



# White cell count and C-reactive protein measurement in patients with possible appendicitis

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## ABSTRACT

**INTRODUCTION** Clinical assessment outweighs the use of investigations in the diagnosis of acute appendicitis. Nevertheless, white cell count (WCC) and C-reactive protein (CRP) are regularly measured in patients with suspected appendicitis. The aim of this study was to assess the utility of these markers in patients presenting with acute lower abdominal pain.

**PATIENTS AND METHODS** WCC and CRP were measured prospectively in 98 patients presenting with lower abdominal pain, and the results were correlated with each patient's outcome.

**RESULTS** No patients with WCC and CRP both in the normal range had acute appendicitis. Raised WCC and CRP were poor positive predictors of appendicitis, both alone and in combination, and correlated poorly with the development of complications.

**CONCLUSIONS** This result may have important clinical and economic implications. We suggest that patients experiencing lower abdominal pain, with normal WCC and CRP values, are unlikely to have acute appendicitis and can be safely sent home.

## KEYWORDS

Appendicitis – White cell count – C-reactive protein

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Acute appendicitis remains the most frequent cause of abdominal pain requiring surgery in the UK; an estimated 16% of people in the Western world require appendicectomy at some stage during their life.<sup>1</sup> The diagnosis of acute appendicitis relies largely on clinical assessment, although both ultrasound and computed tomography (CT) can be helpful.<sup>2,3</sup> Over the years, many studies have looked at various simple blood tests and clinical criteria in an attempt to improve diagnostic accuracy. The white cell count (WCC) and C-reactive protein (CRP) are now often used to guide clinical assessment but past studies have demonstrated sensitivities of CRP measurements ranging from 40% to 94%, and specificities of 38–87%.<sup>4–6</sup> Some groups have reported more specific findings: raised CRP values have been shown to correlate with complications such as perforation or appendix abscess.<sup>7–9</sup> These studies have, however, all been retrospective, focusing on blood tests done on patients who have had appendicectomy. More limited data are available from prospective analyses in patients presenting with right iliac fossa pain. Sensitivities and specificities ranging from 83–96% and 87–94%, respectively, have been reported for CRP measurements.<sup>10,11</sup> Analysis of these studies demonstrates the equivocal nature of data regarding the utility of serum inflammatory markers in patients with suspected

acute appendicitis. In view of this, and the relative paucity of prospective analyses, we have performed a prospective study to evaluate the use of WCC and CRP as adjuncts in the clinical assessment of patients with lower abdominal pain and suspected appendicitis.

## Patients and Methods

All patients presenting to the Royal Infirmary of Edinburgh with lower abdominal pain between 31 December 2006 and 6 February 2007 were included in this study. All clinical information here is collected prospectively using the Lothian Surgical Audit System (LSAS) and all patients with suspected acute appendicitis have WCC and CRP measurements as routine. Patient outcome was ascertained by examining the notes, operative records and pathological reports if appendicectomy was carried out. Results were then correlated with WCC and CRP values obtained on admission, by working out the sensitivity, specificity and positive and negative predictive values for each laboratory test, individually and in combination with one another. A positive WCC was taken as being greater than  $11 \times 10^9$  cells/l and a positive CRP level as greater than 10 mg/l. A substantial proportion of the study population was aged

**Table 1** Sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) for white cell count (WCC) and C-reactive protein (CRP) [*n* = 98]

	WCC raised	CRP raised	Both raised <sup>a</sup>	One raised <sup>b</sup>
<b>For acute appendicitis (%)</b>				
Sensitivity	85	65	50	100
Specificity	72	68	90	51
PPV	44	34	56	34
NPV	95	88	88	100

<sup>a</sup>A negative result, therefore, represents one marker raised in isolation or neither raised.

<sup>b</sup>A negative result, therefore, represents both markers within the normal range.

**Table 2** Sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) for white cell count (WCC) and C-reactive protein (CRP) for patients aged less than 18 years (*n* = 20)

	WCC raised	CRP raised	Both raised <sup>a</sup>	One raised <sup>b</sup>
<b>For acute appendicitis (%)</b>				
Sensitivity	75	75	50	100
Specificity	63	75	88	50
PPV	33	43	50	33
NPV	91	92	88	100

<sup>a</sup>A negative result, therefore, represents one marker raised in isolation or neither raised.

<sup>b</sup>A negative result, therefore, represents both markers within the normal range.

under 18 years, so corresponding values were calculated separately for this age group. Finally, in patients undergoing appendicectomy, the mean and median WCC and CRP values were correlated between those with a normal appendix, acute appendicitis and appendicitis with a complication (peritonitis, gangrene and/or perforation). These groups were compared using *t*-tests.

