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Ultrasound signs of acute appendicitis in children - clinical application

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Background. *Acute appendicitis is a leading cause of the abdominal pain in children that need an urgent surgical treatment. Neither of individually clinical variables doesn't have a real discriminational nor predictive strength to be used as the only diagnostic test. A goal of this study is to define ultrasound criteria of the acute appendicitis by appointing of ultrasound parameters for this pathological condition, determine the relation between ultrasound signs and pathohistological finding, determine the connection of several ultrasound signs with a degree of the inflammation of the acute appendicitis.*

Methods. *In the prospective study with an ultrasound method we examine 50 patients with clinical signs of the acute abdomen. In these patients, the sonographic diagnosis is confirmed by the surgical finding, in fact with a pathohistological diagnosis. A basic, positive sonograph finding of the acute appendicitis was the identification of tubular, noncompresive, aperistaltic bowel which demonstrates a connection with coecum and blind terminal. In our work we analysed the lasting of the symptoms until the hospital intervention in patients stratified according to the pathohistological finding. We used ultrasound equipment- Toshiba Sonolayer with convex 3.75 MHz and linear 8 MHz probes.*

Results. *From 8 ultrasound signs of the acute appendicitis, only an anterior-posterior (AP) diameter of appendices, FAT (width of periappendicular fat tissue) and a peristaltic absence are positive ultrasound signs of the acute appendicitis. Appendicitis phlegmonosa is the most common pathohistological finding in our study (44%). Perforate gangrenous appendicitis and gangrenous appendicitis are represented in more than half of patients (30% + 22%), which suggests a long period of persisting symptoms until a hospital treatment. A statistic analysis shows a great possibility for using values of AP diameter, width of periapendicular fat tissue, just like the values of mural thickness in the evaluation of the appendix inflammation level.*

Conclusions*. Ultrasound is an absolute method of choice in the eventual doubt of the existing state of acute appendicitis, with 8 ultrasound signs that defined this pathological condition.*

AP appendix diameter, mural thickness and width of periapendicular fat tissue represents highly significant ultrasound criteria in the evaluation of the appendix inflammation level.

Key words: appendicitis-ultrasonography; child

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Introduction

Acute abdomen is characterized by appearing of a sudden pain in the abdomen with a dysfunction; it appears suddenly and unexpectantly and it is caused with large number of changes on different abdomen organs. A clinical picture of the acute abdomen is one of the most divert and most complex conditions in the human body because of the beginning and course of the illness which is dependent o a large number of different organs in the abdomen. Acute appendicitis is a leading cause of an abdominal pain in children which demands an urgent surgical treatment. Clinical symptoms and signs depend, in the first place, on children's age, as well as on the pathological phase of appendicitis during the clinical examine. Beside the abdominal pain the acute inflammation of appendix is characterized with nausea, vomiting, anorexia, fever, diarrhoea, constipation, face blushing and tachycardia. Little patients preferred lying on the back in the supinatory position or on the right decubitus, quietly, because every motion causes pains. Cope made a list of 34 illnesses which lead to acute abdominal pains, and those conditions, according to signs and symptoms, which imitate the acute appendicitis. This list could be a longer, if we include immunodeficiency syndromes and another immunodeficiency states.[1]

The differential diagnosis of an abdominal pain is one of the fascinating, but mysterious questions for the clinical surgery. Reginald Fitz (1886) gave his own historical session describing a new pathological entity - appendicitis. And after 100 years, the exact diagnosis of this mysterious disease is still a huge problem.[1,2]

A diagnostic imaging of an acute abdominal pain in children is very hard, because little patients are not capable to give us relevant data. Besides, an acute, non-specific abdominal pain, which is very common in children, these little patients with an abdominal pain usually have symptoms that last longer than 24 hours (2/3 patients). If diagnosis and treatment are delayed, the morbidity and mortality of little patients increase. A diagnosis of typical clinical picture of the acute appendicitis is relatively easy, but in 30-45% of little patients it is presented with atypical clinical signs and symptoms which implicates the additional diagnostic imaging.[3,4]

Neither diagnostic variable individually (clinical and laboratory parameters) doesn't have significant discriminating nor predictive strength to be used as a relevant diagnostic test. There is a high risk of the incorrect diagnosis in some populations, especially in children without the existence of a relevant diagnostic test. The exact and prompt diagnosis is essential for minimizing of morbidity.

