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The diagnostic value of indirect ultrasound signs during acute adult appendicitis

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KEYWORDS
Appendicitis; Abdominal ultrasonography; Abdominal pain; Abdominal emergencies in the adult

Abstract
Purpose: To evaluate the diagnostic value of indirect ultrasound signs during acute appendicitis.
Patients and methods: Our retrospective study lasted 5 years, from May 2005 to April 2010. It concerned 620 cases of appendectomy performed following prior ultrasound examination of the right iliac fossa (RIF). In 448 cases, ultrasonography clearly showed the appendix, which was inflamed. The presence of indirect signs of appendix inflammation without visualisation of the appendix was confirmed by ultrasound examination in 160 cases. In 12 cases, the appendix was not visualised nor were there any indirect signs on the ultrasound image. The indirect signs involved were hypertrophy of the peritoneal fat (HPF), pain caused by compression on exploration of the right iliac fossa, and localised hypokinesia in the digestive loops (LHL). We compared the results found by ultrasonography with the operative and anatomical pathology reports.
Results: The positive predictive value of the indirect signs of appendicitis on the ultrasound scan was 95.8% if the three indirect signs were associated, 87.5% for the association of pain and HPF, 45.8% for the association of pain and LHL, and 25% if there was just pain. The negative predictive value of the indirect signs of appendicitis on the ultrasound scan was 57.2% if the three signs were associated, 65.9% for the association of pain and HPF and 60.7% for the association of pain and LHL, with 83.3% for pain alone. The sensitivity of the indirect signs was 83.9% if the three signs were associated, 31.8% for the association of pain and HPF, 50% for the association of pain and LHL, and 50% if there was just pain. The specificity of the indirect signs was 85.7% if the three signs were associated, 96.7% for the association of pain and HPF, 56.7% for the association of pain and LHL, and 62.5% if there was just pain.
Conclusion: When tomodensitometry cannot be performed and the appendix is not visible on ultrasound examination, indirect ultrasound signs must be systematically sought, particularly in populations in which appendicitis is highly prevalent.

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Acute appendicitis is defined as inflammation of the appendix that has been evolving for less than a week. It is a very common condition, treatment of which necessitates a surgical procedure by laparotomy or coelioscopy \[1−3\]. Its prognosis is usually good. However, a great many complications can arise if treatment is not undertaken very quickly, hence the importance of early diagnosis of this condition. Based on a long time on clinical symptoms, diagnosis of appendicitis has been challenged, partly due to the large number of unnecessary laparotomies performed but particularly owing to technical developments in imaging \[1.3\], which nowadays has a major role in the management of appendicitis. Imaging is used to produce a positive and topographical diagnosis of this condition. It is also of use in deciding how to operate on the appendicitis, by revealing signs of complications. The diagnostic protocol for imaging appendicitis is very specific and involves visualising the appendix and measuring its maximum external diameter or the thickness of its wall \[4\]. The prime imaging method is ultrasonography. When an ultrasound examination does not help, tomodensitometry (CT) will be requested \[1,3\]. CT is a source of irradiation and must be used with considerable caution in pregnant women and children, and in developing countries, it is very expensive and is often not available in an emergency. Ultrasonography is therefore the only imaging method that is available and totally effective in diagnosing acute appendicitis. When the inflamed appendix is not visible on the ultrasound image, certain so-called indirect signs \[6\] can be considered to suggest the diagnosis. These signs are sharp localised pain at the tip of the probe on exploration of the right iliac fossa (RIF), hypertyrophy of the peritoneal fat, and localised reduction in intestinal peristalsis. Our study aimed to evaluate the diagnostic value of these indirect ultrasound signs in non-complicated acute appendicitis.

### Patients and methods

Our retrospective study lasted 5 years. It was undertaken in the university hospitals (teaching hospitals) of Yopougon and Treichville (Abidjan, Cote d’Ivoire) from May 2005 to April 2010. It included all the patients who had an appendectomy, following an ultrasound examination of the RIF during the study period. The patients included had to:

- have undergone surgery for non-complicated appendicitis;
- have an operative report and a complete anatomical pathology examination;
- have a very detailed ultrasound report specifying whether the appendix could be visualised or not, its topography, its maximum external diameter and giving information about the periappendicular region. If the appendix could not be seen, there had to be a mention of looking for indirect signs. These indirect signs were hypertyrophy of the peritoneal fat (HPF), pain caused by compression on exploration of the RIF, and localised hypokinesia of the digestive loops (LHL).

Patients were excluded:

- whose appendix was located subhepatically or in situs inversus;
- who had no or only incomplete operative, anatomical pathology or ultrasound reports.

The ultrasound examinations were conducted by senior doctors, using equipment of the brand Logic 200 and 500 made by General Electric. This equipment was fitted with two low frequency probes (3.5 to 5MHz) and two high frequency probes (7.5 to 11MHz). The examinations consisted first of all of analysing the entire abdomen using the low frequency probe. Then the RIF was more specifically and thoroughly explored using both sensors. The position of the appendix was established using Puylaert’s gradual compression method \[7\]. When it had been found, its maximum external diameter was systematically measured \[4\]. The ultrasound examination then consisted of exploring the periappendicular environment, assessing the periappendicular fat, the mobility of the digestive loops and looking for possible complications (effusion of intraperitoneal fluid, an abscess collection (Fig. 1)) or pain specifically at the tip of the probe. Acute appendicitis was diagnosed when the maximum external diameter of the appendix was greater or equal to 6mm and the appendix was painful and incompressible and associated with hypertrophy of the periappendicular fat (Fig. 2). When the appendix could not be seen, it was concluded that there were indirect signs of appendicitis if specific pain was noted in the RIF as the ultrasound probe was passed over it, if there was reduced digestive peristalsis, and/or if there was thickening of the periappendicular fat.

