ANNALES
UNIVERSITATIS MARIE CURIE-SKŁODOWSKA
LUBLIN-POLONIA
VOL. LVIII, N 1, 81 SECTIO D 2003

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High frequency ultrasound diagnostics of right lower quadrant abdominal pain in children

Abdominal pain is the most common reason why children come to the doctor. It accompanies many different pathological processes in this way creating many diagnostic difficulties. Routine ultrasound examination of abdomen in children with abdominal pain allows assessing parenchymal abdominal organs and organs of pelvis minor. Therefore routine ultrasound examination of abdomen does not permit to assess the most frequent cause of hypogastrial pain, which is appendicitis. Only application of ultrasound high frequency transducer creates the opportunity of visualization of the appendix. High frequency transducer also contributes to obtaining high quality images.

The aim of the study is to assess the usefulness of high frequency transducer in the diagnostics of right lower quadrant abdominal pain.

MATERIAL AND METHODS

Ultrasound examination was performed on 152 patients (89 girls and 63 boys) aged 1 to 19 years (mean 10), who presented abdominal pain with or without assisting symptoms from gastrointestinal tract: vomiting, nausea, appetite loss, diarrhoea, raised temperature. All the patients underwent standard ultrasound examination of abdominal parenchymal organs as well as the evaluation of the intestines with the linear transducer of changeable frequency ranging from 5.1 to 9.0 Mhz with the possibility of creating sector format. The tissue harmoning imaging (THI), Power and Colour Doppler modes were also applied in the examinations. The patients were examined in a supine position while longitudinal, transverse and oblique views were taken; they were also examined from the right flank access. Examinations were performed on Siemens Elegra ultrasound scanner; all images were stored on magnetooptic disc.

RESULTS

Twenty one (13.8%) of 152 examined patients did not demonstrate any abnormalities in ultrasound examination. In the group the appendix was not visible as well. In the rest of 131 (86.2%) patients the following pathologies were observed: • In 96 (73.3%) visible appendix, • In 8 (6.1%) enlarged mesenteric lymph nodes, • In 3 (2.3%) peritoneal fluid, • In 5 (3.8%) right ovary cysts, • In 3 (2.3%) gastrointestinal tract defects were found such as duplication,

enterogenic cyst and Meckel's diverticulum, • In 6 (4.6%) pathological broadening of distal ileum wall, • In 6 (3.2%) pathological broadening of caecum wall, • In 4 (3%) of the patients periappendical abscess was observed.

In 31 (32.2%) patients whose appendix was visualized in ultrasound examination lymph nodes enlargement coexisted. Table 1 presents a detailed analysis of the examined features of appendix:

Table 1

Feature	Diameter > 6 mm	Diameter < 6 mm
Maintained wall	54 (80%)	34 (100%)
Blurred wall (perforation)	8 (13%)	0
Hypervascularization	34 (48%)	8 (23.5%)
Lack of peristalsis	52 (83.8%)	0
Lack of deformity under transducer's pressure	52 (83.8%)	0
Great periappendical reaction	13 (21%)	3 (8.8%)
Appendicolith	6 (9.6%)	1 (2.9%)
Together	62	34

In the examined patients few of the mentioned features were observed. In the group of all 152 patients the appendix was visualized in 96 cases (63 %). In the remaining 56 patients (36.8%) visualisation of the appendix was not successful. Surgery due to appendicitis was performed on 54 patients (35.5%). Table 2 presents a detailed analysis of the morphology of the operated appendixes.

Table 2. Patients operated on due to appendicitis

Appendix	n	Operated n (%)
Diameter > 6 mm	62	34 (52%)
Diameter < 6 mm	34	3 (12.5%)
Invisible in ultrasound	56	11 (19.6%)

In 3 of 6 patients, in whom a thickened wall of distal ileum was seen during ultrasound examination, the final diagnosis, based on laboratory tests, was *Salmonella* infection.