**Results**

No exclusion criteria were applied, although one patient among the 99 could not be included as his laboratory results could not be found. Of the remaining 98 (75 females and 23 males), 28 underwent an operation for suspected appendicitis. Six had a diagnostic laparoscopy with a normal appendix (not removed); of these, four had ovarian cysts and two were presumed to have mesenteric adenitis. One patient had a macroscopically normal-looking appendix

removed at diagnostic laparoscopy, because of adhesions between the appendix and the pelvic side wall. Eleven had a laparoscopic appendicectomy and 10 underwent conversion from laparoscopic to open appendicectomy. Acute appendicitis was confirmed in all but two of the patients undergoing appendicectomy, one of whom had a perforated Meckel’s diverticulum and the other being the normal appendix removed at laparoscopy in view of adhesions. The remaining 70 patients were either discharged home or referred to other specialties such as gynaecology and urology.

This study showed a positive predictive value of 44% for a raised WCC and 34% for a raised CRP level in acute appendicitis. The positive predictive value improved to a value of 56% when both parameters were raised.

WCC alone had a high negative predictive value of 95% for acute appendicitis. However, no patients with both values within the normal range had acute appendicitis, giving a sensitivity and a negative predictive value of 100% each

**Table 3** Mean and median white cell count (WCC; expressed as × 10<sup>9</sup> cells/l) and C-reactive protein (CRP; expressed in mg/l) according to pathology result in patients undergoing appendicectomy

	Normal appendix	Acute appendicitis	
	( <i>n</i> = 2)	Without complication ( <i>n</i> = 9)	With complication ( <i>n</i> = 11)
Mean WCC	8.1	13.4	15.5
Median WCC	8.1	14.6	15.7
Mean CRP	31	45	100
Median CRP	31	20	58

(Table 1). A similar picture was seen in the under-18-years subgroup of patients (Table 2): WCC and CRP had a positive predictive value of 33% and 43%, respectively. This only increased to 50% when the two were combined. Again, no patients with both values within the normal range were found to have appendicitis.

In patients who underwent appendicectomy, the mean and median WCC and CRP level for various sub-groups are shown in Table 3. No significant difference was found in WCC ( $P = 0.12$ ), nor in CRP level ( $P = 0.064$ ), between those with simple acute appendicitis and those with complications such as perforation and gangrene.

## Discussion

The results of this investigation have largely confirmed those of other studies in that the presence of raised inflammatory markers is not a good discriminator for patients with acute appendicitis, even when both WCC and CRP levels are raised. These findings, of course, only reflect the fact that various pathological processes can cause an acute phase response and, therefore, raised inflammatory markers; these features are unlikely to predict a specific diagnosis such as acute appendicitis. Furthermore, this study also failed to show that the levels of WCC and CRP could predict the development of a complication such as gangrene or perforation.

The most important finding of this study that, to our knowledge, has not previously been demonstrated, is the 100% negative predictive value for acute appendicitis if both WCC and CRP are normal, *i.e.* no patients with both values within the normal range had acute appendicitis. Clearly, it is possible that some patients may have had early and self-limiting appendicitis, which settled spontaneously. However, irrespective of this possibility, no patient with normal WCC and CRP needed appendicectomy, and therefore, depending on other clinical criteria, these patients do not require admission to hospital.

Obviously, the assessment of patients with acute abdominal pain, and particularly suspected appendicitis, remains multifactorial, and still relies to a large extent on clinical judgement. In some patients, further investigations such as ultrasound, CT and even laparoscopy may be indicated, whereas in others a short period of observation is all that is required, before the diagnosis becomes clearer. On the basis of the results from this study, we suggest an algorithm for the assessment of patients with lower abdominal pain and possible acute appendicitis:

If the history and examination findings are typical, clinical assessment should outweigh the use of investigations.

However, where the diagnosis of appendicitis is considered unlikely, and no other obvious diagnosis of concern is being considered, the presence of a normal WCC and CRP can reassure the clinician and allow the patient to be discharged home. If either or both markers are raised, it would be prudent to admit the patient for further investigations, observations and treatment as required. In these patients, other investigations (*e.g.* ultrasound, CT and diagnostic laparoscopy) will be dictated by local guidelines.

## Conclusions

We suggest that the white cell count and C-reactive protein measurements are useful in the assessment of acute appendicitis: if used judiciously, they may spare a group of patients not only an unnecessary surgical procedure, but also unnecessary admission to hospital for observation.

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