The goal of a modern surgical approach essentially is the same as in the 19th century, but today it is focused between percent of false negative appendectomy and percent of perforation in the time of the surgical observation. Introducing of ultrasound in the diagnosis of acute appendicitis, as this study shows, represents our aspect in leading of a modern medical protocol for young patients in this condition.

Methods

In the prospective study we analysed the possibilities of ultrasound in diagnosis of the acute appendicitis in children.

The research compassed 50 children in age from 0 to 16 years in whom ultrasound findings are confirmed with an operative, respectively, with a pathohistological finding (verification). These patients are observed and treated in the Clinic for Children's Surgery of Clinical Center Sarajevo initiated from Dom zdravlja Sarajevo. The study includes patients with both genders, with a clinical picture of the acute abdomen with its symptoms that occurred for the first time.

All patients are initially examined by the children's surgeon who, after clinical and laboratory findings, referred children to the ultrasound examination.

After the examination of the pelvis minor abdomen - the area of a maximum pain which a patient pointed with his/her finger (self-localisation) - the ileocoecal area was examined with a systematic ultrasound approach because of the possibility of the aberrant localisation of appendix.

A definition of the positive acute appendicitis sonograph finding was based on the identification of tubular, non-compressed, aperistaltic bowel which demonstrates a connection with caecum and clearly visible bowel blind terminal. By a careful approach, on the basis of eight ultrasound signs of acute appendicitis, we determined a connection between some US signs and a degree of the inflammation of the acute appendicitis. In the study we tried to analyse the lasting of symptoms until the hospital intervention in patients divided according to the pathohistological finding.

All examinations were done with the ultrasound unit Toshiba Sonolayer SAL 77 with convex (3.7 MHz) and linear (8 MHz) probes. Little patients were coming to be ultrasound examined as the urgent cases during the day or in the evening hours after they had been examined by their surgeon. A dosed compression in the ileocaecal area with a linear probe enabled the approach of ultrasound waves by gaping bowels with its content. Patients can suffer moderate compression as long as it is gentle, and according to the intensity it is identical to moderate deep palpation of the physical examination. For the identification of appendix it is necessary to find essential constraints: identify coecum and right colon in the transversal and longitudinal plane, identify musculus psoas and external iliac artery, and also identify terminal ileum.

Results

Table 1 shows basic demographic data of all patients. There is no significant statistical difference of the mean value (using age frequencies) between two groups of patients ($p>0.05$).

Table 2 shows eight ultrasound signs of acute appendicitis that are individually analysed in each patient.

Figure 1 shows pathohistological findings of the examined group of little patients. From these data we can see that appendicitis flegmonosa is the most common pathohistological finding (44%) (Figures 2a, 2b). In more than half of examined patients gangrenous appendicitis and perforate gangrenous appendicitis (30% + 22%) were found, which suggests a long existence of symptoms until the hospital treatment. Table 3 analysed the lasting of symptoms until the hospital inter-

Table 1. Basic demographic data in the examined group of patients

		Group I	Total
	Male	Female	
Age interval	3-16	4-16	3-16
N	26	24	50
X	9.864	11.083	10.440
S	3.518	3.900	3.721
Sx	0.690	0.796	0.526
Mediana	9.5	11.5	11
X2= 0.0801; p=0.777			

Table 2. Ultrasound signs in the examined group of patients

Anterior-posterior diameter (AP)	Mural wall thickness (MWT)	Air in lumen (AIR)	Inflame surrounding fat tissue (FAT)	Lack of peristaltic	Intra-luminal appendicolitis	Persistence of lymphonodes in appendix region	Local pericoecal fluid in abdomen
NegativeUS signs 0	0	0	0	0	15 (30%)	4 (8%)	29 (78%)
Uncertain signs 0	6 (12%)	10 (20%)	0	0	9 (18%)	11 (22%)	0
Positive US signs 50 (100%)	44 (88%)	40 (80%)	50 (100%)	50 (100%)	26 (52%)	35 (70%)	11 (22%)

Table 3. Existing of symptoms until hospital intervention

Appendicitis catharalis	Appendicitis flegmonosa	Appendicitis gangrenosa	Appendicitis gangrenosa perforata
N 2	22	11	15
Interval 4-8	4-48	10-48	14-72
X 6	20.091	24.909	34.067
S 2.828	12.641	12.661	19.073
Sx 2	2.695	3.817	4.925
Mediana 6	16	20	24
Mann-Whitney test		t = 5.00 , p= 0.042	

