Ultrasonographic diagnosis of acute appendicitis

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Abstract

Introduction. Appendectomy, the most frequent surgical intervention, has 20-30% rate of negative appendectomy mostly because of 30-45% cases with unspecific clinical examination. The objective of this study was to determine the contribution of ultrasonography in acute appendicitis (AA) diagnosis in patients with abdominal pain in the right lower quadrant.

Material and method. A number of 262 patients with clinical suspicion of AA were investigated. The positive diagnosis criteria were considered to be the appendix external diameter >6 mm, appendix wall thickness >3 mm, partial or total absence of wall stratification, coprolites or/and liquid in excess in the appendix lumen, hypervascularization of appendix wall, echogenicity enhanced and hyperemia in periappendicular mesenteric fat, periappendicular collection (abscess) or peritoneal collection (peritonitis).

Results. Appendix was identified by ultrasonography in 199 out of 262 of patients (75.9%). Normal appendix was less visualized (in 61.9%) comparing to pathologic appendix (91.3%). Ultrasonography demonstrated an 89.4% sensibility, 95.2% specificity, positive predictable value 95.5% and negative predictable value 88.9% in the detection of AA. Preoperative ultrasonographic examination in patients with abdominal pain of the right lower quadrant leads to 9.9% negative rate of appendectomies.

Conclusions. In cases of abdominal pain located in the right lower quadrant, ultrasonography is a quick non-invasive and low cost method which can contribute to an early positive diagnosis and also a decrease in the number of unnecessary appendectomies.

Key-words: acute appendicitis, ultrasound, diagnosis

Rezumat

Introducere. Apendicectomia, cea mai frecventă intervenție chirurgicală, are o rată de 20-30% de apendicectomii negative, în primul rind deoarece în aproximativ 30-45% cazuri examenul clinic este nespecific. Scopul studiului este de a determina contribuția ecografiei în diagnosticul apendicitei acute la cazurile cu sindrom durerii de fosă iliacă dreaptă.

Materiale și metodă. S-au evaluat ecografic 262 de pacienți cu suspiciunea clinică de apendicită acută. Criteriile ecografice de diagnostic pozitiv au fost: diametrul extern al apendicelui peste 6 mm, grosimea a peretelui peste 3 mm, dispariția parcelară sau totală a stratificării peretelilor, prezența în lumen a coproliților și/sau a lichidului în exces, hipervascularizarea peretelui apendicular, creșterea ecogenității și hiperemia grăsimii mezenterice periapendiculară, prezența unei colecții periapendiculare (abces) sau peritoneale (peritonită).

Rezultate. Apendicile a fost identificat ecografic la 199 dintre cei 262 de pacienți (75.9%). Apendicile normală a fost mai rar vizualizat (61.9%) comparativ cu cel patologic (91.3%). Ecografia are sensibilitatea de 89,4%, specificitatea de 95,2%, acuratețe de 94,3%, valoare predictivă pozitivă de 95,5% și valoare predictivă negativă de 88,9% in detectarea apendicitei acută. Examinarea ecografică preoperatorie a pacienților cu suspiciunea clinică de apendicită acută a dus la o rata de apendicectomii negative de doar 9,9%.

Concluzii. În cazul unei simptomatologii dureroase de fosă iliacă dreaptă, ecografia este o metodă neinvazivă, rapidă și cu preț de cost scăzut care poate să contribuie la un diagnostic pozitiv precoce, la diminuarea ratei de apendicectomii cu apendice normal sau la clarificarea diagnosticului diferențial.

Cuvinte cheie: apendicită acută, ecografie, diagnostic

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Acute appendicitis (AA) is the most common acute surgical condition [1], about 7% of the population having an appendectomy during their lifetime [2]. Maximum incidence is between 6 and 30 years [3,4]. In about 30-45% of cases the clinical evaluation is unspecific [5].
The appendix is a worm-shaped pouch originating from the lowest part of cecum. It usually has an intraperitoneal position (anterior or retrocecal) in contact with the anterior parietal peritoneum. A wide mesentery permits the appendix rotation in several positions. So in 30% of cases the appendix is placed in the pelvis, retrocecal or retroperitoneal. These positions can modify clinical signs and symptoms of AA [6].

