



## The Alvarado score in acute appendicitis: A 3-year audit to evaluate the usefulness in predicting negative appendicectomies in $\leq 16$ s at QHBFT



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### ABSTRACT

**Objective:** To evaluate the diagnostic accuracy of the Alvarado score in reducing the rate of negative appendicectomy at Queen's Hospital, a small district general hospital in England.

**Methodology:** The retrospective, analytical study included all children who were  $\leq 16$  years old with a preliminary diagnosis of acute appendicitis undergoing appendicectomy subsequently. Children with other causes of acute abdominal pain were excluded from the study. A total of 118 patients were included. Based on their calculated Alvarado scores, they were stratified into two groups: Group A (Alvarado score  $< 6$ ) and Group B (Alvarado score  $\geq 6$ ). Alvarado scores were compared with the histopathology reports, the gold standard for diagnosing acute appendicitis. The data gathered was then subjected to statistical analysis to measure our objective.

**Results:** Out of the 118 patients (85 males, 33 females), 46 belonged to Group A and 72 to Group B.

Final diagnosis of acute appendicitis from histopathology reports was confirmed in 94 cases (79.6%). The overall sensitivity and positive predictive value of Alvarado score for acute appendicitis were 92% and 94% respectively. The area under the ROC curve was 0.9 indicating a highly accurate test.

The sensitivity was only slightly higher for males with a score of  $< 6$  than females (94.9% vs. 89.5%,  $p < 0.05$ ).

However, for scores  $\geq 6$ , sensitivity among males was significantly higher than females (79% vs. 62.6%;  $p < 0.05$ ).

A multivariate analysis revealed that anorexia, right iliac fossa tenderness and rebound tenderness are significantly correlated with a correct diagnosis of acute appendicitis ( $p = 0.025$ , 0.037 and 0.026 respectively).

**Conclusion:** The presence of a high Alvarado score ( $\geq 6$ ) is highly predictive of acute appendicitis.

In women of childbearing age and Alvarado scores of  $< 6$ , other pathologies that mimic appendicitis must be considered. An US scan of abdomen and pelvis should be considered in a woman of child-bearing age before proceeding to a surgical intervention.

### 1. Introduction

Globally, acute appendicitis is the most common paediatric intra-abdominal surgical emergency [1,2]. The diagnosis is based on history, clinical examination and routine laboratory tests. The classical presentation of acute appendicitis is easily diagnosed and treated. However, subtle clinical features in the early stages and atypical presentation of the disease can make diagnosis challenging even for experienced surgeons [3].

Prompt appendicectomy of an unhealthy appendix reduces mortality from perforation and gangrene which can occur within 24–48 h of untreated appendicitis [4]. On the other hand, available statistics have shown that there is a misdiagnosis of 1 in 5 cases of acute appendicitis

and up to 40% of patients who have undergone emergency appendicectomy have a normal appendix [5].

Several scoring systems, imaging modalities and novel techniques have been devised in an attempt to increase the diagnostic accuracy, and thereby reduce the rate of negative appendicectomy. The idea is to differentiate appendicitis from non-specific abdominal pain, the latter diagnosed in 50% of children presenting with abdominal pain in an emergency setting [6]. However, most of these investigative tools are complex, expensive and difficult to implement in emergency situations [7,8].

A simple scoring system employed by some surgeons is the Alvarado scoring system [9].

Our study aimed to evaluate the usefulness of the Alvarado score in

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**Table 1**  
The Alvarado scoring system for appendicitis.

Variables score	Clinical features
Symptoms	<b>Migratory RIF pain</b>
1	
1	<b>Anorexia</b>
1	<b>Nausea/vomiting</b>
Signs	<b>RIF tenderness</b>
2	
1	<b>Rebound tenderness</b>
1	<b>Raised temperature</b>
Laboratory	<b>Leukocytosis</b>
2	
1	<b>Neutrophils &gt; 75%</b>
Total	score
10	

reducing the rate of negative appendicectomy, and hence devise an evidence-based guideline that would aid in the clinical decision-making approach in patients presenting with clinical features suggestive of acute appendicitis.

## 2. Methodology

The study included all male and female patients between the ages of 4 and 16 years of age who had presented as non-elective cases with clinical features of acute appendicitis and who subsequently underwent appendicectomy with histopathological examinations of resected specimens. Patients under 4 years old are not admitted at our hospital and referred to a tertiary paediatric centre in the West Midlands.

