PERFORATED APPENDICITIS: A SONOGRAPHIC DIAGNOSTIC CHALLENGE

PERFORE APANDİSİT: ULTRASONOGRAFİK BİR TANISAL ZORLUK

Sonay AYDIN[1], Erdem FATİHOĞLU[2]

[1] Saglik Bilimleri University, Dr. Sami Ulus SUAM, Department of Radiology, Ankara, TURKEY
[2] Erzincan University, Department of Radiology, Erzincan, TURKEY

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ABSTRACT

INTRODUCTION: Perforated appendicitis (PA) cases are more common amongst pediatric population. Imaging plays an important role in PA diagnosis; clinical distinction can be quietly difficult, especially in younger children. Unfortunately, PA is defined as a potential pitfall in Ultrasound (US) evaluation, because a perforated appendix usually decompresses and becomes difficult to identify. In the current study, we mainly aim to define diagnostic US characteristics of PA, and determine most specific and sensitive US findings.

MATERIALS AND METHODS: We retrospectively evaluated the medical records and US reports of the children who were referred to the radiology department with a clinical diagnosis of acute appendicitis. We have recorded sedimentation (ESR), C reactive protein (CRP), and leukocyte count. We have recorded presence of loculated fluid in periappendiceal area, appendicolith, presence of complex fluid, increase in echogenicity of periappendiceal fat, fluid collection in abdominal recesses, increase in periportal liver echogenicity.

RESULTS: Study population consists of 132 patients. Loculated fluid collection in periappendiceal area, presence of appendicolith, fluid collection in 3-4 areas, and in all five areas, ESR, and CRP values are found to be effective for the differentiation. We define the combination of loculated fluid collection, presence of ascites in all five areas, and elevation of CRP levels as the most successful combination for detecting PA (98.2% specificity, 48.3% sensitivity).

CONCLUSION: Detection of loculated fluid in periappendiceal area, and fluid collection in all abdominal recesses is the most valuable US parameters. Combination of these parameters with CRP levels can increase diagnostic performance. Keywords: US, perforated appendicitis, diagnosis

Key Words: *Ultrasound, Perforated Appendicitis , Diagnosis*

ÖZET

AMAÇ: Perfore apandisit (PA) vakaları pediyatrik popülasyonda, özellikle 5 yaş altı çocuklarda daha sık görülmektedir. Perfore apandisit vakalarında klinik pek çok başka patoloji ile örtüşebildiğinden görüntüleme yöntemleri tanıda önem kazanmaktadır. Ne yazık ki, perforasyon sonucu apendiks dekomprese olduğundan, ultrason incelemesi ile perfore apandisiti tanımlamak güç olabilmektedir. Güncel çalışmada, perfore apandisit tanısı için en yararlı sonografik parametrelerin belirlenmesi hedeflenmiştir.

GEREÇ VE YÖNTEM: Radyoloji bölümüne akut apandisit ön tanısı ile yönlendirilen çocukların medikal kayıtları geriye dönük olarak taranmıştır. Eritrosit sedimentasyon hızı (ESH), C reaktif protein (CRP) düzeyleri, lökosit sayımları kaydedilmiştir. Ayrıca sonografik paramatreler olarak; apendiks çevresinde lokule sıvı varlığı, apendikolit tespiti, kompleks serbest sıvı bulunması, periapendisyel yağ dokuda ekojenite artışı olması, abdominal reseslerde asit tespit edilmesi ve periportal ekojenite artışı olması belirlenmiştir.

BULGULAR: Araştırma popülasyonu 132 hastadan oluşmaktadır. Apendiks çevresinde lokule koleksiyon tespit edilmesi, apendikolit varlığı, 3-4 abdominal reseste sıvı bulunması, tüm abdominal reseslerde sıvı bulunması, ESH, CRP değerlerinde artış olması parametreleri PA varlığını başarı ile öngörmektedir. Ayrıca, apendiks çevresinde lokule koleksiyon tespit edilmesi, tüm abdominal reseslerde sıvı bulunması ve CRP değerlerinde artış olması paramaterelerinin kombinasyonu (%98.2 spesifik, %48.3 sensitf), PA tanısında oldukça yararlı bulunmuştur.