AA are caused by obstruction of the appendix lumen through several causes: lymph hyperplasia (especially in children and young adults in viral infections, mononucleosis, gastroenteritis or ileocolitis), coprolites, parasites, foreign body, Crohn’s disease or neoplasm [5,7,8,9].

If the diagnosis of AA is based only on clinical and laboratory findings, about 20-30% of appendectomies are not confirmed at pathologic examination [9,10,11]. In AA an early diagnosis is crucial to reduce the risk of complications (perforation, occlusion, sepsis) which can increase the mortality especially at extreme ages [1].

In a small number of patients with AA (between 1-10%) the appendix inflammation is discrete, clinical signs are blurred and rapidly subsided, and the clinical evolution is rapidly to spontaneous remission. These are called abortive appendicitis, limited appendicitis or spontaneous healing appendicitis [12,13]. In atypical cases of AA, the surgeon have to choose between instant and delayed surgery. The ultrasonography (US) of abdomen and appendix region can help the surgeon to take the proper decision.

The advantages of US in AA diagnosis are the low cost, the lack of irradiation, and the possibility to examine carefully and repetitively the maximum sensibility zone. The main disadvantage of the US is the operator-dependence and the difficulty in scanning obese patients. [14,15,16]. An experienced operator, with the aid of a modern devices (with high resolution probe), could have a sensitivity, accuracy and specificity around 90% in US diagnostic of AA. Also, in the patients with appendicitis-like symptoms, US can reveal the correct diagnosis in almost 70-80% of cases [17].

The aim of our study was to evaluate the contribution of the US for the positive and differential diagnosis of the AA, in patients with abdominal pain localized in the right lower quadrant.

**Material and method**

The study comprised 262 patients (136 males, 126 females, aged between 4–73) presenting with right lower quadrant abdominal pain at the Beius County Hospital between December 2007 and July 2009. They all had clinical suspicion of AA. US was performed by a doctor (CM) with experience in gastrointestinal tract US. A Voluson 730 PRO General Electric Kretz Technik ultrasound machine with multifrequency probe (1.5-18.5 MHz) was used.

The examination protocol, based on graded compression describe by Puylaert [18] included:

1. **Convex probe use.** The US examination started with an abdominal general scanning (to exclude an extraappendicular pathology) using a 1.5-4.5 MHz or 4.0-8.5 MHz convex probe, depending on body weight. For obese patients the same convex probe was used for appendix region examination.

2. **Linear probe use.** For the examination of the appendix region we used a 5-18.5 MHz linear probe. According to the Puylaert technique [18,19] a graded compression was exerted with the transducer, to dislocate the air and to identify the most painful region. The landmarks of the region (cecum, last portion of the ileum, iliopectas muscle, iliac vessels and appendix) were identified. The examination began with sections from the ascending colon to the cecum. After the identification of the cecum base, longitudinal sections from the lateral to the median part of the cecum were made. Usually the appendix was identified in the maximum painful zone. If the appendix was not identified in its normal position, the examination continued to explore the retrocecal, retrococile, pelvic and retroileal regions using the appendix base as a landmark (always the base was situated in the same position).

We used US in gray scale for morphological analysis and Doppler US for the examination of appendix vascularization (with a small velocity scale and 70-120 Hz parietal filter).

**US exclusion criteria** for AA were an US unidentifiable appendix or a compressible appendix, oval shape in transverse section, with external diameter under 6 mm, wall thickness under 3 mm, wall layers and normal periappendicular mesenteric fat. **US positive diagnosis criteria** for AA were considered the external diameter of the appendix over 6 mm, the appendix wall thickness over 3 mm, total or partial wall layers nonvisualisation, coprolites and/or fluid excess into appendix lumen, hypervasculatization of the appendix wall, enhance of echogenicity and hyperemia of the periaappendicular mesenteric fat, periappendicular collection (abscess) or peritoneal collection (peritonitis).

The histopathological examination of the appendix was performed in all surgical cases.

