

Research Article

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A Modified Alvarado Score: >24 h RIF Tenderness, <48 h Positive USS and Elevated CRP Yield the Best Predictive Rate of Negative Appendicectomies in Patients under 16

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Abstract

Objective: The Alvarado score is one of many scoring systems employed by surgeons in diagnosing acute appendicitis. We aim to evaluate its relative diagnostic accuracy, as well as add to it and develop a combination which leads to the best outcome in predicting acute appendicitis and hence the rate of negative appendicectomies.

Methods: A retrospective, analytical study was performed in \leq 16s with acute appendicitis. Of the total 311 children in the sample size, 270 children were diagnosed with acute appendicitis following histopathological analyses of resected specimens. Clinical features including symptoms, physical signs, and laboratory and imaging findings were recorded and individual sensitivities, predicted values and joint probabilities were calculated. Each clinical feature was then assigned a diagnostic weight to measure the authors' objective.

Results: Three predicted factors were found to be useful in making an early diagnosis of acute appendicitis. Their importance, according to their diagnostic weight (sums of positive and negative predicted values) were persisting RIF pain lasting >24 hrs, positive USS in <48 hrs and elevated CRP.

Conclusion: Acute appendicitis is a clinical diagnosis but may not always be straightforward. The aforementioned indicators should help in the clinical decision-making process.

Keywords: Alvarado; Scoring; Appendicitis; Imaging; Appendicectomy

Introduction

Acute appendicitis is the most common paediatric intra-abdominal surgical emergency [1,2]. Its classical presentation is straight-forward to diagnose, even among the most junior of surgeons. However, subtle clinical features in the early stages of the disease process are often vague and atypical, posing challenges even to experienced surgeons [3]. Failure to make an early diagnosis is a primary reason for morbidity and mortality associated with perforation and gangrene, which can occur within 24-48 hrs of untreated appendicitis [4,5]. On the other hand, studies have shown misdiagnoses in 1 in 5 cases of acute appendicitis, and up to 40% have normal appendices following emergency appendicectomy [6]. In an attempt to increase the diagnostic accuracy of the disease, the Alvarado score is one of many scoring systems employed by surgeons. The authors aim to assess the diagnostic accuracy of the Alvarado parameters and based on this scoring system with the addition of other indicators, aim to devise a simple, cost-effective, evidence-based scoring algorithm to reduce the rate of negative appendicectomies whilst minimising the fatal risk of perforation and gangrene.

Methodology

The study included male and female patients between the ages of 5 and 16 presenting with acute appendicitis and subsequently undergoing appendectomy with histopathological analyses of resected specimens. Patients under 5 years old were transferred to tertiary pediatric centers. In total, 311 patients admitted to the Queen's Hospital, Burton, between February 2012 and February 2017, were included in the study.

All patients received standard emergency perioperative management including nil by mouth status, intravenous fluids, antibiotics, analgesics and antiemetics, as clinically appropriate. Patients with alternative diagnosis of acute abdomen were excluded. Demographics (age and gender), symptoms, signs, laboratory tests, urinalysis, pregnancy tests and imaging reports were recorded and subjected to statistical analysis through Statistical Package for Social Sciences (SPSS) version 10. Calculations included frequencies, percentages, means and standard deviation. Numerical data such as age were expressed as mean \pm standard deviation and categorical data such as histopathology of the resected specimens were expressed as frequency and percentages. Negative appendectomy was defined as a patient who did not have appendicitis upon histopathological analysis of the excised appendix. 2 * 2 tables were employed to determine sensitivities, predictive values, joint probabilities and diagnostic weights of individual indicators.

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Percentages were compared by employing chi-square test and a p<0.05 was regarded as statistically significant.

Results

Overview:

Out of the 311 patients, n=193 (62%) were males and n=118 (38%) were females. The mean age was 13.3 ± 0.47 . The largest age group was represented by 13 to 16 years old patients, n=193 (62.1%) (Table 1).

| Characteristic | Value |
|-----------------------|---------------|
| Age (years) | |
| Mean | 13.3 ± 0.47 |
| Median | 13.2 |
| | |
| Gender | |
| Males | 193 (62%) |
| Females | 118 (38%) |
| | |
| Age incidence (years) | |
| 5-8 | 31 (10%) |
| 9-12 | 87 (28%) |
| 13-16 | 193 (62%) |

Table 1: Patient characteristics. Data presented as mean (± SD),median (min-max) and value (number and %).

Symptoms at presentation included: Right iliac fossa (RIF) pain (n=199, 64.0%), LIF pain (n=62, 20.0%), migratory RIF pain (n=265, 85.2%), nausea/vomiting (n=265, 85.2%), anorexia (n=212, 68.2%). Clinical examination included: elevated temperature of more than 38° C per SIRS criteria (n=56, 18.0%) [7]. RIF tenderness (n=308, 99.0%) and LIF tenderness (n=101, 32.5%).