SONUÇ: Apendiks çevresinde lokule koleksiyon tespit edilmesi ve tüm abdominal reseslerde sıvı bulunması en değerli sonografik parametrelerdir. Bu parametrelere CRP değerinin de eklenmesi tanısal başarıyı arttırabilir. Anahtar kelimeler: Ultrason, perfore apandisit, tanı

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Sorumlu Yazar / Corresponding Author:
Sonay AYDIN
Saglik Bilimleri University, Dr. Sami Ulus SUAM, Department of Radiology, Ankara, TURKEY
Tel:+90 506 625 91 55 **Fax:** +90 312 595 38 98 **e-mail:** sonaydin89@hotmail.com

INTRODUCTION

Acute appendicitis, being the most common cause of surgical acute abdomen has an estimated lifetime prevalence of 7% (1). Despite its high prevalence, its diagnosis still remains challenging. The clinical presentation can be atypical and symptoms often overlap with other conditions (2). For acute appendicitis diagnosis, Ultrasound (US) is a widely preferred method of evaluation, especially in pediatric population, because of lacking ionizing radiation exposure (3).

Acute appendicitis can be divided into two main groups according to clinical approach: simple appendicitis (SA) and perforated appendicitis. Sonographically, simple appendicitis can be defined as presence of a dilated, noncompressible appendix without evidence of a phlegmon, abscess, or perforation (4).

Perforated appendicitis (PA) cases are more common amongst pediatric population, and children younger than 5 years have higher perforation rates (5). Imaging plays an important role in perforated appendicits diagnosis, seeing that clinical distinction between perforated and non-perforated appendicitis can be quietly difficult, especially in younger children (6). Unfortunately, PA is defined as a potential pitfall in US evaluation, because a perforated appendix usually decompresses and becomes difficult to identify. Nonvisualisation of the appendix vermiformis is a common condition for normal appendix cases with a prevalence of 2.4% - 86.2%. This condition makes the differentiation of PA from normal appendix cases challenging (7-10).

Sonographic appearances and some more specific US findings are defined for PA in the literature. However these studies are generally old ones and defined parameters are limited. In the current study, we mainly aim to define diagnostic US characteristics of PA, and determine most specific and sensitive US findings.

MATERIAL AND METHODS

Local institutional review board approved the study. Patient informed consent was waived according to retrospective design of the study.

We retrospectively evaluated the medical records and US reports of the children who were referred to the radiology department with a clinical diagnosis of acute appendicitis between 2014-2017 (445 patients). We excluded the patients without pathologic diagnosis and insufficient clinical, laboratory information. Also, we have excluded the patients whose US examination reports did not contain all of the parameters examined in the study (313 patients). 132 patients are included into the current study.

We have recorded sedimentation (ESR), C reactive protein (CRP), and leukocytosis presence as laboratory findings.

As US findings, we have recorded presence of loculated fluid in periappendiceal area, appendicolith, presence of complex fluid, increase in echogenicity of periappendiceal fat (echogenic fat), fluid collection in abdominal recesses (four quadrant and pelvis), increase in periportal liver echogenicity **(Figure 1).** Complex fluid is defined as fluid collection containing multiple echoes in it **(Figure 2).** For grading degree of fluid collection in abdominal recesses, we divided abdomen into five areas as left and right lower and upper quadrants an pelvis.

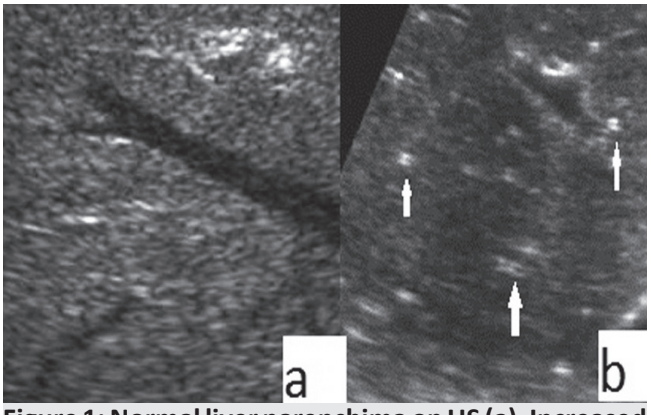

Figure 1: Normal liver parenchima on US (a). Increased periportal echogenicities in a perforated appendicitis case (b, arrows).