The result was considered true positive when the US diagnosis concurred with the histopathological findings and true negative when the histopathology for AA was negative or there was no relapse in 2 weeks of follow up of the nonsurgical patients.
The result was considered false positive when there was a US diagnosis of AA with normal histopathological findings in the appendix, and false negative when US found a normal or unidentifiable appendix with positive histopathology for AA.

A 2x2 table and \( \chi^2 \) test were used for the evaluation of the results. The sensitivity, specificity, accuracy, positive and negative predictive values were determinate (PPV, NPV). The confidence interval was 95%.

**Results**

In the majority of the cases the appendix was identified in about 1-3 minutes. An unidentified US appendix was considered a normal appendix. From 262 examined patients, 141 were submitted to appendicectomy. In 127 patients there was a histological confirmation of AA. In 14 patients the histological examination was negative resulting 9.9% appendicectomies for a normal appendix (tab I, tab II).

The clinical situations which led to false positive and false negative results are presented in table III.

The statistical data analysis shows 89% sensibility, 95.2% specificity, 94.3% accuracy, 95.5% PPV and 88.9% NPV of the US in diagnosis of AA.

### Table I. US identification of the appendix and the therapy of the patients with pain in the right lower quadrant (RLQ); AA – acute appendicitis

<table>
<thead>
<tr>
<th>US findings</th>
<th>Number of patients with pain in RLQ (total 262)</th>
<th>Patients with appendectomy (total 141)</th>
<th>Patients with conservative therapy (total 120)</th>
<th>US diagnosis of AA (total 118)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identified appendix</td>
<td>199 (75,9%)</td>
<td>120 (89,4%)</td>
<td>79 (65,8%)</td>
<td>103 (87,3%)</td>
</tr>
<tr>
<td>Unidentified appendix</td>
<td>63 (24,1%)</td>
<td>21 (10,6%)</td>
<td>41 (34,2%)</td>
<td>15 (12,7%)</td>
</tr>
</tbody>
</table>

### Table II. US diagnosis and the therapy of the patients with pain in the right lower quadrant (RLQ); AA- acute appendicitis

<table>
<thead>
<tr>
<th>US diagnosis</th>
<th>Number of patients with pain in RLQ (total 262)</th>
<th>Patients with appendectomy (total 141)</th>
<th>Patients with conservative therapy (total 120)</th>
<th>US diagnosis of AA (total 118)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AA</td>
<td>127 (48,5%)</td>
<td>127 (90,1%)</td>
<td>0 (0%)</td>
<td>112 (94,9%)</td>
</tr>
<tr>
<td>Without AA</td>
<td>135 (51,5%)</td>
<td>14 (9,9%)</td>
<td>120 (100%)</td>
<td>6 (5,1%)</td>
</tr>
</tbody>
</table>

### Table III. The causes of false positive or false negative results at US

<table>
<thead>
<tr>
<th>Outcome type</th>
<th>The cause of false outcome</th>
<th>Number of cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>False positive</td>
<td>• hydrosalpings</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>• mucocele with pseudomyxoma peritonei in small quantity</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>• terminal ileum segmental necrosis</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>• Meckel’s diverticulitis</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>• cecal diverticulitis</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>• ovarian torsion</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Total</strong> 6</td>
</tr>
<tr>
<td>False negative</td>
<td>Appendix lack of identification without real associated pathology</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• obesity</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>• appendix point position</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>• difficulties in practicing graded compression</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>• pain absence at compression in right lower quadrant</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Total</strong> 15</td>
</tr>
<tr>
<td></td>
<td>Appendix lack of identification with associated pathology</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• cecum neoplasm</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>• infectious ileitis</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>• hyperplastic cholecystosis with subhepatic abscess produced by appendix perforation</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>• perforated appendix for an appendix and cecum located in left lower quadrant</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Total</strong> 15</td>
</tr>
</tbody>
</table>
Discussions

The detection by US of the normal appendix vary in published papers between 0% and 95% [18,20,21,22,23,24,25,26], depending mostly on the US machines’ performances. For example, Puylaert in 1986 (in a study describing the graded compression technique for appendix examination) mentions the lack of normal appendix visualization [18]. In a recent paper in 2005 [26] the detection rate of the normal appendix increased to 82%.

