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Additional Diagnostic Findings in Acute Appendicitis in Children: Splenomegaly and Mesenteric Lymph Node Enlargement

Çocuklarda Akut Apandisitte Yardımcı Tanı Bulguları: Splenomegali ve Mezenterik Lenf Nodu Büyümesi

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ABSTRACT

Background: Ultrasonography is an effective diagnostic tool for appendicitis in children. Additional findings such as fatty tissue changes and free fluid are particularly relevant in cases with poor visualization of the appendix. We aimed to investigate splenomegaly and the increase in number and size of mesenteric lymph nodes in acute appendicitis.

Materials and Methods: Because ultrasonography is operator-dependent, and subjective since it is performed by different operators under emergency conditions, we designed this study to re-examine computed tomography studies. In this retrospective study, abdominal tomography scans of 150 children, 75 of whom were diagnosed with acute appendicitis and 75 of whom were in the control group, were evaluated. The number of mesenteric lymph nodes with a short-axis diameter measuring 4-8 mm, exceeding 8 mm, splenic long axis and splenic index were recorded.

Results: Splenic long axis, splenic index and the number of lymph nodes measuring 4-8 mm and exceeding 8 mm were greater in the appendicitis-positive group than in the control group (respectively 107±14 vs. 100±13.0 mm, 276±93 vs. 229±78 cm^3, 4±2.6 vs. 2±2.4 and 1±1.1 vs. 0.2±0.6; p<0.01). Lymph node positivity measuring 4-8 mm, exceeding 8 mm and splenomegaly percentages were 85%, 40%, 19% in the appendicitis group and 52%, 16%, 6.7% in the control group, respectively. The sensitivity/specificity of lymph nodes measuring 4-8 mm, lymph nodes >8 mm and splenomegaly for acute appendicitis were 85%/48%, 40%/84% and 21%/93%, respectively.

Conclusion: Splenic enlargement and increased lymph node number/size may help to diagnose acute appendicitis in equivocal cases where the appendix cannot be visualized.

Keywords: Appendicitis, splenomegaly, spleen, lymph node, computed tomography

ÖZ

Amaç: Çocuklarda apandisit tanısında ultrasonografi etkili bir tanı aracıdır. Apendiksin görüntülenemediği olgularda yağlı doku değişiklikleri, sıvı gibi ek bulgular önem kazanmaktadır. Akut apandisitte splenomegali ve mezenterik lenf nodu sayı ve boyut artışını araştırmayı amaçladık.

Gereç ve Yöntemler: Ultrasonografinin operatör bağımlı olması ve incelemelerin acil şartlarda farklı operatörler tarafından yapılması nedeniyle çalışmayı bilgisayarlı tomografi incelemelerini retrospektif değerlendirmek şeklinde planladık. Bu retrospektif çalışmada, 75'i akut apandisit ve 75'i kontrol grubunda olmak üzere 150 çocuğun abdomen tomografileri değerlendirildi. Kısa çapı 4-8 mm ölçülen lenf nodu sayısı, kısa çapı 8 mm'yi geçen lenf nodu sayısı, dalak uzun boyutu ve splenik indeks not edildi.

Bulgular: Apandisit pozitif grubun dalak uzun aksı, splenik indeks, 4-8 mm ölçülen lenf nodu ve >8mm ölçülen lenf nodu sayısı kontrol grubundan yüksekti (sırasıyla 107±14 vs. 100±13,0 mm, 276±93 vs. 229±78 cm^3, 4±2,6 vs. 2±2,4 ve 1±1,1 vs. 0,2±0,6; p<0,01). Çapı 4-8 mm ölçülen lenf nodu >8mm ölçülen lenf nodu ve splenomegali yüzdesi sırasıyla apandisit pozitif grupta 85%, 40%, 19% ve kontrol grubunda 52%, 16%, 6,7% idi. Çapı 4-8 mm ölçülen lenf nodu >8mm ölçülen lenf nodu ve splenomegali pozitifliğinin apandisit için sensitivite/spesifisitesi sırasıyla 85%/48%, 40%/84% ve 21%/93% idi.

Sonuç: Akut apandisit tanısında apendiksin gösterilemediği şüpheli olgularda dalak büyümesi ve lenf nodu sayı/ boyut artışı ek bulgu olarak tanıya yardımcı olabilir.