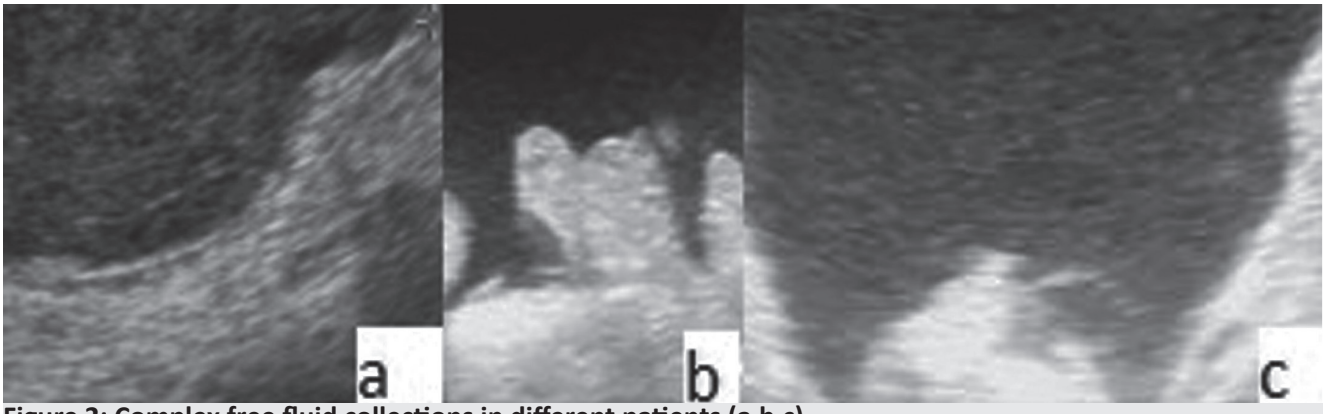

Figure 2: Complex free fluid collections in different patients (a,b,c).

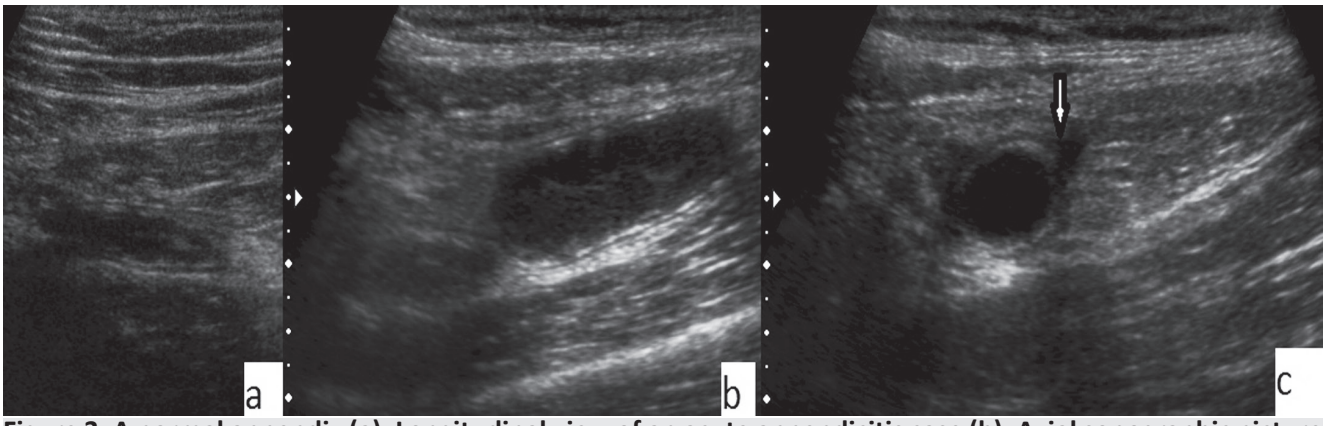

Figure 3: A normal appendix (a). Longitudinal view of an acute appendicitis case (b). Axial sonographic picture of a perforated appendicitis, free fluid (arrows) is seen around the appendix (c).

Patients are divided into three subgroups according to pathology results: simple appendicitis, perforated appendicitis, and normal appendix.

