>93/39</td>
<td>&lt;.001&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Age, mean (years) ± SD</td>
<td>10.4 ± 2.5</td>
<td>9.9 ± 2.5</td>
<td>.152&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Duration of symptoms (h) ± SD</td>
<td>25.8 ± 16.9</td>
<td>24.2 ± 15.9</td>
<td>.406&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Tenderness with coughing, hopping and/or percussion, n (%)</td>
<td>20 (14.0)</td>
<td>84 (63.6)</td>
<td>&lt;.001&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Migration of pain to RIF, n (%)  
Anorexia, n (%)  
Nausea and/or vomiting, n (%)  
Body temperature (°C), mean ± SD  
Leukocytes (<10⁹/L), mean ± SD  
Neutrophils (<10⁹/L), mean ± SD  
CRP (mg/L), mean ± SD

Table 5 Logistic regression analysis.

<table>
<thead>
<tr>
<th>Variable</th>
<th>OR</th>
<th>95% CI</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tenderness with coughing/hopping/percussion</td>
<td>20.0</td>
<td>7.8–51.3</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Migration of pain to the RIF</td>
<td>11.4</td>
<td>4.5–28.9</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Anorexia</td>
<td>7.5</td>
<td>3.2–17.5</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Neutrophils &gt;7.5 × 10⁹/L</td>
<td>7.3</td>
<td>1.3–41.2</td>
<td>.025</td>
</tr>
<tr>
<td>Leucocytes &gt; 0.0 × 10⁹/L</td>
<td>4.9</td>
<td>0.7–31.0</td>
<td>.093</td>
</tr>
</tbody>
</table>

CI, confidence interval; OR, odds ratio; RIF, right iliac fossa.

The analysis of the diagnostic yield based on the AUCs of ROC curves for body temperature and inflammatory markers in the appendicitis vs NSAP groups (Table 6) showed that the yield of body temperature was all but negligible (AUC, 0.51), the yield of CRP was low (AUC, 0.64) (Fig. 1) and the yield of leukocyte and neutrophil counts was moderate (AUC, 0.79). In this analysis, the PAS exhibited a high yield (AUC, 0.90), with 3 and 7 being the best cut-off points for the differentiation of low-, intermediate- and high-risk groups. The analysis of the modified PAS where body temperature was replaced by CRP category based on the cut-off point (CRP < 25.5 mg/L: 0 points; CRP > 25.5 mg/L: 1 point) showed that it had a higher diagnostic yield compared to the PAS (ROC, 0.92), although the difference was not statistically significant (P = 0.552) (Table 6) (Fig. 1). The modified PAS improved patient stratification, placing a greater number of NSAP cases in the low-risk group and of complicated appendicitis cases in the high-risk group (Table 7).

Discussion

Nonspecific abdominal pain refers to an acute abdominal pain process without a suspected organic cause that is self-limiting and does not recur. It is a diagnosis of exclusion that is safe in children, as a specific disease is subsequently found in only 1.6% to 5.8% of diagnosed cases with a low associated risk of undetected appendicitis. It is the most frequent discharge diagnosis in cases of acute abdominal pain in paediatric emergency departments, and the process that most frequently requires a differential diagnosis with appendicitis in clinical practice. In our study, NSAP was the most frequent diagnosis (42%) in cases of suspected appendicitis.

Non-specific abdominal pain is distributed fairly evenly between the two sexes, but appendicitis is more frequent in males, with a male: female ratio of 1.5–1.9:1, a fact
Table 6 Area under ROC curve and cut-off points for variables and the PAS in the differentiation of appendicitis and NSAP.

<table>
<thead>
<tr>
<th>Variable</th>
<th>AUC</th>
<th>95% CI</th>
<th>COP</th>
<th>Sen, %</th>
<th>Spe, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body temperature (°C)</td>
<td>0.51</td>
<td>0.44–0.57</td>
<td>37.2</td>
<td>50.8</td>
<td>53.1</td>
</tr>
<tr>
<td>Leucocytes (×10^9/L)</td>
<td>0.79</td>
<td>0.74–0.85</td>
<td>10.5</td>
<td>89.4</td>
<td>57.3</td>
</tr>
<tr>
<td>Neutrophils (×10^9/L)</td>
<td>0.79</td>
<td>0.73–0.84</td>
<td>7.5</td>
<td>90.2</td>
<td>60.1</td>
</tr>
<tr>
<td>CRP (mg/L)</td>
<td>0.64</td>
<td>0.56–0.71</td>
<td>25.5</td>
<td>43.2</td>
<td>79.7</td>
</tr>
<tr>
<td>PAS (1–10)</td>
<td>0.90</td>
<td>0.87–0.94</td>
<td>3</td>
<td>99.6</td>
<td>21.3</td>
</tr>
<tr>
<td>PAS-CRP (1–10)</td>
<td>0.92</td>
<td>0.89–0.95</td>
<td>7</td>
<td>57.5</td>
<td>96.2</td>
</tr>
</tbody>
</table>

Table 6: Area under ROC curve and cut-off points for variables and the PAS in the differentiation of appendicitis and NSAP. 