Anahtar Kelimeler: Apandisit, splenomegali, dalak, lenf nodu, bilgisayarlı tomografi

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Introduction

Acute appendicitis is the most common surgical emergency in children, which peaks especially in teenagers. Although it may be seen in all age groups, it is rare in infants (1,2). Children present with variable clinical symptoms such as pain, nausea, vomiting, and loss of appetite. History and physical examination are important steps in the diagnosis of acute appendicitis in children (2). Appendicitis scoring systems such as the Alvarado score and pediatric appendicitis score (PAS) can be used to diagnose appendicitis (3,4).

Ultrasonography (US) is an effective diagnostic tool for appendicitis with a sensitivity above 85% and a specificity above 90%. The sonographic criteria include a non-compressed, non-peristaltic appendix with a diameter of 6 mm or greater and an edematous wall. Other ancillary signs include fatty tissue changes around the appendix, mesenteric lymph node enlargement, free fluid, and collection (5). Inability to visualize the appendix and operator dependence are the disadvantages of US (6).

Computed tomography (CT) can also be used to diagnose acute appendicitis. Compared to US, CT is more specific and sensitive for appendicitis. However, due to the radiation exposure risk, it should be performed in equivocal cases (2).

Additional findings such as fatty tissue changes, free fluid, and mesenteric lymph node enlargement are particularly relevant in cases with poor visualization of the appendix. These findings detected on ultrasound may be helpful for decision making on CT scan in equivocal cases. There are few studies showing the relationship between mesenteric lymph node enlargement and appendicitis but they have both enrolled an insufficient number of patients and provided rough data or have not specified the values taken as a basis for evaluating lymph node enlargement (7,8,9,10). In short, there is no comprehensive study evaluating the increase of lymph node number and size in acute appendicitis. We have not come across any study in the literature that has evaluated splenic size or reported splenomegaly in acute appendicitis.

This study aimed to investigate the increase in splenic size, splenomegaly, and the increase in number and size of mesenteric lymph nodes in acute appendicitis.

Material and Methods

This retrospective study was approved by the Ethics committee of Sakarya University (approval date: 01.12.2020, approval number: E.10771). We retrospectively reviewed the CT images of patients presenting with abdominal pain between January 2016 and December 2020, who were evaluated with CT due to vague clinical signs and the inability to visualize the appendix on US, and whose diagnosis of appendicitis was confirmed at surgery. Patients with stable clinical signs who were evaluated with contrast-enhanced CT due to trauma but found to have no parenchymal organ injury or other organ injuries/bleeding during the same period were enrolled as the control group and their CT images were also retrospectively evaluated. The past clinical findings of the patient and control groups were reviewed. The exclusion criteria included infectious-inflammatory diseases, obesity, diabetes, and other acute and chronic disorders that might affect splenic size and size/number of lymph nodes.

The patients' IV contrast-enhanced abdominal CT images scanned with a 16 MDCT device (Toshiba Alexion, Ōtawara, Japan) with a scan thickness of 5 mm were evaluated.

A dilated appendicitis (>6 mm), thickening of the appendiceal wall (>1 mm), and contrast enhancement are diagnostic findings of appendicitis on CT examination (2). Appendix diameter and wall thickness were measured for each group. In our study, mesenteric lymph nodes with a short-axis diameter smaller than 4 mm were not taken into consideration. Lymph nodes were divided into two groups according to short axis diameter of 4-8 mm and ⩾8 mm (8,11). The number of lymph nodes with a short-axis diameter measuring 4-8 mm, the number of lymph nodes with a short-axis diameter exceeding 8 mm, and the total number of lymph nodes were recorded for each patient.

The splenic size was measured in three dimensions (craniocaudal, anteroposterior, and transverse). The splenic index was calculated using the formula: S Vol=30 + 0.58 (W × L × Th) for each patient (12). Splenic long axis dimensions were evaluated for splenomegaly by age group.

Splenic size is correlated to height, weight, and waist circumference (13). The patients' height and weight measurements at the time of imaging could not be accessed. However, each patient's waist circumference was measured and recorded during the time of the CT studies.

Statistical Analysis

Statistical analyses were performed using IBM SPSS Statistics 25 IBM Software. Numerical variables were reported as mean and standard deviation and categorical variables as numbers and percentages. The Mann-Whitney U test was used to compare numerical variables between two independent groups, and the chi-square test was used to compare categorical variables. Correlation analyses of parametric and non-parametric variables were performed with the Pearson's correlation analysis and Spearman's correlation analysis, respectively.

