

# Diagnostic value of inflammatory markers (complete blood count, erythrocyte sedimentation rate, and C-reactive protein) in children with acute appendicitis

Omid Amanollahi<sup>a</sup>, Javad Salimi<sup>b</sup> and Diana Noemi Diaz<sup>c</sup>

**Objective** The aim of the study was to evaluate the diagnostic value of inflammatory markers [complete blood cell count (CBC), erythrocyte sedimentation rate (ESR), C-reactive protein (CRP)] for the differentiation of acute appendicitis from nonspecific abdominal pain in children.

**Patients and methods** In this prospective study, 150 children admitted for referral to Mohammad Kermanshahi Hospital (Kermanshah, Iran) (from June 2011 to May 2012), and suspected to have acute appendicitis were enrolled. Careful assessment of history and observation of physical signs were performed and evaluated during the hospitalization period; decisions to operate or to observe were made on the basis of clinical characteristics. Patients who had acute appendicitis, according to the pathologic report, were included in the study group and patients who had nonspecific abdominal pain were included in the control group. Venous blood samples were taken from all patients on admission and sent to the laboratory and CBC, ESR, and CRP levels were measured. Serum CRP level more than 8 µg/ml, ESR more than 20 mm/h, and white blood cell (WBC) count more than 10 000/mm<sup>3</sup> were considered abnormal. Sensitivity, specificity, positive predictive, and negative predictive values were calculated for each test and in combination.

**Results** In total, 150 patients were studied in two groups; 54% were females and 46% were males. The mean age of the patients was 7.7 ± 1.3 years in the study group and

8.7 ± 1.3 years in the control group. In the study group, 80% had leukocytosis (WBC > 10 000), 64% had elevated ESR, and 70.6% had elevated CRP. However, in the control group (nonspecific abdominal pain), 17.3% had leukocytosis, 25.3% had elevated ESR, and 26.6% had elevated CRP.

**Conclusion** The results of our studies showed that inflammatory markers in patients with acute appendicitis are significantly higher than those in children who have nonspecific abdominal pain. Measurement of these markers is valuable in the diagnosis of appendicitis in children. The diagnostic value of CBC is higher than that of ESR and CRP. *Ann Pediatr Surg* 10:39–41 © 2014 Annals of Pediatric Surgery.

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**Keywords:** acute appendicitis, childrens, inflammatory markers (complete blood count, erythrocyte sedimentation rate, and C-reactive protein), leukocytosis

<sup>a</sup>Department of Pediatric Surgery, Mohammad Kermanshahi Hospital, <sup>b</sup>Department of Pediatric Surgery, Imam Reza Hospital, Kermanshah University of Medical Sciences, Kermanshah and <sup>c</sup>Department of Pediatric Surgery, Madani Hospital, Zanjan University of Medical Sciences, Zanjan, Iran

Correspondence to Omid Amanollahi, MD, Department of Pediatric Surgery, Mohammad Kermanshahi Hospital, Kermanshah University of Medical Sciences, PO Box 6714415333, Kermanshah 6714745886, Iran  
Tel: +98 831 427 6315; fax: +98 831 427 6315;  
e-mail: oamanollahi@yahoo.com

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## Introduction

Abdominal pain is a common problem in children. Although most children with acute abdominal pain have self-limited conditions, the pain may lead to surgical or medical emergency. The most difficult challenge is making a timely diagnosis so that treatment can be initiated and morbidity can be prevented. Although many cases of acute abdominal pain are benign, some require rapid diagnosis and treatment to minimize morbidity. Usually diagnosis of acute appendicitis is not difficult but sometimes its differentiation from non specific abdominal pain is a problem [1]. Imaging diagnostic methods can increase the diagnostic accuracy, but diagnosis of other causes of abdominal pain in children may be difficult, especially when the child does not talk, delaying definitive treatment [2]. Measurement of inflammatory markers such as white blood cell (WBC) count, C-reactive protein (CRP), and erythrocyte sedimentation rate (ESR) is commonly used to support the clinical diagnosis of appendicitis, although many other conditions can result in an increase of those indicators as well.

The aim of this study was to compare the increase in inflammatory markers in cases of confirmed acute appendicitis from other causes of abdominal pain that were suspected to be appendicitis initially.

## Patients and methods

This was a prospective study that included 150 consecutive patients, aged between 3 and 12 years, suspected of having acute appendicitis who were admitted to the referral Pediatric Surgical Department, Mohammad Kermanshahi Teaching Hospital (Kermanshah, Iran). This study was carried out from June 2011 to May 2012. The inclusion criterion was abdominal pain leading to a suspicion of acute appendicitis. All other known surgical or nonsurgical reasons for abdominal pain were excluded in the study (on the basis of clinical exam, assessment of history, and other investigations). Informed consent obtained from all patients and, or their parents (depending of patients age). This research was approved by the Research Ethics Committee of the Kermanshah University of Medical Sciences.

