Could Preoperative Ultrasound Examination Improve the Final Outcome of Appendectomies?

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Objective: To assess the efficacy of abdominal ultrasound in diagnosing acute appendicitis.

Design: Retrospective study.

Setting: Salmaniya Medical Complex, Kingdom of Bahrain.

Method: Data collected from files of 312 patients who had appendectomy between 1 January to 31 December 2009.

Result: Three hundred twelve patients had appendectomy, 114 (36.5%) had ultrasound (US) examination and only 57 (50%) showed radiological findings positive for appendicitis.

Thirty-seven (11.9%) patients had negative appendectomy. Twenty-three (11.6%) had negative appendectomy in clinical group, 3 (5.3%) patients were negative in positive ultrasound group and 11 (19.3%) patients in negative ultrasound group.

Conclusion: Ultrasound is not a reliable test to diagnose appendicitis as it carries low sensitivity and specificity, although it showed good predictive positive value.


Abdominal pain is a common presenting symptom, accounting for nearly 7%-8% of emergency department visits. Acute appendicitis is the most common cause of abdominal emergency. The lifetime risk of developing appendicitis is approximately 7% and usually requires surgical treatment.

The overall incidence of this condition is approximately 11 cases per 10,000 populations per year. Acute appendicitis may occur at any age, although it is relatively rare at extremes of age.

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The diagnosis of acute appendicitis can be challenging even in the most experienced hands
and is predominantly clinical\(^3\). Delayed diagnosis may result in perforation of the inflamed appendix, peritonitis, appendiceal mass or abscess formation. Clinical diagnosis of appendicitis is often difficult as it is not possible to have the definitive diagnosis by gold standard test “histopathology” preoperatively\(^4\). The accepted rate of negative appendectomies ranges from 7% to 25\(^%\)\(^2\,5\).

The current management of appendicitis is to lower the percentage of negative appendectomies and avoid perforation.

Clinical scoring systems are good supporting tools for diagnosing acute appendicitis because they are simple, easy to use and non-invasive, requiring no special equipments. Alvarado score based on analysis of symptoms, sign and laboratory data is easy to apply\(^6\). Abdominal sonography became one of the common non-invasive tool used to reach the diagnosis of appendicitis.

The aim of the study is to determine the efficacy of ultrasound in early detection of acute appendicitis.

**METHOD**

A retrospective study was performed to evaluate patients who had appendectomy in Salmaniya Medical Complex (SMC) from 1 January to 31 December 2009.

The following data were reviewed: age, sex, abdominal pain, nausea, vomiting, urinary symptoms, diarrhea or constipation, anorexia, menstrual cycle, WBC count, urine analysis, temperature, tachycardia, blood pressure, right iliac fossa tenderness, rebound tenderness, guarding, generalized peritonitis, ultrasound, open or laparoscopic appendectomy, operative findings, histopathology report and duration of hospitalization.

Patients were grouped according to the usage of ultrasound or not and Alvarado scoring system. Ultrasound group was subdivided according to suggestive of appendicitis or not. Ultrasound group and Alvarado scoring system were compared and contrasted, see table 1 and 2.

**Table 1: Alvarado Scoring System**

<table>
<thead>
<tr>
<th>Symptoms</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Migration of pain to right lower quadrant</td>
<td>1</td>
</tr>
<tr>
<td>Anorexia or acetone in urine</td>
<td>1</td>
</tr>
<tr>
<td>Nausea or/and vomiting</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Signs</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Tenderness in right lower quadrant</td>
<td>2</td>
</tr>
<tr>
<td>Rebound pain</td>
<td>1</td>
</tr>
<tr>
<td>Elevation of temperature</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Laboratory</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Leucocytosis</td>
<td>2</td>
</tr>
<tr>
<td>Shift to the left</td>
<td>1</td>
</tr>
</tbody>
</table>

**Table 2: Impact of Alvarado Scoring**
Score | Probability of Appendicitis
---|---
≤ 4 | Unlikely to be acute appendicitis
5 or 6 | Compatible with the diagnosis of acute appendicitis
7 or 8 | A probable appendicitis
9 or 10 | Very probable appendicitis

Direct visualization of an incompressible appendix with an outer diameter more or equal to 6 mm and echogenic incompressible periappendicular inflamed tissue with or without an appendicolith was the primary criterion to establish ultrasonic diagnosis of acute appendicitis.

SPSS version 17 was used for statistical analysis.

**RESULT**

Seven hundred thirty-four patients had appendectomy in 2009 according to SMC registry record. Three hundred fourteen files were retrieved for data analysis, two patients were excluded because histopathology report was not found; 233 (74.7%) were males and 79 (25.3%) were females. The age ranged from 1 to 64 years, a mean of 29.2 years (SD: +/- 12.908).