The main examination technique is one of the graded compression [18]. Some authors consider that anterior graded compression combined with posterior compression can increase significantly the rate of appendix detection [24]. The appendix examination must be performed in its entire length because there are situations with focal inflammation, especially on the tip of appendix. The incomplete examination of the appendix can generate false results [27].

On longitudinal scan, the normal appendix is a compressible tubular blind-ending structure, without peristaltic movements, no mucosal stripes and usually without visible hypervascularization. External maximum diameter is considered to be 4.7±1.2 mm [28] but in exceptional cases can increase up to 8-11 mm [28]. Most of the authors considered a diameter of 6 mm as the superior value for a normal appendix (fig 1, fig 2) [29,30].

Normal appendix lumen can occasionally be filled with noninflammatory content (faecals, mucus) achieving an uncompressible appendix and an external diameter over 6 mm (up to 10-11 mm) [30,31,32]. For this reason there are authors who consider that the parietal thickness (the distance from the hyperechoic serosa to the hyperechoic lumen, normal<3 mm) is a more specific criteria for appendix evaluation [33, 34]. A normal appendix contains intraluminal gas (linear or punctiform image with reverberation shadow) in 75-85% of cases (fig.3, fig 4) [35, 36].

![Fig 1. Normal appendix, longitudinal scan (tubular blind-ending structure with laminal layer structure).](image1)

![Fig 2. Normal appendix, transverse scan (ovoid laminal layer structure).](image2)

![Fig 3. Normal appendix with non-inflammatory content (faecal, mucus, gas), longitudinal scan.](image3)

![Fig 4. Normal appendix, transverse scan (intraluminal gas is a punctiform image with reverberation shadow).](image4)
The appendix compression is considered to be adequate when in the transverse section the appendix become oval and the anteroposterior diameter of the contiguous ileum has no more than 4 mm [19]. An incomplete oval appendix is a normal appendix in 86% of cases and a complete oval appendix excludes AA [37].

The normal appendix wall has a laminar layer structure with echoic submucosal and serosa layers and hypoechoic mucosa and muscular layers [38,39]. Periappendicular mesenteric fat is an echogenic structure in which some spots of vascularization can be detected. Normal small bowel loops are visualized as tubular structures with mucosal folds, thin walls (<2 mm) and peristaltic movements. The colon is a large tubular structure with haustra, thick walls (2-5 mm), mixed content and with occasionally peristaltic movements [40,25].

Deuticke et al. [41] described in 1981 an inflamed appendix for the first time. US identification of inflamed appendix is high (80-99%) [42,43]. The phlegmonous and gangrenous appendicitis are always identified while catarrhal appendicitis have a smaller rate of identification [44].

Dimensions, structure, localisation and absence of peristaltic movements contribute to differentiate an inflamed appendix from the small intestine or cecum. An inflamed appendix is characterized by the absence of peristaltic movement, diameter over 6 mm, tubular finger tip shape in longitudinal section and target appearance in cross section (fig 5, fig 6) [40,45,46].

Himeno et al. [42] and Takada et al. [44] had established the US criteria for the three histopathological forms of AA: 1) catarrhal appendicitis: normal appendix wall structure with mucosa oedema; 2) phlegmonous appendicitis: a less clear structure of appendix wall layers with transverse diameter over 10 mm; 3) gangrenous appendicitis: the absence of parietal layers and marked appendix thickening. These criteria were in accordance with the histopathological findings in 61.2% of cases [44]. In our opinion these criteria are restrictive. We examined numerous cases with an appendix having a calibre <1 cm and a phlegmonous or gangrenous histopathological aspect. That is why in our study we took also the vascularization criteria into account.

The pathologic appendix wall is a hypoechoic structure, >3 mm thickness (fig 7).

First, at the onset of an AA, the continuous hyperechoic line of the submucosa becomes discontinued [29, 40]. Than, as a consequence of the necrosis, dishomogeneity and hypoecogenicity of the submucosa appear (fig 8, fig 9) [47].
In the advanced stage (gangrenous stage) the stratification of the appendix wall completely disappears (fig 10) [44].