Careful assessment of history and observation of physical signs were performed and evaluated during the hospitalization period. The decision to operate or not was made on the basis of clinical characteristics. The patients were classified into two groups: the study group included children who underwent appendectomy, with appendicitis confirmed by pathology report, and the control group included patients who were suspected to have acute appendicitis initially, but their signs and symptoms resolved after a short period of observation. They did not undergo appendectomy and were discharged. Most of them had nonspecific abdominal pain. In addition, a few patients underwent appendectomy, but had normal appendix on the basis of the pathology report. After appendectomy, all specimens were sent to pathology in order to confirm the diagnosis. If it was confirmed, the patient remained in the study group and if not, he/she was switched to the control group – suspicious of appendicitis. Sampling was continued in each group until reaching 75 cases (total 150). All abdominal examinations were performed by the same pediatric surgeon. Blood samples were collected at the time of admission for the measurement of inflammatory markers (WBC count, CRP, and ESR). WBC count more than  $10\,000/\text{mm}^3$ , ESR greater than  $20\text{ mm/h}$ , and CRP level higher than  $8\mu\text{g/ml}$  were considered abnormal. The results of laboratory tests were compared; the sensitivity, specificity, and positive and negative predictive values were calculated for each test and in combination.

### Statistical analysis

Statistical analysis was carried out using the descriptive  $\chi^2$  *t*-test and statistical methods such as the Mann–Whitney *U*-test. To evaluate the sensitivity and specificity of data, the receiver operating characteristic curve analysis test was used.

### Results

In this study, 150 patients were divided into two groups: the study group, which included patients with definitive acute appendicitis according to the pathology reports, and a control group, which included patients who improved with conservative management or underwent appendectomy, but had normal appendix according to the pathology reports.

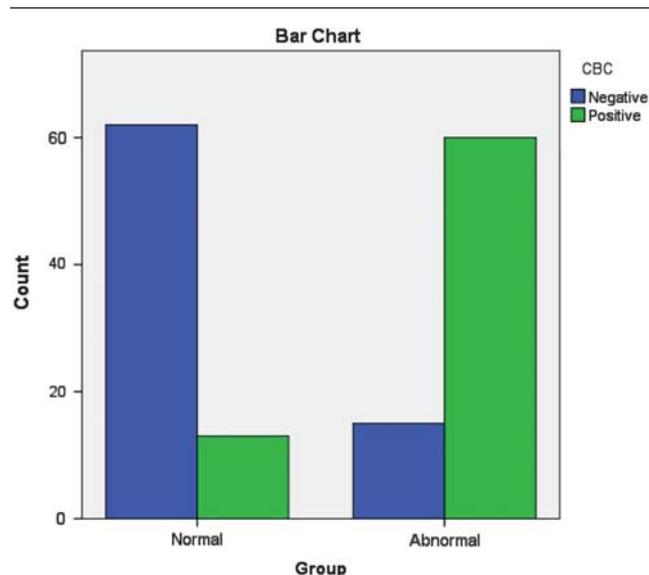
The mean age of the patients was  $7.7 \pm 1.3$  years in the study group and  $8.7 \pm 1.3$  years in the control group. There was no statistically significant difference between the mean age in both groups. The ratio of girls to boys was 42 to 33 in the study group and 39 to 36 in the control group. There was no statistically significant difference in the sex distribution between groups.

### Results of laboratory analysis

Sixty of 75 (80%) patients in the study group had leukocytosis whereas in the control group (nonappendicitis), 13 of 75 (17.3%) patients had leukocytosis as shown in Fig. 1.

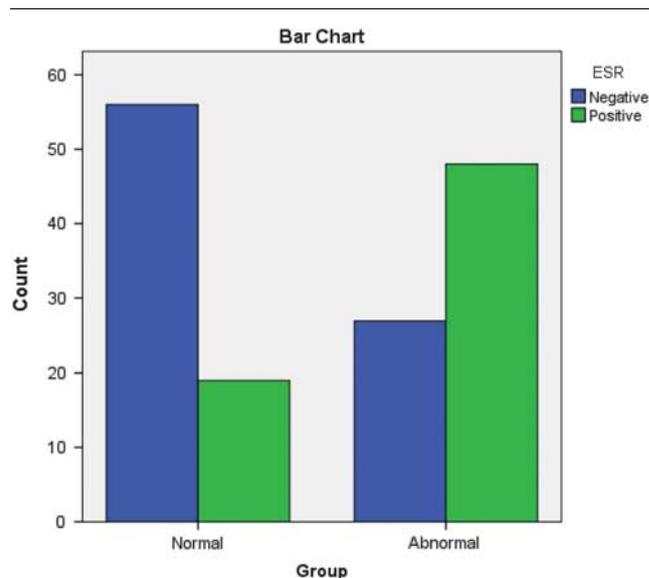
Forty-eight (64%) patients in the study group and 19 (25.3%) children in the control group (nonappendicitis) had elevated ESR as shown in Fig. 2.