Thirty-seven (11.9%) had negative appendectomy and 64 (20.5%) had complicated appendicitis. One hundred eighty-four (56.3%) had open appendectomy, 127 (43.3%) had been operated laparoscopically and one patient (0.3%) had laparotomy. Ultrasound was done for 114 (36.3%) patients, appendix diameter measures 6 mm or more in 57 (50%) patients. The patients were divided into two groups, clinical assessment and ultrasound investigation groups.

One hundred and fourteen patients had ultrasound and 198 did not. Fifty-seven (50%) of ultrasound group showed positive appendicitis. Fourteen (12.3%) had negative appendectomy in ultrasound group and 23 (11.6%) in clinical group. Twenty-five (21.8%) had complicated appendicitis in ultrasound group and 39 (19.7%) in clinical group, see table 3 and figure 1.

**Table 3: Comparing Clinical and Ultrasound Groups**

<table>
<thead>
<tr>
<th></th>
<th>Clinical Group</th>
<th>US Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patients Number</td>
<td>198</td>
<td>114</td>
</tr>
<tr>
<td>Mean Age</td>
<td>27.56</td>
<td>32.08</td>
</tr>
<tr>
<td>Male</td>
<td>87.9%</td>
<td>51.8%</td>
</tr>
<tr>
<td>Female</td>
<td>12.1%</td>
<td>48.2%</td>
</tr>
<tr>
<td>Negative Appendectomy</td>
<td>11.6%</td>
<td>12.3%</td>
</tr>
<tr>
<td>Complicated Appendicitis</td>
<td>19.7%</td>
<td>1.8%</td>
</tr>
</tbody>
</table>
Figure 1: Comparing Results of Clinical and Ultrasound Group

We could apply Alvarado scoring system on 259 patients; therefore, four groups of patients according to the probability of appendicitis were revealed, see table 2 and figure 2. Then we looked for negative appendectomy, complicated appendicitis, usage of ultrasound and positive and negative results in table 4 and figure 3.

Figure 2: Stratification of Patients According to Alvarado Scoring

Table 4: Comparison According to Alvarado Scoring

<table>
<thead>
<tr>
<th></th>
<th>Less likely</th>
<th>Possible Appendicitis</th>
<th>Probably Appendicitis</th>
<th>Very Probably Appendicitis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patients Number</td>
<td>17</td>
<td>58</td>
<td>108</td>
<td>76</td>
</tr>
<tr>
<td>Male</td>
<td>82.3%</td>
<td>77.6%</td>
<td>74%</td>
<td>73.7%</td>
</tr>
<tr>
<td>Female</td>
<td>17.7%</td>
<td>22.4%</td>
<td>26%</td>
<td>26.3%</td>
</tr>
<tr>
<td>Negative Appendectomy</td>
<td>11.8%</td>
<td>22.4%</td>
<td>12.96%</td>
<td>1.3%</td>
</tr>
<tr>
<td>Complicated Appendicitis</td>
<td>11.8%</td>
<td>17.2%</td>
<td>21.3%</td>
<td>25%</td>
</tr>
<tr>
<td>US</td>
<td>52.9%</td>
<td>36.2%</td>
<td>33.3%</td>
<td>28.9%</td>
</tr>
<tr>
<td>6 mm Appendix</td>
<td>55.5%</td>
<td>66.7%</td>
<td>52.8%</td>
<td>54.5%</td>
</tr>
</tbody>
</table>
Finally, we compared the three groups: clinical, US positive and US negative, which resulted in negative rate of 11.6%, 5.3%, 19.3% and complicated appendicitis of 19.7%, 15.8%, 28.1% respectively, see table 5 and figure 5. The negative appendectomy and complicated appendicitis were evaluated, see figures 5 and 6.

**Table 5: Comparing Results of Negative and Complicated Appendix between Clinical, US Positive and US Negative Groups**

<table>
<thead>
<tr>
<th></th>
<th>Clinical Group</th>
<th>US Positive</th>
<th>US Negative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of sample</td>
<td>198</td>
<td>57</td>
<td>57</td>
</tr>
<tr>
<td>Negative appendectomy</td>
<td>11.6%</td>
<td>5.3%</td>
<td>19.3%</td>
</tr>
<tr>
<td>Complicated appendix</td>
<td>19.7%</td>
<td>15.8%</td>
<td>28.1%</td>
</tr>
</tbody>
</table>

**Figure 5: Negative Appendectomy Percentage Comparison According to Alvarado Scoring**
Figure 6: Complicated Appendicitis Percentage Comparison According to Alvarado Scoring

DISCUSSION

Acute appendicitis is a common and challenging diagnosis in daily surgical practice. It is a clinical diagnosis and many patients present with atypical history and findings on examination. The accuracy of diagnosing acute appendicitis on clinical grounds ranges from 70 to 87\%\textsuperscript{7}. The chance of undergoing an appendectomy during a lifetime is high, up to 23\% in females and 12\% in males\textsuperscript{2}.