Results

Seventy-five patients who were operated on for acute appendicitis were enrolled as the patient group and 75

children who were imaged with CT after trauma as the control group. An analysis of the study groups regarding their waist circumference showed no significant difference between the appendicitis-positive patients and the control group (p>0.05). Similarly, there was no significant difference between the two groups in terms of sex distribution and age (p>0.05) (Table 1).

Appendicitis and control groups were significantly different regarding appendiceal wall diameter, wall thickness, splenic long axis, and splenic index (Table 2). Appendix diameter and wall thickness were significantly greater in the appendicitis-positive group than in the control group (9.6±2.6 vs. 4.5±0.7 mm, respectively and 2.2±0.4 vs. 1.0±0.2 mm, respectively; p<0.0001 for both comparisons) (Figure 1). Splenic long axis and splenic index were significantly greater in the appendicitis-positive group than in the control group (107±14 vs. 100±13.0 mm, respectively and 276±93 vs. 229±78 cm^3, respectively; p=0.0075 and p=0.0016 respectively) (Figure 2). The appendicitis-positive group had a much higher number of mesenteric lymph node measuring 4-8 mm and exceeding 8 mm than the controls (4±2.6 vs. 2±2.4, respectively and 1±1.1 vs. 0.2±0.6, respectively; p=0.0003 and p=0.0049 respectively). Similarly, the total number of lymph nodes of the appendicitis-positive group was significantly higher than that of the control group (4±3.4 vs. 2±2.9; p<0.001) (Figure 3).

Sixty-four (85%) patients in the appendicitis-positive group and 39 (52%) children in the control group had lymph nodes with a diameter exceeding 4 mm. Thirty (40%) patients with acute appendicitis and 12 (16%) control subjects had lymph nodes with a diameter exceeding 8 mm. There was

Table 1. Comparison of the demographic structures of patients with appendicitis and control group

	Patients with appendicitis	Control group	p
Gender, F (%) M (%)	 24 (32) 51 (68)	 24 (32) 51 (68)	1,000
Age, year	14±4.20 16 (3-18)	14±4.16 16 (3-18)	0.757
WC, cm	75.4±14.0 74.3 (44-106)	74.4±13.3 72.2 (51.2-112.6)	0.583

Non-parametric data are given as mean, standard deviation and median (min-max). If p value is less than 0.05, the difference is significant. F: Female, M: Male, WC: Waist circumference

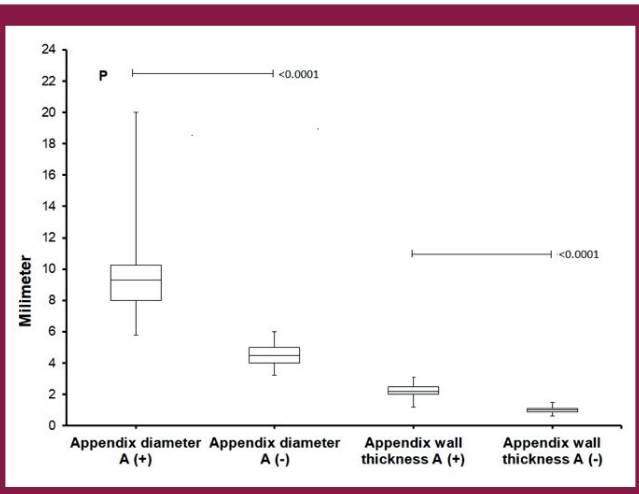

Figure 1. Appendiceal diameter and wall thickness of groups. It can be noted that the appendicitis-positive group (A) has both larger appendiceal diameter and wall thickness

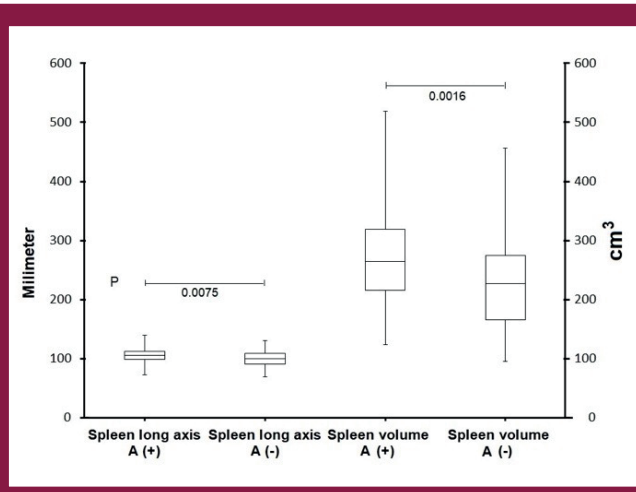

Figure 2. Graphic representation of the comparison of the spleen's long axis and splenic volume (index). It can be noticed that the appendicitis-positive group (A) has both larger spleen long axis and splenic volume

