The diagnostic value of C-reactive protein and white blood cell count in diagnosis of acute appendicitis

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Introduction
Appendectomy is one of the commonest operations performed annually. Despite the advancement in the laboratory tests and radiological tests, still the rate of negative appendectomies is 15–30%. This study was designed to assess the diagnostic value of quantitative C-reactive protein (CRP) and white blood cell count (WCC) in patients suspected to have acute appendicitis.

Patients and methods
Our study is a prospective study that was conducted between December 2012 and March 2013 after approval of the ethical committee.

Inclusion criteria
1. Patients with clinically diagnosed acute appendicitis without generalized peritonitis.

Exclusion criteria
1. Patients with generalized peritonitis

All patients were subjected to the following
1. Clinical examination
2. Routine bloods immediately after decision to admit including full blood count and CRP.
3. Urine test
4. Pregnancy test for all females
5. Ultra sound scan to rule out other causes of abdominal pain

All the patients were operated upon via open approach and the appendix was sent for histopathological analysis and the results were compared with C-Reactive protein (CRP) and the WBC (White blood cell count) and the results were compared using *t*-tests.

Results
Our study recruited 100 patients, 60 males (60%) and 40 females (40%), in the age range 20–55 years. The histopathological analysis showed acute appendicitis in 85 patients (85%), the operative notes showed 60 patients with noncomplicated appendicitis, 25 patients with complicated appendicitis; the WCC alone has a sensitivity of 85%, specificity of 75%, CRP alone has a sensitivity of 93.3% and specificity of 86.6%, WCC alone had positive predictive value of 44% and it improves to 70% when both parameters are combined together, whereas the negative predictive value of the WCC was 100%. In patients with normal appendix the mean CRP level was 10.6 mg/l, the median level was 10.6 mg/l, and the mean WCC was 8×10^9 cells/l, the median WCC 7×10^9 cells/l, whereas in patients with noncomplicated acute appendicitis ($n = 60$) the mean CRP was 40 mg/l, the median was 20 mg/l; in patients with complicated appendicitis ($n = 25$) the mean CRP was 90 mg/l and the median was CRP 60 mg/l.

Conclusion
We suggest that patients experiencing lower abdominal pain, with normal CRP values and normal WCC are unlikely to have acute appendicitis and need further investigations before embarking onto surgery.

Keywords:
acute appendicitis, C-reactive protein, inflammatory markers

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Introduction

Acute appendicitis is one of the most common causes of hospital admission in the emergency settings, and appendectomy is one of the most common surgical procedures all over the world and despite the advancement in the diagnostic and laboratory methods still the rate of negative appendectomy is 15–30% [1].

Health systems nowadays are driven by the cost effectiveness; thus, many studies evolved to find tests that could increase the accuracy of diagnosis and reduce the number of unnecessary operations. C-reactive protein (CRP) and white blood cell count (WCC) are inflammatory markers used in the diagnosis of infection. CRP was first identified in 1930 by Tillet and Francis. It is an acute phase protein produced in the liver. Normal serum concentration is less than 10 mg/l, and it usually increases 8–12 h after infection or trauma. Production of CRP is controlled by interleukin-6. CRP is increased in infections,

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inflammatory arthritis, autoimmune disorders, neoplasia, and pregnancy [2].

The aim of this study was to analyze the role of CRP and WCC values, in the accuracy of diagnosis of acute appendicitis.

Patients and methods

Our study is a prospective study that was conducted between December 2012 and March 2013 after approval of the ethical committee.

Inclusion criteria

Patients with clinically diagnosed acute appendicitis without generalized peritonitis.

Exclusion criteria

Patients with generalized peritonitis.

All patients were subjected to the following:

(1) Clinical examination.
(2) Routine blood tests immediately after decision to admit including full blood count and CRP.
(3) Urine test.
(4) Pregnancy test for all females.
(5) Ultrasound scan to rule out other causes of abdominal pain.

All the patients were operated upon through the open approach and the appendix was sent for histopathological analysis and the results were compared with CRP and the WBC (WCC) and the results were compared using *t*-tests.

Results

Our study recruited 100 patients, males were 60 patients (60%) and females 40 patients (40%), and the age range was 20–55 years.

The histopathological analysis showed acute appendicitis in 85 patients (85%) and normal appendix in 15 patients (15%); the different causes of abdominal pain are shown in Table 1. The operative notes showed 60 patients with noncomplicated appendicitis and 25 patients with complicated appendicitis.

This study showed that WCC alone has a sensitivity of 85% and specificity of 75%, whereas on the other hand raised CRP alone has a sensitivity of 93.3% and specificity of 86.6% and our results showed that WCC alone had a positive predictive value of 44% and it improves to 70% when both parameters are combined together, whereas the negative predictive value of the WCC was 100% and none of the patients with normal levels showed acute appendicitis (Table 2).