Laboratory tests included: Raised white cell counts (n=217, 69.8%), raised neutrophils/left shift (n=212, 68.2%), as well as elevated CRP levels (n=267, 85.9%). Of the 311 patients, n=270 (86.2%) were confirmed to have acute appendicitis on histopathological analyses of resected appendiceal specimens: Simple (n=188), suppurative (n=35), perforated (n=28), gangrenous (n=13) and abscess (n=6) (Table 2). Of the 41 patients with normal appendices, the underlying pathologies were: ovarian cyst pathology (n=12; 3 were ruptured), pelvic inflammatory disease/pain due to retrograde menstruation (n=9), and 'no surgical diagnosis' (n=20). Of the 20 patients without a surgical diagnosis, 8 had mesenteric adenitis, 6 had urinary tract infection (all of them went on to have a positive urine cultures), 2 had gastroenteritis, 2 had constipation, 1 had acute pancreatitis and 1 showed signs of lower lobe pneumonia.

| Stage | Number | % |
|-------------|--------|-----|
| Simple | 188 | 70 |
| Suppurative | 35 | 13 |
| Perforated | 28 | 10 |
| Gangrenous | 13 | 5 |
| Abscess | 6 | 2 |
| Total | 270 | 100 |

 Table 2: Diagnosis of acute appendicitis and its various pathological states following histological analyses. Data presented as numbers and percentage values.

Evaluation of findings

To analyse and evaluate the data, a 2 * 2 table was designed for each clinical feature serving as a diagnostic indicator. From these tables, probabilities, sensitivities and predictive values were calculated (Table 3). For a 'perfect test', the sensitivities and predicted values should be 100%. In such cases, the total joint probability (the total sample size divided by the number of true positives or true negatives) which statistically serves as the diagnostic weight should be equal to 1.0 for that particular clinical indicator.

| Indicator | Sensitivity | +Predicted | +Joint | -Joint | Diagnostic |
|-----------------|-------------|------------|-------------|-------------|------------|
| | | value | probability | probability | weight |
| RIF pain | 0.51 | 0.87 | 0.09 | 0.32 | 0.41 |
| LIF pain | 0.45 | 0.32 | 0.07 | 0.26 | 0.33 |
| Migrating pain | 0.93 | 0.83 | 0.06 | 0.82 | 0.88 |
| Nausea/vomiting | 0.93 | 0.83 | 0.08 | 0.67 | 0.75 |
| Anorexia | 0.73 | 0.71 | 0.13 | 0.51 | 0.64 |
| Pyrexia | 0.55 | 0.61 | 0.12 | 0.36 | 0.48 |
| RIF tenderness | 1.0 | 0.98 | 0.002 | 0.98 | 0.98 |
| Rebound | 0.79 | 0.71 | 0.04 | 0.78 | 0.82 |
| Leucocytosis | 0.87 | 0.95 | 0.10 | 0.68 | 0.78 |
| Left shift | 0.73 | 0.87 | 0.07 | 0.25 | 0.32 |

 Table 3: Diagnostic indicators. Probabilities, sensitivities and predicted values.



Figure 1: Diagnostic weight for indicators.

Clinical features

RIF pain: This symptom had a good positive predicted value (0.87) but poor sensitivity (0.51).

LIF pain: Pain in the LIF has been reported in some cases of acute appendicitis [8]. In our study, it has both poor sensitivity and positive predicted values (0.45 and 0.32 respectively).

Migratory RIF pain: The so-called 'migratory' or 'migrating' RIF pain is a well-documented symptom of acute appendicitis. This symptom had good positive predicted and sensitivity values (0.83 and 0.93 respectively).

Nausea/vomiting: This symptom had good positive predicted and sensitivity values (0.83 and 0.93 respectively). This symptom is often complex and is reported in other causes of acute abdomen [8].

Anorexia: This is a recognised feature of most intra-abdominal pathologies [8,9]. In our study, it had a fair positive predicted and sensitivity result (0.71 and 0.73 respectively).

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Pyrexia: It had poor positive predicted value and sensitivity values (0.61 and 0.55 respectively).

Tenderness: One of the most common clinical signs of acute appendicitis is tenderness in the RIF. In our study, if tenderness was in the RIF, sensitivity was excellent (1.0) and positive predicted value was very good (0.98). In persisting RIF tenderness i.e., tenderness lasting for more than >24 hrs, both positive predicted and sensitivity values were 1.0. LIF tenderness had poor to average positive predicted and sensitivity values (0.57 and 0.62 respectively).

Rebound tenderness: had fair positive predicted and sensitivity values (0.71 and 0.79 respectively).

Leukocytosis: This had good positive predicted and sensitivity values (0.95 and 0.87 respectively. In neutrophilia/left shift, i.e., neutrophilis >75%, positive predicted value was still good (0.87) but sensitivity was only 0.73.

Urinalysis: This was done to rule out other causes of acute abdominal pain. This was positive for inflammatory markers of UTI in 6 patients. Although, microscopic haematuria has been reported in some cases of acute appendicitis, this is a rare and non-specific sign [9].