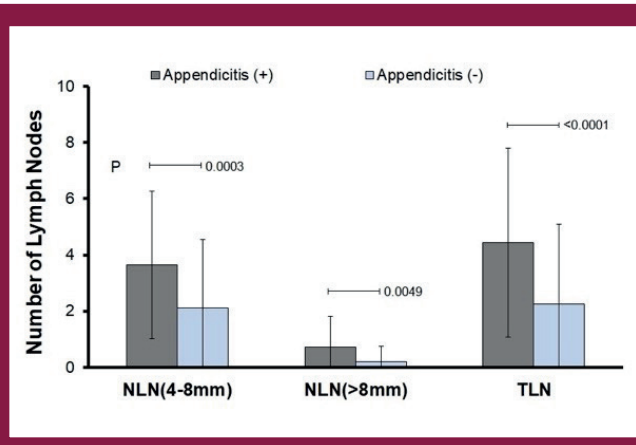

Figure 3. Graphic representation of the evaluation by lymph node size and number. The numbers of lymph nodes with a size of 4-8 mm and >8 mm were significantly greater in the appendicitis-positive group (A) compared to the control group. Similarly, the total number of lymph nodes was also significantly greater

a significant difference between the study groups with respect to the presence of lymph nodes measuring 4-8 mm and exceeding 8 mm. Sixteen (19%) patients in the acute appendicitis group and 5 (6.7%) children in the control group had splenomegaly. The two groups also differed significantly regarding the presence of splenomegaly (Table 3).

Lymph nodes measuring 4-8 mm had a sensitivity of 85% and a specificity of 48%; lymph nodes exceeding 8 mm had a sensitivity of 40% and a specificity of 84% for acute appendicitis. The sensitivity and specificity of splenomegaly for acute appendicitis were 21% and 93%, respectively.

Good positive correlations were found between the status of appendicitis (positive or negative) and appendix diameter, appendiceal wall thickness (Spearman r=0.8652, 95% confidence interval (CI): 0.8168 to 0.9015, p<0.0001 and Spearman r=0.8633, 95% CI: 0.8143 to 0.9001; p<0.0001, respectively). There was a positive correlation close to moderate strength between the presence of appendicitis and the number of lymph nodes (Spearman r=0.3807, 95% CI: 0.2285 to 0.5147, p<0.0001). Similarly, weak, albeit statistically significant, correlations were found between the presence of appendicitis and splenomegaly, splenic index, and splenic long axis size (Spearman r=0.2113, 95% CI: 0.04806 to 0.3636, p=0.0094; Spearman r=0.2582, 95% CI: 0.09740 to 0.4059, p=0.0014 and Spearman r=0.2192, 95% CI: 0.05626 to 0.3707, p=0.0070, respectively).

Table 2. Comparison of the appendix and spleen diameters of patients with appendicitis and control group

	Patients with appendicitis	Control group	p
Appendix diameter, mm	9.6±2.6 9.3 (5.8-20)	4.5±0.7 4.5 (3.2-6)	<0.001
AWT, mm	2.2±0.4 2.2 (1.2-3.1)	1.0±0.2 1 (0.6-1.5)	<0.001
SLA, mm	107±14 106 (73-140)	100±13.0 100 (69-131)	0.007
Splenic index, cm^3	276±93 264 (124-519)	229±78 227 (95-456)	0.002

Non-parametric data are given as mean, standard deviation and median (min-max). If p value is less than 0.05, the difference is significant. AWT: Appendix wall thickness, SLA: Spleen long axis

Table 3. Comparison of the lymph node with a short axis measuring 4-8 mm and exceeding 8 mm, and splenomegaly between appendicitis and control groups

	Patients with appendicitis	Control group	p
Lymph node (4-8 mm), n (%)	64 (85)	39 (52)	<0.001
Lymph node (>8 mm), n (%)	30 (40)	12 (16)	0.001
Splenomegaly, n (%)	16 (21)	5 (6.7)	0.010

Non-parametric data are given as mean, standard deviation. If p value is less than 0.05, the difference is significant

Discussion

History and physical examination are important tools for making the diagnosis of appendicitis in children (2). In 1986, Puylaert defined the staged compression technique (7). Sonographic identification of an edematous, non-compressed appendix is an important clue for the diagnosis. Furthermore, additional findings such as peri-appendiceal fat tissue changes, appendicolitis, mesenteric lymph node enlargement, and free fluid may be found (14). In the present study, we defined splenomegaly as an additional finding. In our study, 16 (19%) patients with acute appendicitis and 4 (6.7%) children in the control group had splenomegaly. There was a significant difference between the two groups in terms of the presence of splenomegaly.

