Is There Any Association Between the Efficacy of Imaging Techniques and the Age of the Patient in the Diagnosis of Acute Appendicitis?

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Introduction

Acute appendicitis (AA) is one of the most common causes that requires an operation in patients visiting hospital with an abdominal pain (1). These cases are usually seen in patients under 50 years of age and peak in the second and third decades (2). The developments in imaging methods that support the diagnosis of AA have reduced the number of patients who were operated unnecessarily and shortened the waiting period in the complicated cases before surgery. Although this is such a common case about which many studies have been done, there are still debates about the diagnostic methods for AA.

Ultrasonography (US) and computerized tomography (CT) are the two basic imaging modalities used in AA; they are still the most important and valid diagnostic tools. Even though CT is considered more successful for diagnosis in many studies, we can never abandon US because of the radiation exposure aspect of CT (3, 4). To determine the imaging method that is used during diagnosis according to patient history and symptoms will also increase the effectiveness of the method.

In this study, selected imaging modalities in the diagnostic process of cases operated on the basis of an AA diagnosis and whose histopathologic examinations were compatible with AA were retrospectively reviewed. The aim of this study was to examine whether

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Diagnosis of Acute Appendicitis

During the 6-month period between October 1, 2015, and April 1, 2016, we retrospectively reviewed the files of the persons who visited our emergency clinic, a third-step emergency department of a university hospital, and then operated at our hospital. The ethics committee’s approval for the study was given by the same institution.

Materials and Methods

During the 6-month period between October 1, 2015, and April 1, 2016, we retrospectively reviewed the files of the persons who visited our emergency clinic, a third-step emergency department of a university hospital, and then operated at our hospital. The ethics committee’s approval for the study was given by the same institution.

Statistical analysis

IBM Statistical Package for the Social Sciences 20.0 (IBM SPSS Statistics; Armonk, NY, USA) was used for the statistical analyses of the data. The normal distribution suitability of continuous variables...
The Mann-Whitney U test was used for the comparison of the mean of the related binary groups of continuous variables without normal distribution, and Kruskal-Wallis test was used for the comparison of the mean of more than two groups. The chi-square test was used to compare categorical variables. The descriptive statistics were given as percent, frequency, mean, and standard deviation. Significance was tested at a level of alpha equal to 0.05.

### Results

In this study, 97 patients (59.1%) were male and 67 patients (40.9%) were female. The ages ranged from 19 to 86 years (mean age, 36.7 ± 14.7 years). When the age distribution of the patients was analyzed with Kolmogorov–Smirnov test, because the skewness-kurtosis values were calculated between −1.5 and +1.5, this dataset fit normal distribution (Figure 2). According to age groups, the most patients were observed in the first age group (111 patients, 67.7%) and then second age group (38 patients, 23.2%) and followed by third age group (15 patients, 9.1%).

In our study, US was used to diagnose 77.4% (127 patients) of the patients. US application percentages in different groups were 84.7% in the first age group, 71.1% in the second age group, and 40% in the third age group (p<0.0001). The rate of patients undergoing only US because it was preferred during diagnosis was 52.3% in the first age group, 39.5% in the second age group, and 0.0% in the third age group (p<0.0001).

In all, 55.5% of our patients (91 patients) were evaluated with CT: 47.7%, 60.5%, and 100.0% of the patients in the first, second, and third groups, respectively (p<0.0001). The proportion of patients for whom only CT was preferred in the diagnosis process was 15.3%, 28.9%, and 60% in the first, second, and third age groups, respectively (p<0.0001).

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**Table 1.** CT and US comparison results in the acute appendicitis diagnosis

<table>
<thead>
<tr>
<th>AA diagnosis with US</th>
<th>Negative</th>
<th>Positive</th>
<th>Unclear</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>% US</td>
<td>% CT</td>
<td></td>
</tr>
<tr>
<td>Negative</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Positive</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unclear</td>
<td>% US</td>
<td>% CT</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 2.** CT and US sensitivity rates by age group

<table>
<thead>
<tr>
<th>Sensitivity</th>
<th>1st age group</th>
<th>2nd age group</th>
<th>3rd age group</th>
<th>Significant difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT</td>
<td>42.3%</td>
<td>52.6%</td>
<td>93.3%</td>
<td>+</td>
</tr>
<tr>
<td>US</td>
<td>55.0%</td>
<td>47.4%</td>
<td>26.7%</td>
<td>+</td>
</tr>
</tbody>
</table>

CT: computerized tomography; US: ultrasonography

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**Figure 3.** Boxplots comparing the time passed until imaging stratified by imaging methods. There was a significant difference in the data showing the time passed until imaging between the US only group and both US and CT group (p=0.0000). CT: computerized tomography; US: ultrasonography

was measured by the Kolmogorov–Smirnov test. The Mann-Whitney U test was used for the comparison of the mean of the related binary groups of continuous variables without normal distribution, and Kruskal-Wallis test was used for the comparison of the mean of more than two groups. The chi-square test was used to compare categorical variables. The descriptive statistics were given as percent, frequency, mean, and standard deviation. Significance was tested at a level of alpha equal to 0.05.
were used were categorized according to their age groups, no statistically significant difference was observed between groups.