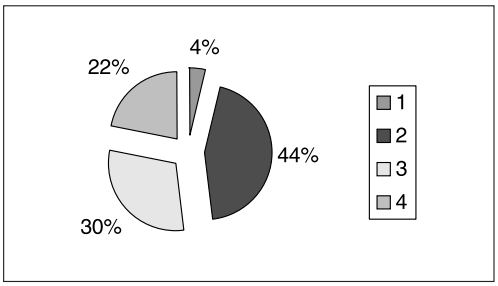
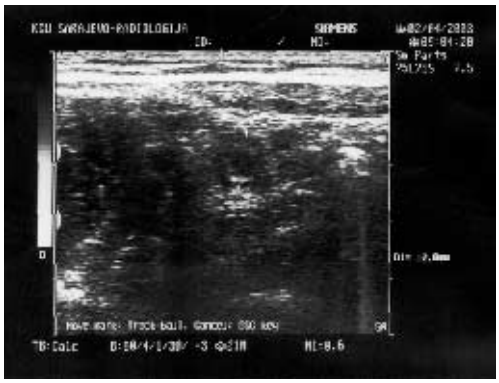


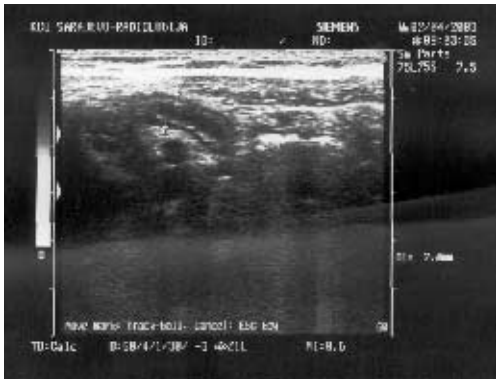
Figure 1. Patohistological findings in the examined group of patients. 1 apendicitis gangrenosa perforata; 2 apendicitis flegmonosa; 3 apendicitis catharalis; 4. apendicitis gangrenosa.

vention in all patients divided according to the pathohistological finding.

Using a suma range test we can see that 2/3 of patients with acute appendicitis have symptoms which last more than 24 h. There is a direct correlation between the percent of perforations and the period of lasting symptoms; and also time of delay of the hospital treatment and time of the observation before admitting to hospital have a significant influence.

In the following tables, using suma range test, we tested the possibility of using values





Figures 2a, 2b. Appendicitis phlegmonosa.

Table 4. Anterior-posterior (AP) diameter of appendix in the examined group of patients (n=48), except appendicitis catharalis (n=2)

	Appendicitis flegmonosa	Appendicitis gangrenosa	Appendicitis gangrenosa perforata
N	22	11	15
Interval AP diameter	7-12	10-18	9-14
X	9.318	13.455	11.067
S	1.427	2.659	1.534
Sx	0.304	0.802	0.396
Mediana	9	13	11
	T=-5,854; p<0,001	T=2.894; p=0,008	
Mann-Whitney test (app.flegmonosa vs app. perforata gangrenosa)		P=0,003	

Table 5. Mural wall thickness (MWT) of appendix in the examined group of patients (n=48), except appendicitis catharralis (n=2)

	Pathohistological finding		
	Appendicitis. flegmonosa	Appendicitis gangrenosa	App. gangrenosa perforata
N	22	11	15
MWT interval	2.5-4	3-5	2.8-5
X	3.145	3.664	4.056
S	0.436	0.612	0.816
Sx	0.093	0.185	0.204
Mediana	3	3.5	4
	p = 0.012*		
			p = 0.217*
Mann-Whitney test (app.flegmonosa vs. app. perforata gangrenosa)		p = 0.001*	

Table 6. Inflame surrounding fat tissue (FAT) around appendix in the examined group of patients (n=48) except appendicitis catharralis (n=2)

	Pathohistological finding		
	Appendicitis. flegmonosa	Appendicitis gangrenosa	App. gangrenosa perforata
n	22	11	15
MWT interval	7-13	9-15	11-20
X	10.045	12.182	14.200
S	1.430	2.272	2.426
Sx	0.305	0.685	0.626
mediana	10	12	14
	p = 0.013		
			p = 0.042
Mann-Whitney test (app.flegmonosa vs. app. perforata gangrenosa)		p < 0.001	

of: Anterior-posterior diameter (AP), Mural wall thickness (MWT), Inflame surrounding fat tissue (FAT) (Tables 4, 5, 6) in estimating of degree of appendix inflammation. Statistic analysis shows a great potential and possibilities of using AP and FAT in estimation of the inflammation degree in everyday practice. A statistical analysis shows the limited possibility of using mural wall thickness values in gangrenous appendicitis and perforate gangrenous appendicitis. In that case we use other ultrasound signs that can determinate these pathological conditions. Sensitivity of ultrasound method in our study is 85%.