AUC, area under the curve; CI, confidence interval; CRP, C-reactive protein; COP, cut-off point with highest discriminatory power; NSAP: nonspecific abdominal pain; PAS, Paediatric Appendicitis Score; PAS-CRP, modified PAS including CRP; Sen, sensitivity; Spe, specificity.

Figure 1 Receiver operating characteristic curves for body temperature and CRP (A) and for the PAS and the PAS modified with addition of the CRP (B) for differentiation of appendicitis and NSAP.

Table 7 PAS and modified PAS in NSAP and different types of appendicitis.

<table>
<thead>
<tr>
<th></th>
<th>NSAP</th>
<th>UA</th>
<th>CA</th>
</tr>
</thead>
<tbody>
<tr>
<td>PAS</td>
<td>1–3</td>
<td>41 (28.7%)</td>
<td>1 (1.0%)</td>
</tr>
<tr>
<td></td>
<td>4–7</td>
<td>101 (70.6%)</td>
<td>61 (61.0%)</td>
</tr>
<tr>
<td></td>
<td>8–10</td>
<td>1 (0.7%)</td>
<td>38 (38.0%)</td>
</tr>
<tr>
<td>PAS-CRP</td>
<td>1–3</td>
<td>46 (32.2%)</td>
<td>1 (1.0%)</td>
</tr>
<tr>
<td></td>
<td>4–7</td>
<td>95 (66.4%)</td>
<td>64 (64.0%)</td>
</tr>
<tr>
<td></td>
<td>8–10</td>
<td>2 (1.4%)</td>
<td>35 (35.0%)</td>
</tr>
</tbody>
</table>

Table 7: PAS and modified PAS in NSAP and different types of appendicitis.

CA, complicated appendicitis; NSAP, nonspecific abdominal pain; PAS: Paediatric Appendicitis Score; PAS-CRP, Paediatric Appendicitis Score modified to include C-reactive protein; UC, uncomplicated appendicitis.

reflected in the larger proportion of this sex in our group of patients (2.4:1 ratio).

Up to 40% to 50% of appendicitis cases may present without one or more of the classic signs or symptoms, such as migration of abdominal pain toward the RIF, signs of peritoneal irritation or anorexia. In our study, we found statistically significant differences between cases of appendicitis and cases of NSAP in all the signs and symptoms under study except for body temperature and pain in RIF on palpation, although a considerable percentage of patients did not exhibit a classic presentation.

There is evidence that peritoneal irritation, such as abdominal pain on percussion, and a history of migration of abdominal pain toward the RIF are the strongest predictors of appendicitis. In our multivariate analysis, these two variables exhibited the strongest associations with appendicitis, with odds ratios of 20 and 11, respectively. The strong association of coughing, hopping and/or percussion tenderness, which assesses the presence of peritoneal irritation in the PAS, explains the higher weight it is given in the score.

Some studies have already suggested that body temperature is of limited use in the diagnosis of appendicitis. In our study, body temperature was not useful in differentiating between appendicitis and NSAP. The inflammatory markers used most commonly in the diagnosis of appendicitis are the total leukocyte count, the
total neutrophil count and the serum level of CRP, and to
date no other markers have been found that offer better
results. There is considerable variability in the sensitivity
and specificity of leukocyte and neutrophil counts reported
in the literature, with values ranging from 55% to 89% and
from 43% to 66%, respectively.18,19 Their low specificity is
due to the elevation of these counts in many other pro-
cesses that manifest with pain in the RIF.16,20 They are more
useful in the first 24 h from onset, as inflammatory and infec-
tious processes are associated to neutrophil activation in
the first 3–6 h from onset.21 For the purpose of diagnosing
appendicitis, leukocytes and neutrophils are considered to be
elevated when their total counts exceed $10.0 \times 10^9$ /L and
$7.5 \times 10^9$ /L, respectively.4,16,22 The cut-off points with the
most discriminatory power and the sensitivity and speci-
ficity found in our study were consistent with the existing
literature.