US is operator-dependent and requires experience, which makes sonographic diagnosis difficult, as well as various factors such as retrocecal appendix and obesity (15,16). Nonspecific signs such as peri-appendiceal fatty tissue changes and free fluid may guide the clinician especially in pediatric cases where the appendix cannot be visualized in sonographic imaging. Our study detected a weak but significant correlation between acute appendicitis and splenomegaly.

The spleen is composed of red pulp, a white pulp, and the marginal zone (MZ) that forms an interface between the two. Red pulp filters the blood and recycles the iron. Leukocytes in the spleen consist of various T and B cells, dendritic cells (DCs), and macrophages with different functions. Macrophages found in the MZ eliminate bacteria and viruses originating from blood. In addition to macrophages, the MZ also contains B cells and DCs that present antigens to lymphocytes in the white pulp. White pulp is structurally resembling a lymph node in which it contains T-cell and B-cell zones and allows the formation of antigen-specific immune responses against blood-borne infections (17). Considering all these functions of the spleen, which is an important lymphoid organ, a relationship between appendicitis and splenomegaly can be expected. However, no study has ever been conducted to assess splenic size in acute appendicitis. In our study, the splenic long axis and splenic index were significantly greater in the appendicitis-positive group than the controls. There was a weak, albeit significant, correlation between acute appendicitis and splenic index and splenic long axis.

Our study demonstrated a much higher number of lymph nodes measuring 4-8 mm, lymph nodes exceeding 8 mm, and total lymph nodes in the appendicitis-positive group compared to the control group. Puylaert reported that enlarged mesenteric lymph nodes were present in about

40% of acute appendicitis cases (7). Sivit et al. (8) examined patients with mesenteric lymph node enlargement and acute abdominal pain. They reported that among patients with mesenteric lymph node enlargement, acute appendicitis was the most common specific diagnosis following gastroenteritis and abdominal pain of unknown origin (8). Those studies have both had an insufficient number of patients and/or scant data because they took 4 mm as the limit for the short axis lymph node diameter. In our study, when lymph nodes larger than 4 mm were taken into consideration, lymph node positivity had a sensitivity of 85% and a specificity of 48% for acute appendicitis. When only lymph nodes with a diameter larger than 8 mm were considered, sensitivity and specificity were 40% and 84%, respectively. These results suggest that as lymph nodes enlarge, specificity increases but sensitivity decreases.

In various studies, mesenteric adenitis was a common diagnosis in patients operated for suspected appendicitis (18,19,20). Although mesenteric lymphadenitis has been formerly defined as a cluster of lymph nodes with a number exceeding 3 and a diameter exceeding 5 mm, the current definition involves the detection of at least 1 lymph node with a diameter larger than 8 mm (21). Our study detected lymph nodes having a diameter exceeding 8 mm in 30 (40%) patients with acute appendicitis and 12 (16%) of the control subjects. This suggests that acute appendicitis should be considered in addition to mesenteric adenitis in the differential diagnosis of cases presenting with acute abdominal pain in which the appendix cannot be visualized. Our study enrolled no patient group with mesenteric lymphadenitis, which may be considered a limitation of our study.

Our study aimed to stress the importance of detecting an increased splenic size and lymph node number/size as an additional sign when the appendix cannot be visualized by US. However, as US is operator-dependent, and it may not provide objective information since it is performed by different operators under emergency conditions, we designed this study to re-examine CT studies. Again, this is another limitation of our study.

Conclusion

In conclusion, in equivocal cases where the appendix cannot be visualized with US, additional findings such as splenic enlargement and increased lymph node number/size may guide for the evaluation of the appendix with CT. However, as sonography is an operator-dependent modality and these findings are nonspecific, a well-performed physical examination is the most important stage for the decision of CT scan and for an accurate diagnosis.

Ethics

Ethics Committee Approval: This retrospective study was approved by the Ethics Committee of Sakarya University (approval date: 01.12.2020, approval number: E.10771).

Informed Consent: Retrospective study.

Peer-review: Externally peer-reviewed.

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