Discussion

The incidence of appendicitis appearance is usually between 5-10 years of age. Homogeneity of the group is showed with mean value where it is proved that there is no significant difference in the examined age frequency ($p > 0.05$). Homogeneity of our group also showed that the appearance of acute appendicitis will be most common in age between 5 and 10 years, without gender predominance. Until puberty, the incidence of appendicitis is the same at boys and girls, and in the puberty prevalence is in male population with rate 2:1.[5] There is no significant connection between life style, taking some specific food or genetic predispose for arising of the acute inflammation of appendix.[6] Until 1986, the conventional radiography, including standard abdomen radiography and irigography, represents the only radiological methods, beside clinical and laboratory findings, that tried to limit the differential diagnosis of the acute appendicitis. Detailed classifying of the clinical examination can in certain percent reduced the differential diagnosis and constrains it to possible acute appendicitis: pain migration to lower right quadrant, pain deterioration because of motion, cough, anorexia and vomiting and indirect tenderness (Rovsing sign). Children with an »uncertain« diagnosis deserved further diagnostic imaging or observation depending to aspect and lasting of symptoms.

High percent of acute gangrenous appendicitis and perforate gangrenous appendicitis, which our study shows, suggests a long period of persisting symptoms until the hospital treatment. Unfortunately, only two patients had appendicitis catharalis. Percent of perforations and complications of the acute appendicitis in children's age is still very high. The reasons for that are because little patients don't recognise and don't show signs and symptoms of the disease, appearance of clinically atypical picture of the acute appendicitis, quick evaluation of disease in these patients, health ignorance of parents. Worell S *et al.* in its study on 200 patients offered only four criteria for the analysis of acute appendicitis: 1. visualisation of appendix, 2. anterior-posterior diameter AP > 6 mm, 3. mural thickness of appendix MWT > 3 mm, 4. appearance of complex mass in ileocaecal area. Because of limiting factors that characterized this study, its sensitivity was only 68%.[7]

Our study offered eight ultrasound signs of the acute appendicitis. Results showed that AP diameter, FAT and peristaltic absence are certain ultrasound signs of the acute appendicitis, and also FAT and AP have a great potential in defining the appendix inflammation degree, while MWT have a limited possibility in that case. According to the experience in our study, in patients without the possibility of visualisation of appendix, and with the appearance of good and clearly visible pericaecal fluid and changed pericaecal fat tissue, we can make a conclusion that it is perforate appendicitis.

Most common mistakes in US imaging of appendicitis compassed the commutation between appendix and terminal ileum, and also between normal and inflame appendix.[8]

Terminal ileum doesn't rise from caecum base, doesn't have blind terminal but shows

very accelerating peristaltic, and in transversal scanning it is oval describing to appendix which is clearly round as a »target«. False negative results in the ultrasound examination can appear in overweight patients and in atypical localisation of appendix.[9]

Conclusions

The initiation of ultrasound in diagnostic imaging of the acute abdomen allowed a high percent of diagnostic assurance in little patients. With the experience true continuous work with an ultrasound technique and by understanding of criteria of acute appendicitis, the improvement of diagnostic assurance can be achieved. The continuation of hospital observation and treatment increase the morbidity and mortality of patients with the acute abdomen. Concretely, the persistence of symptoms from beginning of the disease until the initial ultrasound examinations and surgical treatment is in a direct proportional relation with the degree of appendix inflammation. Anterior-posterior diameter (AP), mural thickness (MWT), periapendicular fat tissue width (FAT) represent highly reliable US signs in the evaluation of degree of the acute appendicitis inflammation. Ultrasound is a cheap method, without a harmful effect, quick and simple, and using a real-time interactive technique.

The aim of a modern surgical approach is essentially the same as in the 19th century, but today, it is focused between the percent of false negative appendectomies and the one of the perforation during the time of the surgical observation. The initiation of ultrasound in imaging of specific cases of the acute appendicitis, as this study shows, represents a modern (up to date) surgical approach and qualifies a modern medical protocol for little patients in this condition.

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