Fig. 1



Comparison of leukocytosis in the abnormal group (acute appendicitis) and the normal group (nonspecific abdominal pain). CBC, complete blood cell count.

Fig. 2

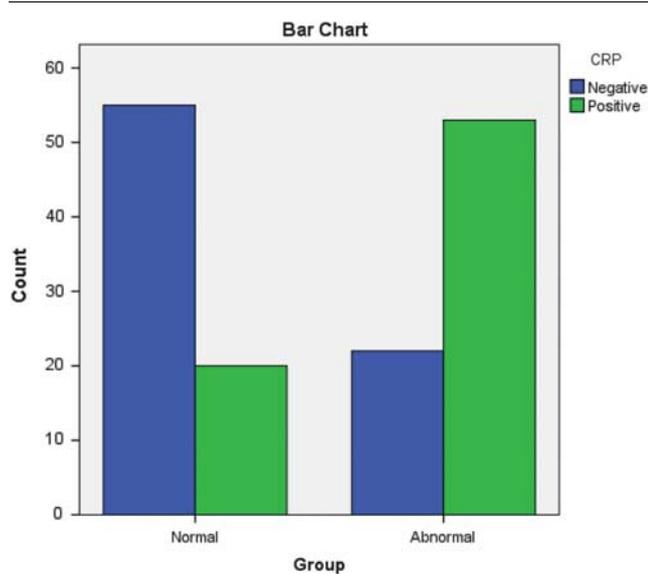


Comparison of elevated erythrocyte sedimentation rate (ESR) in the abnormal group (acute appendicitis) and the normal group (nonspecific abdominal pain).

Fifty-three (70.6%) cases in the study group and 20 (26.6%) in the control group had elevated CRP as shown in Fig. 3.

Given the above data, it appears that the elevated levels of complete blood cell count (CBC), ESR, and CRP are significant in patients with acute appendicitis compared with the control group. Statistical analysis showed that leukocytosis in patients diagnosed with acute appendicitis had 80% sensitivity and 82% specificity, with a positive predictive value of 82% and a negative predictive value of 80%.

Fig. 3



Comparison of elevated C-reactive protein (CRP) in the abnormal group (acute appendicitis) and the normal group (nonspecific abdominal pain).

Elevated ESR in patients with acute appendicitis had a sensitivity of 64%, specificity of 74%, a positive predictive value of 71%, and a negative predictive value of 67%. CRP elevation in patients with appendicitis had a sensitivity of 70%, specificity of 73%, a positive predictive value of 72%, and a negative predictive value of 73%.

### Discussion

The results of our study showed that blood levels of WBC, ESR, and CRP increase significantly in children with acute appendicitis. The diagnostic value of CBC is higher than that of ESR and CRP.

A similar study showed that WBC count, CRP, and interleukin-6 (IL-6) correlated significantly with the severity of appendiceal inflammation. Identification of children with severe appendicitis was supported by IL-6 or CRP, but not WBC. Between IL-6 and CRP, there were no significant differences in diagnostic use [3]. Another study has been carried out to assess the diagnostic value of procalcitonin (PCT) in emergency department (ED) patients with suspected appendicitis.

The result of that study does not support the hypothesis that the PCT test may be useful for screening ED patients for appendicitis. However, determination of the PCT level may be useful for risk assessment of ED patients with suspected complicated appendicitis [4]. In our study, we found that when all three markers increased, all of the cases corresponded to acute appendicitis.

Another study by Yildirim *et al.* [5] showed that WBC or CRP values alone do not appear to provide any useful additional information to the surgeon. However, the

sensitivity of the two combined tests is very high, and normal values of both WBC and CRP are very unlikely in pathologically confirmed appendicitis.

In our study, CRP had a sensitivity of 73% and a specificity of 70%. Ng and Lai [6] reported that using a combination of elevated CRP, leukocytosis, and elevated neutrophil ratio, satisfactory specificity, and positive predictive value were obtained in the diagnosis of acute appendicitis.

Another study compared imaging with laboratory tests and concluded that ultrasonography was a more accurate diagnostic method than IL-6 serum concentration (laboratory marker with the highest diagnostic accuracy in their study), and hence, it should be a part of the diagnostic procedure for acute appendicitis in children [7].

In our study, in about 79% of patients with acute appendicitis, both ESR and CRP were increased.

### Conclusion

The results of our study showed that inflammatory markers (CBC, ESR, and CRP) increased in patients with acute appendicitis. The diagnostic value of CBC is higher than that of ESR and CRP. The sensitivity of CRP is higher than that of ESR, but the specificity of ESR is higher than that of CRP.

Determination of these serum markers in children suspected to have acute appendicitis can be a useful diagnostic tool and can result in better decision making, faster necessary surgical interventions, and finally, reduction in disease morbidity and improvement in the long-term outcome of acute appendicitis in children.

### Acknowledgements

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### Conflicts of interest

There are no conflicts of interest.

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