DISCUSSION

The diagnostics of right lower quadrant abdominal pain in children is difficult and complex. It results from the fact that the child cannot define precisely the character of the pain, which actually is a non-specific symptom itself. Cooperation during examination between the doctor and the small patient is also hindered.

Among the possible causes of the right lower quadrant abdominal pain appendicitis is the most common. However, its clinical appearance and ultrasound examinations are not unequivocal; according to Baldissera in 30 % (1) they of patients are not obvious.

After Pollack 'proper diagnostics of appendicitis boils down to excluding other possible causes of abdominal pain in children'. Thus, it is very important to assess precisely not only abdominal parenchymal organs but also organs of pelvis minor as well as intestines. Application

of high frequency transducers in evaluation of intestines increases greatly the quality of images of the visualized organs thanks to reducing the distance between the organ and the transducer.

Ultrasound image of the appendicitis is characterized by the following features (2,4,9,12): • Tubular non-echogenic space of the diameter over 6 mm, • Maintained layer structure of the wall, • Increased vascularization of the wall, • Non- deformable wall under the pressure of transducer, • Lack of peristalsis.

Very often appendicitis is accompanied by great reaction of the surrounding tissues (peri-intestinal fat tissue and mesentery), and in 20–30% (8) the appedicolith/coprolith is visible in the lumen of the appendix.

In the majority of patients appendicitis coexists with enlargement of mesenteric lymph nodes (8). In the analyzed group of patients, in whom appendix was visible in ultrasound examination, enlarged mesenteric lymph nodes coexisted in 32% of cases.

Thickening of the caecum wall or distal ileum seems to have less the significance as the symptom of small specificity accompanying many pathologies of hypogastrium (12). It may happen that the right lower quadrant abdominal pain is caused by distal ileitis evoked by Yersinia or Salmonella and rarely occurred caecitis in patients with decreased immunity (5,10). In the study, 6 of the examined patients who reported right lower quadrant abdominal pain presented abnormalities of ileum, in 3 of the cases the cause was *Salmonella*. In another 6 patients only the thickening of the caecum wall was noticed.

According to Puyleart thickening of the intestine wall is a secondary symptom of appendicitis and may be treated as an indirect symptom of the disease (9). Many authors recognize the appendix diameter of 6 mm or more as characteristic of appendicitis. After Rettenbacher (11), the value of 6 mm characterizes great sensitivity (100%) and limited specificity (68%). In the control group described by him the diameter of normal appendix ranged from 2 to 13 mm. Similar values (3-15mm) were observed in our study. In 29 operated patients, in whom the appendix was visible in ultrasound examination preoperatively, the diameter of the appendix was over 6 mm (mean 10,5 mm).

Fig. 1. Acute appendicitis. The level of fluid in the lumen of appendix

Fig. 2. Acute appendicitis. Hypervascularization the wall of appendix visualizaed in Power Doppler mode

Fig. 3. Gangrenous acute appendicitis. Blured wall of appendix

In 1986 Puylaert (2) introduced application of high frequency transducer and the method of gradated pressure in the assessment of appendicitis. The purpose of the method of gradated pressure of the transducer is to dislocate gases and faeces in the intestine lumen from the examined area, reducing the distance between the examined organ and the transducer, and the

assessment of susceptibility of "inflammatory" fat tissue for pressure. According to Baldisseratto (1), the method of gradated pressure of the transducer in not necessary, particularly in children who have severe acute pain. He recommends right flank examinations in suspicion of retrocaecal appendix or examinations through the bladder when the appendix lies deeply in pelvis minor.

In our study, in 80% of the cases, application of gradated pressure method did not cause deformity of the appendix. In the rest of 20 % the pain was severe enough not to apply the method. Another very important feature suggesting the presence of active inflammation process is the increase of vascularity of the appendix wall (11, 12).