STATISTICAL ANALYSIS:

Study information was entered into an Excel (2007, Microsoft Corp., Redmond, WA) spreadsheet for analysis. All data entries were double-checked by one of the investigators. Data were analyzed using Statistical Package for the Social Sciences (SPSS) for Windows 20 (IBM SPSS Inc., Chicago, IL). Normal distribution of the data was evaluated with the Kolmogorov-Smirnov test. Numeric variables with normal distribution were showed as mean±standard deviation. The variables that did not have a normal distribution were shown as median (interquartile range). For comparison of the numeric variables between the two groups student's T test and Mann-Whitney U test were used. ANOVA and Kruskall Wallis H test was utilized for comparison between three or more groups. For categorical variables, Chi-Square and Fisher's Exact Chi- Square tests were used. Pearson and Spearman correlation analysis was utilized to evaluate the relationship between numeric variables. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and receiver operating characteristic (ROC) analysis were used to assess the performance of parameters. $P < 0.05$ was considered statistically significant.

RESULTS

Study population consists of 132 patients (83 (62.8%) male, 49 (37.1%) female). Mean age of the population is 7.2 ± 2.6 years. Distribution of the patients according to pathological diagnosis is shown in **Table 1.** Mean age of PA cases is significantly fewer than the others. There is no significant difference according to sex between three groups.

Mean leukocyte count values is higher in SA and PA groups than normal appendix group, however we cannot detect any significant difference between SA and PA groups. Mean ESR and CRP values are significantly higher in PA group than the others **(Table 2).**

The distribution of US findings according to pathological diagnosis is summarized in **Table 3.**

We evaluated the parameters success in differentiating PA from SA and normal appendix. Loculated fluid collection in periappendiceal area, presence of appendicolith, fluid collection in 3-4 areas, and in all five areas, ESR, and CRP values are found to be effective for the differentiation **(Table 4).** Also, we define the combination of loculated fluid collection, presence of ascites in all five areas, and elevation of CRP levels as the most successful combination for detecting PA (98.2% specificity, 48.3% sensitivity).

Table 1: Distribution of patients

	Normal appendix	Simple Appendicitis	Perforated Appendicitis
Number	42	62	28
Age	8.1±3.0	7.4±2.4	6.2±2.8
Male	30	38	15
Female	12	24	13

Table 2: Laboratory results according to pathological diagnosis

	Normal appendix	Simple Appendicitis	Perforated Appendicitis
Mean LC (103/mL)	10.5±2.8	13.2±3.1	13.8±2.7
Mean ESR level (mm/h)	6.3±2.1	18.9±3.7	25.2±5.1
Mean CRP level (mg/L)	2.7±1.3	32±5.6	131±10.2

LC: Leukocyte count, ESR: Erythrocyte sedimentation rate, CRP: C reactive protein

Table 3: Distribution of US parameters according to pathological results

	Normal appendix n (%)	Simple Appendicitis n (%)	Perforated Appendicitis n (%)
Loculated fluid	0 (0%)	5 (8%)	13 (46.4%)
Appendicolith	0 (0%)	18 (29%)	11 (39.2%)
Complex fluid	3 (7.1%)	9 (14.5%)	15 (53.5%)
Echogenic fat	4 (9.52%)	57 (91.9%)	25 (89.2%)
Fluid in 1-2 areas	23 (54.7%)	31(50%)	14 (50%)
Fluid in 3-4 areas	5 (11.9%)	15 (24.1%)	8 (28.5%)
Fluid in 5 areas	2 (4.7%)	4 (6.4%)	4 (14.2%)
Periportal echogenicity	5 (11.9%)	36 (58%)	9 (32.1%)

Table 4: Performance of the parameters for discriminating perforated appendicitis

	Sensitivity (%)	Specificity (%)	P value
Loculated fluid	25.2	98.3	< 0.01
Appendicolith	41.4	72.3	< 0.01
Complex fluid	31.2	96.7	< 0.01
Echogenic fat	31.3	70.6	0.22
Periportal echogenicity	43.8	72.5	0.18
Fluid in 1-2 areas	38.5	68.4	0.20
Fluid in 3-4 areas	49.3	88.1	< 0.01
Fluid in 5 areas	25.3	97.9	< 0.01
ESR levels	40.3	75.2	< 0.01
CRP levels	42.4	86.3	< 0.01
LC values	32.7	55.3	0.31

LC: Leukocyte count, ESR: Erythrocyte sedimentation rate, CRP: C reactive protein