When the results of the imaging methods were compared, of the 59 patients with a negative US result, CT was positive in 51, negative in four, and unclear in four patients. Of the 83 patients with a positive US diagnosis, 12 had a positive CT scan and 71 had a negative CT scan result. We found that CT was positive in 81.8% of the cases who ended up with an unclear US, and it was negative and unclear in the remaining four (18.2%) patients (Table 1). The difference between the positive diagnostic decisions for the patients was statistically significant (p<0.0001).

When the patients included in the study were evaluated on the basis of the age group, there was no statistically significant difference between the sensitivity of CT and US (p<0.001) (Table 2).

The time passed until imaging was calculated as 151±27 min in the US group only, 180±74 min in the CT group only, and 253±59 min in both the US and CT groups (Figure 3). There was a significant difference in the data showing the time passed until imaging between the US group and both US and CT groups (p=0.000).

The data showing the time passed until imaging according to different age groups were 187±65 min, 185±69 min, and 242±79 min in first, second, and third age groups, respectively. A 55-min difference was detected between second and third age groups; this difference was statistically significant as well (p=0.017, 95% CI, 8.33–104.95).

**Discussion**

In this study, it was found that making an examination based on age group in the diagnosis of AA provides high sensitivity and accelerates the diagnosis. The incidence of AA is around 9% in Western societies, and its incidence is increasing in both developed and developing countries (8, 9). Early diagnosis and treatment of this disease is important. Pre-hospital and hospital delays should be prevented. US, CT, and diagnostic scoring systems are available to assist the clinician to prevent hospital delays (10-12). However, despite these developments, the diagnosis of AA may not be as easy as it assumed.

The incidence of AA at an early age is higher than that in the elderly population (13, 14). However, the presentation of these diseases in younger patients may be different from that in middle-aged and older patient groups. The diagnosis can be difficult, especially in the elderly patient population; this situation may lead to delays in the diagnosis (15, 16). For this reason, it would be more useful to determine the diagnostic tests based on age group and disease presentation before diagnosing a patient suspected as having AA. In our study, the majority of the cases were younger compared to elderly. Although there were more studies in the literature that showed more women are diagnosed with AA, there were more males in the population with an AA diagnosis in our study (14).

In the literature, it was noted that US can be safely used for its high sensitivity values in AA diagnosis. In one study, the sensitivity of the US was given as 88%, whereas it was given as 71.2% in another study (17, 18). Some studies with lower sensitivity rates have also been reported in the literature (14). The sensitivity was reported as 67.6% with the head-up US (13). Besides not having a high sensitivity, US has other limitations including its limited use in non-working hours and on weekends because a trained technician is not present (19). However, it is the method that should be preferably used first in children and the younger population because it can be done quickly, and it does not include any radiation (19-21). In our study, US sensitivity was found to be high; this rate is even higher in the young patient population. In our study, the level of sensitivity was found high in the young population. Therefore, US was more preferable in young patients who had symptoms possibly indicative of AA.

Sensitivity of CT in AA was between 83.3% and 100%, which is higher than that of US (14, 18). The CT method, which is more sensitive compared to US, is usually used for older patients and for patients who are more likely to have complications (19, 22). In one study, the possibility of peritonitis and the length of hospitalization were found higher in the patient group where CT was preferred (22). Because of the possibility of malignancy in the elderly patient group, a CT scan is usually performed in the preoperative period. For this reason, CT should be preferred in these patients to avoid missing a diagnosis in a patient more likely to have complications and to avoid delay in the diagnosis. In our study, CT was more preferred in the elderly group and the sensitivity was found quite high.

Another group of patients cannot be diagnosed by either US or CT only. Literature reports suggest that CT can be used as a complementary method in patients who cannot be diagnosed with US (23). Even more interestingly, 5 (12.2%) of the 41 patients with a negative CT in a study conducted with 104 patients noted that US reassessment helps avoid missing the diagnosis in patients who were found as AA-negative in a CT scan before the US (24). These studies showed that US and CT are complementary diagnostic tools. The necessity of using them together is usually helpful in a patient population with atypical presentation and therefore difficult to diagnose. In our study, approximately one in four patients who needed to have both US and CT scan and presented with symptoms suspicious of AA were diagnosed.

It is possible to make a faster AA diagnosis with US compared to CT, especially in the experienced centers that allow visualization of appendicitis (25). It is the first choice in the young population. CT should be preferred in elderly patients, although it delays the diagnosis compared to US. The time to diagnosis is even longer in the patient population in which both methods need to be used together.

**Study limitations**

In our study, we evaluated a well-defined patient group commonly encountered in emergency services where a large population is examined. Also, the need for diagnostic imaging methods used in different patient groups was assessed. The limitations of the present study include being single-centered and retrospective. However, because our hospital is a high-volume center, has an expert emergency department group working with the same clinical practices, and patient records are kept regularly, we think that our study presents valuable evidence.

**Conclusion**

As a result, US should be the first choice to be preferred in young and uncomplicated cases in the AA diagnosis, but it should not be preferred in elderly and patients with atypical presentations. It is very important to determine an age-related diagnostic algorithm for this disease, which is frequently encountered in emergency departments. More prospective studies are needed in this area.
Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of Medeniyet University Göztepe Training and Research Hospital.

Informed Consent: Written informed consent was obtained from patients who participated in this study.

Peer-review: Externally peer-reviewed.

Conflict of Interest: No conflict of interest was declared by the authors.

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