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Original research

Augmenting the decision making process in acute appendicitis: A retrospective cohort study

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HIGHLIGHTS

- Pre-operative investigation in acute appendicitis is analysed.
- Elevated WCC and CRP are sensitive but non-specific markers in acute appendicitis.
- Elevated serum bilirubin is a specific but insensitive marker in acute appendicitis.
- CT scanning reduces negative appendicectomy rate to 1%.
- Ultrasound scanning does not reduce negative appendicectomy rate.

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ABSTRACT

Introduction: Acute appendicitis is a common surgical diagnosis. We investigated the use of blood markers (WCC, CRP and serum bilirubin) and diagnostic imaging (USS and CT scan) to arrive at this diagnosis, as well as the surgical approach used for appendicectomy.
Methods: This was a retrospective analysis of consecutive patients undergoing appendicectomy in seven hospitals within GG&C Health Board during a 6 month study period. Data were collected from electronic patient records. Sensitivity and specificity of each investigation for diagnosing acute appendicitis was calculated.
Results: 363 patients were included. Appendicectomy was performed open in 53%, laparoscopically in 43% and converted in 4%. Diagnostic imaging was used in 38%. The overall negative appendicectomy rate was 15% (18% when no imaging was used, 23% when USS was used and 1% when CT scanning was used). Elevated bilirubin had a sensitivity of 0.44 and a specificity of 0.84 for detecting acute appendicitis. Sensitivity and specificity for elevated WCC were 0.78 and 0.55, and for elevated CRP were 0.81 and 0.59, respectively. The specificity of bilirubin for diagnosing perforated appendicitis was 0.63.
Discussion: WCC and CRP were sensitive blood markers in acute appendicitis, whereas serum bilirubin was more specific. Diagnostic imaging with a CT scan was very effective at reducing the rate of negative appendicectomy, but USS was not.
Conclusion: Serum bilirubin has utility in diagnosing acute appendicitis, irrespective of whether perforation has occurred. CT scanning should be considered the first line imaging modality for investigation of acute appendicitis if diagnosis is in doubt.

1. Introduction

Acute appendicitis is a common surgical emergency. However, the differential diagnosis is wide, especially in females. Mesenteric adenitis, ovarian pathologies, mittelschmerz, pelvic inflammatory disease and inflammatory bowel disease are all possible causes of right iliac fossa pain. This diagnostic conundrum has been appreciated for many years. Additional biochemical investigations have long been used to compliment the clinical diagnosis [1]. The main investigations in current use are blood inflammatory markers, namely white cell count (WCC) and C-reactive protein (CRP), as well as the imaging modalities of abdominal ultrasound scan (USS) and computed tomography (CT) scan. More recently, serum

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bilirubin has been shown to be a more specific marker for acute appendicitis, especially when perforation is more likely [2–5].

The pathophysiology of this bilirubin rise is unclear. It may be that with inflammation and infection of the appendix, especially if there is perforation, bacteria are allowed to enter the portal circulation. These bacteria would then arrive at the liver and if the load is high enough to overwhelm the Kupffer cell function of the liver, a degree of hepatocyte damage may occur, which would be reflected as a rise in serum bilirubin [6].

A negative appendicectomy has the drawbacks of exposing the patient to unnecessary surgery and delaying the definitive diagnosis, as well as incurring unnecessary financial cost. The overall rate of negative appendicectomy is reducing. This could be attributed to better diagnostics [7]. It does however remain a common problem that general surgeons strive to avoid. Any appropriate test that can increase the accuracy of diagnosis is therefore valuable.

The open appendicectomy for treatment of acute appendicitis is an old operation, with the popular McBurney incision being described in 1894 [8]. Although the open approach remains entirely valid, there has been a recent move to the more modern laparoscopic approach, especially in women [9]. There are conflicting opinions about whether open or laparoscopic appendicectomy should be favoured routinely and it seems that both approaches are equally safe and effective in experienced hands [10–14].

The study aims to examine the current utilisation of pre-operative investigations to diagnose acute appendicitis. The value of the blood markers WCC, CRP and serum bilirubin as well as the imaging modalities of abdominal USS and CT scan in diagnosing acute appendicitis and avoiding negative appendicectomy will be investigated.