In the appendix the content could be anechoic (fluid) or echoic (air, appendicolite). The air is less frequently observed (15%) than in the normal appendix [35]. Appendicolite (an intraluminal hyperechoic image with or without acoustic shadow), represents a mixture of inorganic salts and undissolved stools. The presence of an appendicolite makes the appendicectomy imperious even when the appendix diameter is normal [48, 49, 50]. Real appendicular stones are less common but are often associated with perforation [49]. The inflammation of the periappendicular fat produces an enhancement of its echogenicity [51]. So, an inflamed and hypoechoic appendix is surrounded with hyperechoic fat.

**Fig 8.** AA with fluid, appendicolite with posterior acoustic shadow and echogenic submucosa absence at the tip of the appendix due to necrosis.

**Fig 9.** AA with fluid, appendicolite (arrow) and echogenic submucosa disappearance as a consequence of the necrosis.

**Fig 10.** AA with fluid in the lumen and gas in the anterior wall (arrow). The stratification of the appendix wall is completely disappeared (gangrenous appendicitis).

**Fig 11.** Small perforation of the appendix (arrows) – loss of the submucosal echogenicity near the perforation.

**Fig 12.** Periappendicular collection. Note that the thick echogenic fat and the cecum delimitate the collection.
Appendix perforation is suggested by the presence of a periappendicular collection (periappendicular abscess), submucosal discontinuity zones, asymmetric appendix walls thickening with possible intramural air, periappendicular fat thickening >10 mm (fig 11, fig 12, fig 13).

Sometimes, there is no significant pain during examination (due to decreased pressure following appendix rupture) [47, 52]. The most specific feature is the presence of the pericecal abscess, with impure fluid content and small echoes inside and mass effect on the nearby intestinal ansae [52]. In small perforations, an emergency appendicectomy is necessary. In cases with periappendicular phlegmons, an initial conservative therapy followed by postponed appendicectomy is preferred. For well defined abscesses a US guided drainage can be performed before appendicectomy [52, 53, 54, 55, 56, 57].

In abortive appendicitis (7-10% of cases) the appendix usually does not contain coprolites, no periappendicular abscess or inflammatory signs are detected, and the average the appendix diameter is 8.5 mm [12, 13]. Recurrence rate after an abortive appendicitis is 38% after 3 months and 70% after 1 year. The recurrence is significantly enhanced if the appendix diameter is >8 mm under compression [13].

**The position of the appendix** can influence its detection. A retrocecal appendix is better visualized from coronal sections (with the probe direction from lateral to medial). A pelvic appendix can be detected by using an endovaginal probe. An unidentified appendix is suggestive but not revealing for a normal appendix.

**In the differential diagnosis** of AA, miscellaneous abdominal and extrabdominal pathology should be taken into account (tab IV).

In the last years, new techniques for the improvement of the US images have been used. In a recent study [58] the use of Spatial Compounding Imaging (cross beam) and Tissue Harmonic Imaging increased the rate of detection of the appendix by 19%.

The examiner’s experience in appendix US is very important. During this study the improvement in examiner’s abilities, especially for normal appendix identification, were recorded.

The normal appendicular vessels are of small calibres with slow blood velocities. The normal appendix does not usually present distinguishable vascularization at Doppler US. In AA the vascular diameters and blood velocities are increased, being easy to detect in Doppler US (fig 14, fig 15, fig 16) [59, 60]