It is safer to proceed to surgical intervention when in doubt, because a negative appendectomy is preferable to a perforation. A negative appendectomy rate of 7\%-30\% has been accepted to be the clinical standard because that kept the rate of perforated appendicitis 7\%-30\%\textsuperscript{8-10}. Morbidity was 5\%-15\% after negative appendectomy, which is not significantly different from cases of non-perforated appendicitis\textsuperscript{8,11,12}. Perforation compared to no perforation is associated with a double increased in mortality rate\textsuperscript{10}.

Ultrasound and computed tomography have been advocated to reduce the negative appendectomy rate\textsuperscript{13,14}. The ideal test should be 100\% sensitive and 100\% specific and should have a predictive value of 100\%. Also, there should be no false positive or false negative results, so that the total joint probability should add up to 100\%, currently no such test is available.

Implementation of US and CT in clinical studies resulted in high accuracy of diagnosing appendicitis. A low negative appendicitis rate could be achieved without adverse events due to a delay in treatment because of false negative imaging\textsuperscript{15}.

CT evaluated by general radiology staff has similar accuracy to that of sonography\textsuperscript{16}. Ultrasound is inexpensive, rapid test, non-invasive and requires no patient preparation or contrast material. Graded compression ultrasound is operator dependent and requires high level of expertise. The ultrasound images are not helpful for reevaluation. Moreover there are many limitation for ultrasound e.g., obese patients, retrocecal appendix or severe abdominal pain\textsuperscript{14,17}. Another important limitation of sonography is that the sensitivity and specificity for perforated appendicitis are lower than for non-perforated appendicitis\textsuperscript{18}. The sensitivity of ultrasonic detection of appendicitis is 55 to 98\% and the specificity is 78 to 100\%\textsuperscript{3,6,9,17,18,22}. 
However, perforated appendicitis and negative appendectomy have not declined despite the use of US and CT scan\textsuperscript{11}. Perforation rates have remained at constant level, approximately 20% over the last decade\textsuperscript{2,7,10,13}.

Although US is non-invasive, the tests add expense, burden hospital resources and can delay surgical intervention\textsuperscript{14}. Moreover, false negative results may delay surgery and subsequently increase morbidity\textsuperscript{24}.

Livingston et al found a slow but steady increase in the incidence of perforated appendicitis despite a decline in non-perforated appendicitis until a nadir in 1995, after which the incidence of non-perforated appendicitis increased presumably due to advancement in imaging diagnosis and low-morbidity laparoscopic surgical techniques, while the incidence of perforated appendicitis continued on the same slow steady climb\textsuperscript{25,26}.

The Alvarado score was originally described in 1986. However, this score alone is not accurate enough to diagnose or exclude appendicitis\textsuperscript{27,28}. Alvarado found the cut-off point of score 6 will have potential perforations, 5.8% and 8.7% will be unnecessary operation. But if score 5 potential perforation will drop to 2.9% and the unnecessary operations would rise to 11.2 \%\textsuperscript{6}. Alvarado reported that patients with a score 7 or higher could be acute appendicitis, a probability of 93\%\textsuperscript{17}. The Alvarado score is dynamic and can be recalculated at intervals over 12 to 24 hours of observation as often occurs in patient with an intermediate score\textsuperscript{29}. Alvarado score showed poor result in assessment of women, children and elderly patient\textsuperscript{28}.

Henrik found the clinical judgment of a junior surgeon was disappointing and diagnostic aids are desirable to reduce the negative appendectomy rate. Diagnostic ultrasound is performed poorly as routine procedure. Application of an up to date scoring system might be of some help to patients with a high or low probability of acute appendicitis\textsuperscript{30}.

Sonography as a standard procedure in the workup of acute appendicitis can be worthwhile only if the surgeon can rely on it to operate. Concern still exists that the overuse or reliance of radiologic tests may distract from careful and timely clinical assessment. How high should accuracy of CT and sonography in acute appendicitis be to convince the surgeon not to operate? If a small risk of a perforated acute appendicitis is still present even when both CT and sonography show a normal appendix, most surgeons will ignore the result\textsuperscript{16}.

In our study we found low sensitivity and specificity of ultrasound in diagnosing acute appendicitis. Review of literature revealed wide variation of ultrasound results which might reflect different equipment, operator’s training and expertise\textsuperscript{31}. One of the weaknesses in our study is the fact that it is retrospective in nature, making it difficult to elucidate the process involved in deciding on preoperative imaging, the timing of surgery and the type of surgery.

CONCLUSION

Ultrasound in our institute showed low sensitivity and specificity which made ultrasound an unreliable method for diagnosing acute appendicitis, as there is no statistical significance between the rates of negative appendectomies if ultrasound was done comparing with the group operated based on clinical finding alone.
Diagnostic imaging will continue to play a large role in the evaluation of patients with suspected appendicitis. The choice of imaging modality depends upon local expertise and should be made with consideration of the individual patient.

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REFERENCES