2. Methods

This was a retrospective analysis of 500 consecutive patients undergoing appendicectomy in seven hospitals within the Greater Glasgow & Clyde Health Board from 19/09/2012 to 05/03/2013. Data were collected from the electronic patient records through the health board Clinical Portal system. Inclusion criteria were then applied to select the appropriate patient group (Fig. 1).

Baseline demographics were recorded for each patient including age, sex, date of operation and hospital. Blood results were reviewed. The white cell count (WCC), C-reactive protein (CRP) and serum bilirubin results on admission were noted. According to local laboratory reference ranges, elevated WCC was taken to be greater than 10.0×10^9/L. Elevated CRP was greater than 10 mg/L and elevated serum bilirubin was greater than 20 μmol/L.

Radiology reports were examined to investigate the use of imaging in the diagnosis of acute appendicitis. Pathology reports were also read to ascertain the final diagnosis. This was recorded as normal appendix, simple acute appendicitis, or acute appendicitis with perforation. The operative approach was obtained from examination of the operative notes.

Biochemical, histopathological and radiological variables were correlated and statistical analysis was then performed using SPSS version 22 [15].

Clinical details on admission were not collected or used in the analysis. However, at the time of operation, all patients in this study had a clinical diagnosis of acute appendicitis. Baseline blood tests were performed in all patients on admission. There is no institutional policy on the use of imaging for acute appendicitis and therefore, when imaging was used, it was due to uncertainty over the diagnosis.

Inclusion Criteria

* Appendicectomy performed for suspected acute appendicitis
* Pathology results available
* Pre-operative serum bilirubin result available

Fig. 1. Inclusion criteria.

3. Results

The patient records of 500 consecutive patients undergoing appendicectomy for suspected acute appendicitis in the Greater Glasgow & Clyde Health Board between 19/09/12 and 05/03/2013 were examined. The inclusion criteria were met by 363 patients, who were included in the analysis (Fig. 1). Of these patients, 226 (62%) were male and 137 (38%) were female. The age range was 3–86 years. Mean age was 31 years.

Pre-operative diagnostic imaging was utilised in 137 (38%) patients. An USS only was performed in 58 (16%) patients and a CT scan only was performed in 71 (20%) patients. Eight patients (2%) were imaged with both USS and CT scan. Of the female patients, 53% had pre-operative diagnostic imaging, compared to only 28% of male patients ($p < 0.005$). There was also a gender difference in the chosen modality of imaging, with a CT scan being performed in 72% of males imaged compared to 40% of females imaged, where ultrasound scan was favoured (Table 1). The negative appendicectomy rate in patients who did not have any pre-operative imaging was 18%, compared to 23% in patients who had an USS and 1% in those who had a CT scan (Table 2). Statistical analysis showed that performance of a CT scan significantly increased the accuracy of diagnosis ($p < 0.005$), whereas USS did not.

Operative data were available for 306 patients in the study. Of these patients, 162 (53%) had an open appendicectomy and 132 (43%) had a laparoscopic appendicectomy. The remaining 12 (4%) patients had the procedure started laparoscopically, then converted to open. A laparoscopic approach was favoured in females and was attempted first in 74%. This compares to only 31% of males, creating a significant gender difference in the choice of approach ($p < 0.005$). Table 3 illustrates the operative approach used by gender.

Pathology results were reviewed for all 363 patients in the study. In 56 (15%) cases, the appendix was found to be normal. Appendicitis without perforation was diagnosed in 254 (70%) cases and perforated appendicitis was found in 53 (15%) patients. Bilirubin, WCC and CRP levels were compared to pathology, as summarised in (Table 4). There was a significant rise in all three blood markers in patients with acute appendicitis ($p < 0.005$). There was also a significant difference in the levels of all blood markers between those with simple appendicitis and those with perforated appendicitis ($p < 0.005$).

When a standard laboratory reference range was used, an elevated bilirubin had a sensitivity of 0.44 and a specificity of 0.84 for detecting acute appendicitis. Meanwhile, an elevated WCC had a sensitivity of 0.78 and specificity of 0.55. Elevated CRP had a sensitivity of 0.81 and specificity of 0.59. Positive predictive value and negative predictive value were also calculated for each of the

Table 1
Pre-operative diagnostic imaging and gender.

	Ultrasound scan	CT scan	No imaging
Male	19 (8%)	48 (21%)	162 (72%)
Female	47 (34%)	31 (23%)	64 (47%)