Children who presented with other causes of abdominal pain were excluded, irrespective of appendicectomy being carried out or not.

We calculated their individual Alvarado scores. The decision to operate was made by the senior surgeon based on the clinical features, irrespective of Alvarado score.

Patients with Alvarado scores of 1–4 were excluded. Based on Alvarado scores [Table 1], the patients were stratified into two groups: Group A (score of < 6) and Group B (score of ≥ 6). All the patients received standard emergency pre-operative management including nil by mouth status, intravenous fluids, antibiotics and analgesics. Operative findings were recorded and the resected specimens were sent for histopathological examination.

Alvarado scores were correlated with the histopathology reports. The data were recorded and subjected to statistical analysis through Statistical Package for Social Sciences (SPSS) version 10 and various descriptive statistics were used to calculate frequencies, percentages, means and standard deviation. The numerical data such as age were expressed as mean ± standard deviation while the categorical data such as histopathology of the resected specimens were expressed as frequency and percentages [10]. Negative appendicectomy was defined as a patient who did not have appendicitis on histopathological analysis.

Two-by-two table was employed to determine sensitivity and positive predictive value. Percentages were compared by employing chi-square test and a p-value of less than 0.05 was regarded as statistically significant.

## 3. Results

Out of the 118 patients, 72% (n = 85) were males and 28% (n = 33) were females. The mean age was 13.4 ± 0.33 years. The largest age group was represented by 13–16 year olds (64.4%, n = 76).

The symptoms at presentation included migratory RIF pain (58.5%,

**Table 2**  
Findings at surgical exploration.

Findings %	No. of patients
<b>Inflamed appendix</b>	
Acute appendicitis	99 83.9
Perforated appendix	8 6.8
Gangrenous appendix	13 11
<b>Normal appendix</b>	
Ovarian cyst	3 2.5
PID	6 5.1
No diagnosis	10 8.5

n = 69), nausea/vomiting (77.1%, n = 91) and anorexia (89.7%, n = 106). Clinical examination included RIF tenderness (89.8%, n = 106), rebound tenderness (92.4%, n = 109) and elevated temperature (19.5%, n = 23). Laboratory analysis included raised white cell count (73.7%, n = 87) and neutrophilia (77.1%, n = 91).

83.9% (n = 99) were confirmed to have inflamed appendix by the surgeon performing the appendicectomy [Table 2]. Perforated appendix was found in 8 cases and gangrenous appendix in 13. In the 19 patients with a normal appendix following appendicectomy, the underlying pathologies were: ovarian cyst disease (n = 3); pelvic inflammatory disease/ pain due to retrograde menstrual flow (n = 6); no surgical diagnosis established (n = 10).

Final diagnosis of inflamed appendix on histopathology was confirmed in 79.6% of cases (n = 94) [Table 3]. The overall negative appendicectomy rate was therefore 20.4% (n = 24). Of 46 patients in group A, 33 had a histopathological confirmation of appendicitis, thus having a negative appendicectomy rate of 28.3%.

Of 72 patients in group B, 61 had a confirmed diagnosis of appendicitis on histopathological examination of the appendix, which equates to a negative appendicectomy rate of 15.3%.

Gender-wise, the rate of negative appendicectomy was significantly higher in females than males (27% vs. 12%; p < 0.05).

The overall sensitivity and positive predictive value of Alvarado score for acute appendicitis were 92% and 94% respectively. The accuracy of our test depended on how well it separated the group being tested into those with positive histopathology reports and those with negative reports. To perform this, the area under the Receiver Operating Characteristic (ROC) curve was calculated as 0.9, a score which indicates an excellent accurate test. The sensitivity was higher though not significant, for males with a score of ≥ 6 than females (94.9% vs. 89.5%). However, for scores < 6, sensitivity among males was significantly higher than females (79% vs. 62.6%; p < 0.05). [Table 4].

## 4. Discussion

Acute appendicitis is the most common pathology requiring surgical intervention [11]. Our study revealed a high incidence in 13–16 years group [Table 5], which is in accordance with many epidemiological studies including that by Limpawattanisiri et al. [12] Males were more frequently affected in our study [Table 5] in contrast with other studies [13,14].