The role of CRP, USS and CT-scan

The role of CRP in the work-up of acute appendicitis is a contentious one. This is mainly centred around its timing. A recent study by Agilinko et al. demonstrated that CRP levels performed within <24 hrs was normal in 28 patients who subsequently developed acute appendicitis, albeit a smaller population size of 118 patients [10].

Nonetheless, CRP levels can be a useful diagnostic measure for predicting outcome of symptomatology. In our study, CRP levels >48 hrs was measured in 83 patients. Out of this, 59 patients with elevated levels (CRP levels >5) had acute appendicitis diagnosed following histopathological analyses of their resected specimens. The remaining 24 patients with normal CRP levels had normal appendix following histological analyses. Results were true only if there was persisting RIF tenderness on examination (tenderness >24 hrs). In total, regardless of timing, elevated CRP levels were found in 267 patients (85.9%).

In our study, the authors showed that USS performed within 48 hours of onset of symptoms is useful. USS was carried out in 77 patients (59 in females, 18 in males). Of this, 62 patients showed radiological diagnosis of inflamed appendix, all of whom had a histological diagnosis at various stages of disease. In the remaining, the above was true only if there was persisting RIF's tenderness and CRP was raised 48 hrs after presentation.

Abdominal CT scans were performed in only 8 patients. All were done <48 hrs following presentation and in 5 patients with possible radiological diagnosis of acute appendicitis, histological analyses were negative. In cases where USS was negative, inconclusive or not performed at all, sensitivity and positive predicted value of CT scan were 0.76 and 0.69 respectively.

Discussion

Acute appendicitis in the paediatric population is the most common pathology requiring surgical intervention [11]. Our study revealed high incidence in 13-16 years group (Table 1), in accordance with many epidemiological studies including that by Agilinko et al. and Limpawattanisiri [10, 12]. Males were more frequently affected in our study (Table 1) similar to others [12] and in contrast to other studies [13,14]. The variations in the presentation of acute appendicitis and the lack of a single reliable diagnostic test can pose a dilemma for surgeons on occasion. The appendix has to be taken out at the right time as negative appendicectomy carries a mortality of up to 10%. At the opposite end of the scale, appendiceal perforation can occur if an unhealthy appendix is not taken out promptly. Indeed, there is no score which gives 100% accuracy and reliability in acute appendicitis work-up and as such, scoring systems are used to aid good clinical assessment. An appropriate approach to diagnosis is a step-wise one incorporating good historytaking, clinical examination and investigations. Results of the Alvarado scoring system is promising, with sensitivities and positive predicted values shown to be >90% especially in high Alvarado scores, albeit a small population study size of only 118 patients in a recent study [12]. In our study, we showed that persisting RIF tenderness >24 hrs, USS performed <48 hrs and elevated CRP levels yielded excellent diagnostic results in predicting the histological diagnosis of acute appendicitis. To further test their individual diagnostic weight and accuracy, first of all, we decided to assign a 'value' to each one of them: 2 to both presence of RIF tenderness >24 hrs and positive >48 hrs USS report, and 1 to raised CRP levels. We are able to obtain a score of 5 that surgeons can use in practice (Table 4). With USS not always readily available, we gave it a score of 2 to allow for a comprehensive individual indicator assessment. Table 5 shows the statistical probabilities of a combination of the 3 diagnostic parameters for simple acute appendicitis. The scores between 4.8 and 5.0 highlight the reliability of the 3 indicators as part of the Alvarado score, in assessing patients with suspected acute appendicitis.

| Indicator | Value |
|---------------------|-------|
| RIF tenderness >48h | 2 |
| Positive USS <48h | 2 |
| Raised CRP | 1 |
| Total score | 5 |

Table 4: The diagnostic score for acute appendicitis.

| Diagnostic indicant | X |
|-----------------------------------|------|
| Persisting RIF+positive <48 h USS | 4.87 |
| Persisting RIF+raised CRP | 5.0 |
| Positive <48 h USS+raised CRP | 4.92 |

Table 5: Mean score for combination of diagnostic parameters in simple acute appendicitis.

Conclusion

The views on the role of scoring systems in acute appendicitis among surgeons are heavily polarised. In recent times however, many surgeons tend to use them to aid clinical assessment before proceeding to the use of CT scans especially in the paediatric population. In this study, the authors have demonstrated promising results with persisting RIF tenderness, <48 hrs USS and elevated CRP. This is a rational and simple approach to the work-up of acute appendicitis. The authors are confident that the combination of the above three diagnostic indicators is the best out there for predicting the need for proceeding with appendicectomy. In an emergency setting, where it is impractical to wait for 48 hrs to assess all 3 diagnostic variables, the authors appreciate and recognise the need to draw on the surgeon's expertise. This is a Citation: Hasan M, W Ken Vin, A Joshua, R Dharshanan, A Bertrand. (2020) A Modified Alvarado Score: >24 h RIF Tenderness, <48 h Positive USS and Elevated CRP Yield the Best Predictive Rate of Negative Appendicectomies in Patients under 16. J Med Imp Surg 5: 149.

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single study test which remains a limitation.

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