Among the examined patients hypervascularization within submucosa was observed in 42 patients (43.7%), and 15 of them underwent surgery (35.7%). In the remaining 27 patients (64.2%) the signal of vascular flow was not detected, which could have been possibly caused by necrosis or an initial stage of inflammation. It is important to remember that the necrosis may concern only a part of appendix, where the vascular flow may not be detected, while the rest of the organ may be hypevascularized (1). Such an ultrasound picture was stated in 8 cases, in which postoperatively the gangrenous appendicitis was diagnosed.

Fig. 4. Acute appendicitis. Hyperechogenic focus in the lumen of appendix – fecolith

In our study there was no case when the appendix would meet all of the sonographic criteria of appendicitis. The most common features were lack of peristalsis, lack of deformity under pressure of transducer and hypervascularisation of appendix' wall. The most common causes of difficulties in visualization of appendix during ultrasound examination might be: • Great amount of gases or faeces in intestines veiling examined area, • Atypical localisation of appendix, • Severe pain precluding application of gradated pain method.

In differential diagnosis of appendicitis the following pathologies should be taken into account: • Distal ileitis (Crone's disease), • Inflammatory diseases of pelvis, • Ovaries' pathologies (cysts, ovarian torsion), • Endometriosis, • Ectopic pregnancy (6).

CONCLUSIONS

1. Ultrasound examination by means of high frequency transducer plays a very important role in differential diagnosis of right lower quadrant abdominal pain.

2. Ultrasound examination is a non-invasive examination, which is very important, particularly in children.

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SUMMARY

In our study we tried to assess the usefulness of high frequency ultrasound examinations in the diagnostics of right lower quadrant abdominal pain, focusing on the differential diagnosis of appendicitis. Ultrasound examinations were performed on 152 patients aged 1 to 19 with abdominal pain. All the children underwent standard abdominal ultrasound examination with B mode of abdominal parenchymal organs as well as the evaluation of the intestines with the linear transducer of changeable frequency with the possibility of creating sector format. The tissue harmoning imaging (THI), Power and Colour Doppler modes were also applied in the examinations. As a result, 21 (13.8%) of 152 examined patients did not demonstrate any abnormalities in ultrasound examination. In the group the appendix was not visible. In the other 131 (86.2%) patients we observed a number of pathologies such as following: in 96 (73.3%) patients visible appendix, in 8 (6.1%) enlarged mesenteric lymph nodes, in 6 (4.6%) pathological broadening of the distal ileum wall, in 6 (3.2%) pathological broadening of the

caecum wall and others. All these symptoms might be treated as indirect symptoms of appendicitis. In conclusion, we would like to state that high frequency ultrasound examination is very useful in the diagnostics of appendicitis.

Przydatność sondy wysokiej częstotliwości w diagnostyce bólu brzucha zlokalizowanego w prawym dole biodrowym

Praca stanowi próbę oceny przydatności badań ultrasonograficznych z zastosowaniem sondy wysokiej rozdzielczości w diagnostyce różnicowej bólu prawego dołu biodrowego, ze szczególnym naciskiem na diagnostykę zapalenia wyrostka robaczkowego. 152 pacjentów poddano standardowemu badaniu ultrasonograficznemu jamy brzusznej z oceną narządów miąższowych w opcji B mode, jak również badaniu sondą liniową wysokiej częstotliwości. Stosowane były również opcje wzmocnienia harmonicznego (THI), kolorowego i Power Dopplera. Wśród 152 badanych w 21 przypadkach badanie ultrasonograficzne nie wykazało odchyleń od normy. W tej grupie pacjentów wyrostek robaczkowy nie był widoczny. U pozostałych 131 pacjentów w badaniu ultrasonograficznym uwidoczniono: wyrostek robaczkowy (73,3%), powiększone węzły chłonne krezkowe (6,1%), pogrubiałą ścianę jelita krętego (4,6%) i kątnicy (4,6%) i inne. Wszystkie wymienione patologie mogą być uznawane za pośrednie objawy zapalenia wyrostka robaczkowego. Zastosowanie głowicy wysokiej częstotliwości jest bardzo przydatne w diagnostyce różnicowej bólu brzucha, zlokalizowanego w prawym dole biodrowym.