The variations in its presentation and the lack of a single reliable diagnostic test can pose a dilemma for surgeons. The right appendix has to be taken out at the right time as negative appendicectomies carries a

**Table 3**  
Histopathological examination of post-operative appendix specimens.

Group	Histology positive	Histology negative	Total (n)
A	33	13	46
B	61	11	72

**Table 4**  
Score-wise distribution of sensitivity including gender variations.

Score	No. of cases (n)	Sensitivity (%) in males	Sensitivity (%) in females
4–6	36	79.0	62.6
7–8	41	91.2	85.3
9–10	41	98.6	93.7

**Table 5**  
Patient characteristics. Data presented as mean ( $\pm$  SD), median (min-max) and number (%).

Characteristics	Value
<b>Age (years)</b>	
Mean	13.4 $\pm$ 0.33
Median	13.1
<b>Gender</b>	
Males	85 (72%)
Females	33 (28%)
<b>Age incidence (years)</b>	
5 - 8	12
9 - 12	30
13 - 16	76

mortality of up to 10% [15]. At the opposite end of the scale, appendiceal perforation can occur if an unhealthy appendix is not taken out promptly.

An appropriate approach to diagnosis is a step-wise one incorporating good history-taking, clinical examination and investigations. C-reactive protein, CT scans and US scans have been used to complement clinical acumen to aid diagnosis of acute appendicitis especially in early, atypical presentations to reduce rate of negative appendicectomies.

A raised C-reactive protein level may suggest an infection but can be normal in the early stages of acute appendicitis. Indeed, in our study, 28 patients presenting within 24 h had normal C-reactive protein levels but underwent appendicectomy as the disease progressed over the next few days. USS is often very helpful especially in females as other diagnoses can be revealed [16]. In our study, 17 patients had undergone USS as part of their work-up. Appendicitis was confirmed in 5 cases and ovarian cyst pathology in 3 cases. CT scans offer the advantage of allowing entire visualisation of the abdomen and this has been shown to reveal alternative diagnoses in 15% of patients in a study by Schumer et al. [17] It does have drawbacks however in such that they take a long time to carry out and during this time the appendix can perforate. Ethically, also, it may not be the ideal scan to carry out in young patients. Only 5 of the patients in our study had a CT scan as part of the diagnostic work up.

The Alvarado scoring system for acute appendicitis was devised in the mid-1980s [18]. It has been shown to be simple and relatively accurate in aiding the clinical diagnosis of acute appendicitis.

In our study, 79.6% of cases ( $n = 94$ ) were confirmed to have acute appendicitis on histopathology, giving the negative appendicectomy rate of 20.4% ( $n = 24$ ), higher than other studies [12,19] but lower compared to others [9,19]. The marginally high rate of negative appendicectomy in our study could be due to the fact that surgeries were performed in all patients we included in the study sample for analysis ( $n = 118$ ).

Appendiceal perforation rate in our study was 6.8% ( $n = 8$ ) which is much less than other studies [9,13]. This low rate could be explained by the fact that there was little delay in presentation to surgery. Indeed, all patients were taken to theatre within 12 h of the decision made to operate. None of the patients with a perforated appendix had an Alvarado score less than 6 which suggests that patients with a score less than 6 may be safely admitted for a period of observation before a

decision is made by the senior surgeon regarding surgical intervention.

In our study, the overall sensitivity was 92% similar to that reported by Shah et al. [20].

The significant difference in outcome of negative appendicectomies in group A and B suggests that it is clinically safe to rely on a high Alvarado score ( $\geq 6$ ) to predict the diagnosis of appendicitis but in lower Alvarado scores ( $< 6$ ), other investigations may need to be carried out to confirm diagnosis before attempting surgery.

The appropriate score which surgeons should be used as a cut-off value in the work-up of appendicitis, was determined by the score which yielded the highest sensitivity. In our study, a score of  $> 7$  is perhaps the score surgeons should at least start thinking about the presence of appendicitis in the child presenting with acute abdominal pain.

Also, in women, particularly those of child bearing age, the predictive value of the Alvarado score falls disappointingly short of expectations. Unnecessary surgery in this latter group can be avoided by employing other diagnostic modalities such as diagnostic laparoscopy or an US scan at the very least.

The authors appreciate the idea that Alvarado score is not new. However, in the UK, this test is rarely used in the work-up of appendicitis. With the increasing use of imaging such as CT scans to diagnose acute appendicitis, many surgeons usually spend less time with the history-taking and examination of these children.

Furthermore, our study is the first to perform a statistical analysis of the clinical features of the Alvarado scoring system particularly related to a positive outcome of acute appendicitis: anorexia, right iliac fossa tenderness and rebound tenderness.

This is a single centre study which remains a limitation.

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