There is also considerable variability in the values
reported in the literature for the sensitivity and speci-
ficity of CRP in the diagnosis of appendicitis, which range
from 58% to 100% and from 28% to 93%, respectively.19,23
C-reactive protein is a nonspecific biomarker of inflamma-
tion whose synthesis starts 4–6 h after the stimulus, with its
doubling every 8 h, so that serum levels are significantly
elevated starting at 12–24 h.24 The discrimina-
tory power of CRP for the diagnosis of appendicitis is not
high, especially in the early stages, whereas its value is within
ranges compatible with other processes, but CRP levels are
useful for differentiating between uncomplicated and com-
pliated appendicitis.19,23,25 Several studies have shown that
CRP concentrations between 10 and 50 mg/L are associated
with uncomplicated appendicitis, with a greater proba-
bility of complications (gangrene or perforation) at higher
concentrations.4,16,26 In our study, CRP was moderately use-
ful for differentiating between appendicitis and NSAP. The
assessment of its diagnostic yield through the analysis of ROC
curves identified a cut-off point for discriminating appendi-
citis that was similar to those reported in the literature
(25.5 mg/L).

There is evidence that the combination of different
inflammatory markers increases their discriminatory and
predictive power in the diagnosis of appendicitis.15,17,21 The
combination of the total leukocyte count and the CRP level
reaches sensitivity and specificity values of 90%-95% for
the prediction of appendicitis, with a stronger correla-
tion between elevation of both values and the severity of
disease.13,25,26 This increase in discriminatory and predictive
power obtained through the combination of the leukocyte
count and CRP level makes the addition of the CRP concen-
tration to the PAS variables particularly attractive.

In recent decades, several clinical prediction rules have
been developed for the diagnosis of appendicitis in chil-
dren, and their use in clinical practice has been associated
with an increase in diagnostic accuracy and a decreased
rate of perforation.28 The PAS prediction rule, published in
2000, is the rule that has been most thoroughly evaluated
in the paediatric age group.29–31 It was developed through a
multiple linear logistic regression analysis of clinical and
laboratory parameters after the prospective evaluation of
1170 children with suspected appendicitis aged 4–15 years.
It comprises 8 variables with a statistically significant asso-
ciation that were assigned values based on their sensitivity,
specificity, predictive values and diagnostic accuracy, so
that the rule categorises patients by risk of appendicitis
on a 10-point scale.4 Recent systematic reviews of dif-
ferent appendicitis prediction rules used in children have
concluded that the validation studies for the PAS are of
higher methodological quality, and that this score offers
a superior diagnostic yield (sensitivity of 93% and nega-
tive predictive value of 10%), with level 2 evidence (rule
broadly validated in multiple settings) according to the hi-
erarchy of evidence for clinical prediction rules published by
the Evidence-Based Medicine Working Group.7,22 Although
at present it is recommended that the PAS be used with caution
in clinical practice, since it does not achieve a diagnostic
yield deemed sufficient,5,29,31 the literature also recognises
its usefulness in the stratification into low- and high-risk
groups of patients in whom further diagnostic tests may then
be rendered unnecessary.30,31,34 in guiding clinical decision
making, and in improving the use of resources.5,35 The PAS
is also useful as a tool for predicting appendicitis severity
and the risk of complications, and can guide the decision to
repeat a structured physical examination during the obser-
vation period.4,33

Variables in clinical prediction rules have rarely been
replaced by other variables,36 and based on the reviewed
literature, this has never been done in the PAS. Given that
body temperature is of little use in differentiating between
appendicitis and NSAP, we substituted the CRP level for it
in the PAS. This modified PAS improved the diagnostic yield
noticeably, as it distributed patients more appropriately in
the different risk groups, although the difference was not
statistically significant.

Some of the possible limitations of the study are: a) the
impossibility of performing histopathological examination
of the appendix, considered the diagnostic gold standard
for appendicitis, in patients in the NSAP group (partial ver-
ification or workup bias).15,37 These unoperated patients
are presumed to be NSAP cases, but epidemiology stud-
ies and observational studies that used imaging tests have
demonstrated that cases of uncomplicated appendicitis may
resolve spontaneously,5,29 so we cannot exclude that some
cases categorised as NSAP were actually cases of resolved
appendicitis. b) The heterogeneity of the NSAP group, with
the potential inclusion of undetected cases of specific dis-
eseas (spectrum bias).37 We attempted to minimise this
bias through the inclusion and exclusion criteria. c) The
time elapsed between performance of laboratory tests and
appendectomy (disease progression bias).37 To reduce this
bias, we excluded cases where this interval exceeded 12 h.

Conclusions

The PAS may be helpful in the differential diagnosis of
appendicitis and NSAP, correctly stratifying patients by risk
of appendicitis. Tenderness in the RIF on coughing, hopping
and/or percussion is the variable most strongly associated
with appendicitis, which justifies its higher weight in the
PAS score. Substituting the CPR level for the body temper-
ature in this score would be advisable, as the latter lacks
power to discriminate between NSAP and appendicitis. The
CRP level, categorised based on the best cut-off point for the
discrimination of appendicitis (25.5 mg/L), could be used in
its place, for while it exhibits only a moderate ability to dif-
ferentiate between appendicitis and NSAP, when combined
with the leukocyte and neutrophil counts, its value can be
particularly useful in the diagnosis of appendicitis.