In the group of patients with normal appendix the mean CRP level was 10.6 mg/l and the median level was 10.6 mg/l, and the mean WCC was 8×10^9 cells/l, the median WCC was 7×10^9 cells/l. In patients with histopathological proven appendicitis we divided them into two groups, a group that included patients without complicated appendicitis (n = 60) and a group that included patients with complicated appendicitis (n = 25) depending on the intraoperative notes. The mean CRP in the first group was 40 mg/l and the median was 20 mg/l, whereas in the group of complicated appendicitis the mean CRP was 90 mg/l and the median CRP was 60 mg/l (Table 3).

Discussion

Although acute appendicitis is considered as one of the commonest surgical emergencies, still the diagnosis could be difficult and appendectomy for normal appendix usually ranges from 15 to 30% [1].

In our study, the tissue histopathology showed normal appendix in 15% of the patients, which goes with the same results published by Lu and colleagues in 2007,

Table 1 Causes of abdominal pain

Ruptured ovarian cyst	8 patients
Mesenteric adenitis	3 patients
Nonspecific pain	4 patients

Table 2 Sensitivity, specificity, positive predictive value and negative predictive value for white cell count and C-reactive protein

	WCC raised	CRP raised	Both raised	One raised
Sensitivity (%)	85	93.3	50	100
Specificity (%)	75	86.6	90	55
PPV	44	55	70	44
NPV	95	88	88	100

CRP, C-reactive protein; NPV, negative predictive value; PPV, positive predictive value; WCC, white blood cell count.

Table 3 Mean and median white blood cell count and C-reactive protein in patients undergoing appendectomy

	Normal (N = 15)	Without complication (N = 60)	With complication (N = 25)
Mean WCC	8	13.4	16
Median WCC	7	14.6	15
Mean CRP	10.6	40	90
Median CRP	10.6	20	60

CRP, C-reactive protein; WCC, white blood cell count.

which recorded 15% negative appendectomies. And this is considered low number of negative appendectomies in comparison with other studies, as Lee and colleagues in 2014 recorded 30% and March and colleagues in 2014 recorded 21%. However, this could be explained by the lower number of patients recruited in our study in comparison with the number of patients recruited in other studies [3–5].

Our study showed that the specificity and sensitivity of CRP as a diagnostic test in acute appendicitis is 86.6 and 93.3% , respectively, and this goes with the results published by Asfar *et al.* [6] in 2000 and Sammalkorpi *et al.* [7] in 2014. Erkasap *et al*. [8] in 2000 showed a higher specificity and lower sensitivity of the CRP.

Different authors believe that elevated CRP improved the diagnostic accuracy and might help in reducing the use of radiological tests to confirm the diagnosis and specially if combined with Alvarado score as Thirumallai *et al*. [9] in 2013 suggested that further imaging is only required in the absence of elevated CRP level.

Our study showed high levels of CRP in patients with complicated appendicitis and this is in accordance with different studies showing that elevated CRP on admission more than 99 mg/l is associated with increased risk of perforation [7]; based on that the authors suggested proceeding into open appendectomy from the start in patients with CRP more than 150 mg/l [10].

In elderly patients above 60 years, studies showed that CRP more than 100 mg/dl is associated with increased risk of perforation and encouraged to proceed to early laparoscopy and avoid delay but our patients were less than 55 years old [11].

The WCC as a marker for acute appendicitis has been studied extensively and we showed in our study that it has a sensitivity of 85% and specificity of 75%; however, the literature shows different results (Table 4) although our study showed a higher % of sensitivity and specificity but we don't think that elevated WCC alone can be relied on totally to diagnose acute appendicitis but we showed that the negative predictive value of WCC was 100% and this is in accordance with most of the literature and also with the Royal College of Surgeons commissioning guidelines published in 2014, which stated that it is less likely to get an inflamed appendix with a normal WCC so it is less likely to diagnose acute appendicitis in the absence of elevated WCC [12–17]. However, according to the same guide the diagnostic value of the WCC is higher when combined with the CRP level.

Table 4 Sensitivity and specificity of white blood cell count in diagnosis of acute appendicitis

References	Sensitivity	Specificity
Yu *et al.* (2012)	62	75
Yang *et al.* (2006)	86	32
Xharra *et al.* (2012)	85	68
Wu *et al.* (2012)	80	71
Agrawal *et al.* (2008)	79	55
Mentes *et al.* (2012)	72	77

Conclusion

Diagnosis of acute appendicitis is still a clinical diagnosis. We found that elevated serum CRP levels and WCC support the surgeon's clinical diagnosis. We recommend CRP measurement as a routine laboratory test in patients with suspected diagnosis of acute appendicitis. And we suggest that patients with lower abdominal pain and not clinically convincing and in the absence of increased inflammatory markers to undergo further imaging.

Acknowledgements

Conflicts of interest

None declared.

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