DISCUSSION

Appendicitis is a common surgical condition, and incidence of acute appendicitis is 4 times greater than the overall population in children. According to literature approximately 20-35% of pediatric acute appendicitis cases perforated, and most of the perforations occur within 72 hours of symptom onset (11). Despite its relatively frequent prevalence, PA is still a diagnostic challenge for both pediatrics and radiologists. CT is often of greater utility than US in identifying complications of appendicitis such as phlegmon - abscess formation or perforation; however ionizing radiation is another

important concern. Perforation can decompress the appendix, underscoring the importance of correlating with the clinical presentation. Appendix vermiformis can be visualized in only 40 to 60% of patients with PA (12). Seeing the problem, it is needed to define more specific sonographic or laboratory parameters to diagnose PA more promptly, and correctly.

In the literature young age is defined as a risk factor for appendiceal perforation (13). Our results are consistent with the literature; mean age of PA group is younger than the others.

Loculated fluid collection in periappendiceal area is found to be the most specific (98.3%) sonographic criteria for PA. Our result is consistent with the literature (6, 14), as expected appendix contents are spilled into the peritoneal cavity, and this situation causes loculated fluid collection/abscess formation. In addition, consistent with the literature, complex free fluid collection is also a good predictor for PA (specificity 96.7%). As widely known, infected fluids, like peritoneal fluids contaminated with appendix content, are seen as complex fluids on US examination (6, 15).

Any kind of inflammation can cause free fluid presence in abdominal and pelvic cavities (16). According to our results, fluid collection in three or more cavities can discriminate SA from PA. Actually it is an expected result, as PA cause more severe inflammation, and a larger amount of fluid. In the literature, there is not so many studies examining the fluid collection in a similar way with us. In Tulin-Silver et al. (6) study there is similar results with ours.

Presence of appendicolith is known to be a risk factor for perforation (17), and also in some studies it is stated as a predicting US finding for PA (6). Different from the literature, in our study, presence of appendicolith is not successful enough to predict PA. Our appendicolith presence rate is lower than the literature; this can be the cause of the mentioned difference.

Increased echogenity around appendix, similar with other parts of the intraabdominal fat, is a good indicator of inflammation. Inflammation is a natural component of both SA, and PA. Consistent with the literature, the above mentioned US finding is not efficient in differentiating PA from SA (6, 15).

Multiple causes can create increased periportal echogenicity, including hepatic congestion, edema, infiltrative processes and excessive intravenous fluid administration. There is not enough study about this finding, according to Tulin-Silver et al. (6); it is useful for discriminating PA from SA. On the contrary, we cannot find such a relationship. Further prospective studies might enlight the exact importance of the finding.

MRI is appeared to be a useful diagnostic tool for diagnosis of AP especially in pediatric population and durin pregnancy (18, 19). It is said in the literature that the diagnostic accuracy of MRI is very similar to CT for diagnosing AP (18). However, there is not enough information about the utility of MRI in PA.

About laboratory results, we showed that ESR and CRP levels might help differentiation of SA and PA. In the literature, similar to our results, leucocyte count (LC), ESR, and CRP are found to be successful in differentiation of SA and PA (20). We found LC values inadequate. The difference can occur as a result of the difference between the designs of the two study. Our study contains more normal appendix cases than the mentioned one.

We also found that the best disgnostic combination for PA diagnosis is seem to be loculated fluid collection, presence of ascites in all five areas, and elevation of CRP levels. This is a contribution to the growing literature; we cannot find a similar combination of US parameters and laboratory results in the literature.

The study has some limitations. First, we cannot define a cut-off value for ESR, CRP values. Defining a cut-off value can increase diagnostic performance. Secondarily, retrospective nature of the study; a prospective study with larger populations, and focused on each parameter specifically might change the diagnostic power. Finally, we did not create a correlation with our parameters, and clinical findings. This kind of a correlation can increase diagnostic power.

To conclude, PA is still a challenging diagnosis. Detection of loculated fluid in periappendiceal area, and fluid collection in all abdominal recesses is the most valuable US parameters, and these findings should raise concern of PA in a suspected patient. Combination of these parameters with CRP levels can increase diagnostic performance.

Conflicts of interest: none
No funding have been received for the study.
The study have not been presented anywhere before.

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