Conflicts of interest

The authors have no conflicts of interest to declare.

References

1. Wai S, Ma L, Kim E, Adekunle-Ojo A. The utility of the emergency
department observation unit for children with abdominal pain.
3. Cheong LH, Emil S. Determinants of appendicitis outcomes in
5. Kulkik DM, Uleryk EM, Maguire JL. Does this child have appendici-
tis? A systematic review of clinical prediction rules for children
Correlation of serum C-reactive protein, white blood
count and neutrophil percentage with histopathology findings
7. Schellekens DH, Hulswé KW, van Acker BA, van Bijnen AA,
de Jaegere TM, Sastrowijoto SH, et al. Evaluation of the
diagnostic accuracy of plasma markers for early diagnosis in
patients suspected for acute appendicitis. Acad Emerg Med.
8. Barker PA, Jutley RS, Youngson GG. Hospital re-admission in
9. Pennel DJ, Goergen N, Driver CP. Non-specific abdominal pain is
2000;4:46–58.
11. St Peter SD, Sharp SW, Holcomb GW, Ostlie DJ. An evidence-
based definition for perforated appendicitis derived from a
outcomes following childhood non-specific abdominal pain: a
13. Aarabi S, Sidiwfa F, Riehle KJ, Chen Q, Mooney DP. Pediatric
appendicitis in New England: epidemiology and outcomes.
14. Becker T, Kharbanda A, Bachur R. Atypical clinical features of
15. Andersson RE. Meta-analysis of the clinical and laboratory diagnos-
16. Hale DA, Molloy M, Pearl RH, Schutt DC, Jaques DP. Appendec-
17. Andersson RE, Hugander A, Ravin H, Offenberg K, Ghazi SH, Nys-
tron PO, et al. Repeated clinical and laboratory examinations
in patients with an equivocal diagnosis of appendicitis. World J
18. Paajanen H, Sompi E. Early childhood appendicitis is still a
19. Stefanutti G, Ghirardo V, Gamba P. Inflammatory markers for
Diagnostic value of blood inflammatory markers for detec-
tion of acute appendicitis in children. BMC Surg. 2006;
6:15.
Kessel KP. The role of tumour necrosis factor in the factor-
etics of lipopolysaccharide-mediated neutrophil priming in whole
22. Prada-Arias M, Vázquez JL, Salgado-Barreira A, Gómez-Veiras
J, Montero-Sánchez M, Fernández-Lorenzo JR. Diagnostic accu-
racry of fibrinogen to differentiate appendicitis from nonspecific
66–70.
23. Calvo Riguil F, Sendra Esteve S, Míalaret Lahiguera A, Montagud
Beltrán E, Llames Domingo S, Medrano González J. The value of
C-reactive protein in the diagnosis of acute appendicitis in
24. Allister L, Bachur R, Glickman J, Horwitz B. Serum markers in
25. Wu HP, Lin CY, Chang CF, Chang YJ, Huang CY. Predictive value
of C-reactive protein at different cutoff levels in acute appendi-
26. Sánchez Echániz J, Luis García M, Vázquez Ronco MA, Minteguí
Raso S, Benito Fernández J, López Alvarez-Buhilla P. Diagnostic
value of reactive C protein in suspected acute appendicitis in
27. Kwan KY, Nager AL. Diagnosing pediatric appendicitis: usefulness
28. Shera AH, Nizami FA, Malik AA, Naikoo ZA, Wani MA. Clinical
scoring system for diagnosis of acute appendicitis in children.
29. Schneider C, Kharbanda A, Bachur R. Evaluating appendicitis
scoring systems using a prospective pediatric cohort. Ann Emerg
Langer JC. Prospective validation of the pediatric appendicitis
Prospective validation of the pediatric appendicitis score in a
Canadian pediatric emergency department. Acad Emerg Med.
32. Maguire JL, Kulkik DM, Laupacis A, Kuppermann N, Uleryk EM,
Parkin PC. Clinical prediction rules for children: a systematic
scores in the pediatric ED. Am J Emerg Med. 2011;29:
972–7.
34. Hatcher-Ross K. Sensitivity and specificity of the Pediatric
35. Zúñiga RV, Arribas JL, Montes SP, Fernandez MN, Abad CG, Martín
LG, et al. Application of Pediatric Appendicitis Score on the
emergency department of a secondary level hospital. Pediatri
36. Srinivasan A, Servaes S, Peña A, Darge K. Utility of CT after
sonography for suspected appendicitis in children: integration
of a clinical scoring system with a staged imaging protocol.
diagnostic tests and diagnostic accuracy in surgical research.
38. Cobben LP, de Van Otterloo AM, Puylaert JB. Guidelines for
resolving appendicitis: frequency and natural history in 60
39. Kirshenbaum M, Mishra V, Kuo D, Kaplan G. Resolving appendici-