### Table IV. Differential diagnosis of the acute appendicitis

<table>
<thead>
<tr>
<th>Differential diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Obstetrical and gynaecologic diseases</td>
</tr>
<tr>
<td>Pelvic inflammatory disease, ovarian cyst rupture, tubular</td>
</tr>
<tr>
<td>pregnancy, tubular pathology, endometriosis</td>
</tr>
<tr>
<td>Gastrointestinal diseases</td>
</tr>
<tr>
<td>Ulcer, diverticulitis, Chron’s disease, infectious enteral</td>
</tr>
<tr>
<td>enteritis, ileoceccitis, ileitis, tuberculosis, intestinal</td>
</tr>
<tr>
<td>occlusion, intestinal infarction, invagination, volvulus,</td>
</tr>
<tr>
<td>tumors, acute pancreatitis, mesenteric adenitis, mesenteric</td>
</tr>
<tr>
<td>infarction</td>
</tr>
<tr>
<td>Urinary diseases</td>
</tr>
<tr>
<td>Renal colic, renal abscess, pyelonephritis, testicular</td>
</tr>
<tr>
<td>torsion</td>
</tr>
<tr>
<td>Liver and gallbladder diseases</td>
</tr>
<tr>
<td>Hepatic abscess, acute cholecystitis</td>
</tr>
<tr>
<td>Muscle diseases</td>
</tr>
<tr>
<td>Iliopsoas muscle abscess or haematoma, rectus abdominis</td>
</tr>
<tr>
<td>muscle sheath haematoma</td>
</tr>
<tr>
<td>Epiploon diseases</td>
</tr>
<tr>
<td>Infarction, torsion, appendagitis</td>
</tr>
<tr>
<td>Pulmonary diseases</td>
</tr>
<tr>
<td>Pneumonia, pulmonary infarction</td>
</tr>
<tr>
<td>Parasitic infections</td>
</tr>
<tr>
<td>Ascaridiosis</td>
</tr>
</tbody>
</table>
Some authors consider that inflammatory activity is proportional to the quantity of color signal found in the appendix wall [61,62]. The hypervascularization is present from the onset of AA. Both arterial and venous vascular signals could be detected. (fig 17) [63].

In evolution, the vascular signal could become difficult to detect (or only the arterial signal is detected) due to parietal necrosis. The extension of the parietal necrosis in the gangrenous AA leads to the absence of appendix vascularization with periappendicular fat hyperemia (fig 18) [59, 64, 65].

In abortive appendicitis, at the onset a parietal hypervascularization can be recorded (fig 19), hypervascularization reversible in evolution [59, 62]. The appendix could be hypervascularized also in ileoceleal inflammatory diseases [66] or if the appendix orifice is obstructed by a cecal tumour [67]. A recent study suggests that Power Doppler in combination with contrast agents is the most sensitive method for AA diagnosis (sensitivity 100%) [68].

The role of the 3D/4D US for appendix evaluation has not been evaluated yet. This study does not concern...
itself with this evaluation but we do confirm that in some cases the 3D reconstruction did improve the US description of the lesions (fig 20, fig 21, fig 22, fig 23, fig 24).

**Fig 19.** Abortive appendicitis with parietal hypervascularization. After 24 hours the patient had a quickly spontaneous favourable course and appendectomy was not necessary.

**Fig 20.** Appendicular and peripappendicular findings in AA evaluated in 3 orthogonal projections.

**Fig 21.** Small periappendicular collection due to appendix perforation. The site of perforation and the extension of collection are better visible on C plane.

**Fig 22.** Periappendicular abscess view with tomographic ultrasound imaging technique – serial tomographic sections.

**Fig 23.** Tridimensional reconstruction of a periappendicular abscess.

**Fig 24.** Tridimensional reconstruction of the vascularization of inflamed appendix.
Our statistical analysis results are in concordance with those from the literature. The majority of studies showed a sensitivity between 64-96%, specificity between 88-99%, accuracy between 82-97%, PPV between 79-99% and NPV between 75-97% of the US in AA diagnosis [18, 25, 40, 60, 69, 70, 71, 72]. Our study confirms that nowadays, with modern devices and an experienced operator, it is possible to achieve the most accurate results.

The sensibility of the method was lower than the specificity because of the uncontrolled factors responsible for the majority of the false negative results (obesity, unspecific localization of appendix and associated diseases).

It must be mentioned that the US in our study was performed only after clinical examination and laboratory tests. The use of the US as a diagnostic method, together with clinical examination and laboratory tests decreased significantly the rate of unnecessary appendicectomies from 20-30% [9, 10, 11, 70] to 9.9%.

Conclusion

Ultrasonography is a sensitive and specific method for AA diagnosis. In patients with right lower quadrant abdominal pain the US can identify the source of the pain-appendicular or non-appendicular. US has an important role in the AA management and also implications in the therapeutic decision. US examination could considerably decrease the number of unnecessary appendicectomies.

Acknowledgments

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