All the appendectomies were performed by laparotomy with an incision at McBurney’s point. The surgical decision depended solely on the surgeon and did not always take the result of the ultrasonography into account. For our study, we compared the results found by ultrasound (noted on the ultrasound reports) with the results found on laparotomy (noted in the operative and anatomical pathology reports). The latter were provided to us by the general and digestive surgery departments of the Yopougon and Treichville teaching hospitals. Epidemiological data (age, sex) and the reason for the ultrasound examination were noted on the ultrasound reports. In total, 620 patients were included in our study.

![Figure 1. Ultrasound image of the right iliac fossa using a 3.5MHz probe showing an appendicular abscess (arrow).](image-url)
Results

The mean age of the patients was 29 years with extremes of 15 and 45 years. Appendicitis dominated in the 25 to 30-year-old age group (25%). The sex ratio was 1.03. The indications for ultrasound examination were dominated by pain in the RIF (70%) followed by generalised abdominal pain (20%) and abdominopelvic pain (10%).

The ultrasound images of the 620 patients included in our study (Table 1) showed the appendix to be inflamed in 448 cases (72.3%). The appendix could not be seen in 172 cases (27.7%) and looking for indirect signs of appendicular inflammation in these patients revealed:

- no indirect sign of appendicular inflammation in 12 cases (7%);
- one indirect sign alone (pain) in eight cases (4.6%);
- the association of two indirect signs in 32 cases (18.6%), (24 cases [75%] of pain + LHL and eight cases [25%] of pain + HPF);
- the association of three indirect signs in 120 cases (69.8%) (pain + LHL + HPF).

Following laparotomy, the results of the operative and anatomical pathology reports were as follows:

- the 448 cases of appendicitis seen by ultrasound (100%) were confirmed on laparotomy and anatomical pathology examination;
- of the 120 patients showing three indirect signs on ultrasound:
  - 115 patients (95.8%) had inflammatory appendicitis, only eight (7%) of which were located anterior to the psoas while 107 cases (93%) were posterior to the caecum;
  - The five (4.2%) other patients each had a normal appendix but they underwent a prophylactic appendectomy. The ultrasound signs were related in two cases to typhoid ileitis and in three cases to lymph node tuberculosis;
- of the 32 patients who showed two indirect signs of appendicitis, the laparotomy and anatomical pathology examination revealed:
  - 18 cases of appendicitis,
  - 14 cases of a normal appendix.

In the cases where pain and HPF were associated:
- seven patients had appendicitis,
- one patient had typhoid ileitis with a healthy appendix.

As regards the association of pain and LHL, there were:
- 11 cases of appendicitis, and

<table>
<thead>
<tr>
<th>Table 1 Appearance of the appendix in ultrasound images compared with the appearance found on laparotomy and anatomical pathology.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Results of ultrasonography of the right iliac fossa prior to surgery</strong></td>
</tr>
<tr>
<td>Appearance of the appendix</td>
</tr>
<tr>
<td>-----------------------------</td>
</tr>
<tr>
<td><strong>Appendix visualised and inflamed (direct signs)</strong></td>
</tr>
<tr>
<td><strong>Appendix not visualised</strong></td>
</tr>
<tr>
<td>0 indirect sign</td>
</tr>
<tr>
<td>1 indirect sign (pain(^a))</td>
</tr>
<tr>
<td>2 indirect signs</td>
</tr>
<tr>
<td>Pain-HPF</td>
</tr>
<tr>
<td>Pain-LHL</td>
</tr>
<tr>
<td>3 indirect signs (Pain-HPF-LHL)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
</tr>
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HPF: hypertrophy of the peritoneal fat; LHL: localised hypokinesia of the digestive loops; in a population highly disposed to appendicitis, the indirect ultrasound signs of appendicular inflammation can be useful. In our study, the true positive rate overall is 79.7% and 95.8% particularly when the three indirect signs are present on the ultrasound image.

\(^a\) Pain caused by the pressure of the probe on the right iliac fossa.
13 cases where the appendix was normal, including two cases of adenitis;

- among the eight patients operated whose only indirect sign on ultrasound was pain, surgery and the anatomical pathology examination found:
  - two cases of appendicitis,
  - six cases of a normal appendix;
- of the 12 patients who presented no direct or indirect sign and whose appendix could not be visualised:
  - two patients had appendicitis,
  - 10 had a healthy appendix.

The positive predictive value (Tables 2–5) of the indirect signs of appendicitis observed on ultrasound was:

- 95.8% for association of the three indirect signs;
- 87.5% for association of pain and HPF;
- 45.8% for association of pain and LHL;
- 25% for the presence of pain alone.

The negative predictive value (Tables 2–5) of the indirect signs of appendicitis observed on ultrasound was:

- 57.2% if the three signs were associated;
- 65.9% if pain and HPF were associated;
- 60.7% if pain and LHL were associated;
- 83.3% for pain alone.

The sensitivity (Tables 2–5) of the indirect signs was:

- 83.9% if the three signs were associated;
- 31.8% if pain and HPF were associated;
- 50% if pain and LHL were associated;
- 50% for pain alone.

The specificity (Tables 2–5) of the indirect signs was:

- 85.7% if the three signs were associated;
- 96.7% if pain and HPF were associated;
- 56.7% if pain and LHL were associated;
- 62.5% for pain alone.

### Discussion

The value of medical imaging in diagnosing appendicitis no longer needs to be proved. According to the literature [6,8], the sensitivity and specificity of ultrasound examinations varies from 90 to 95%. These values are a little higher for CT [8]. This ability of imaging has brought the age of Mondor to an end, an age in which clinical symptoms and diagnostic doubt recommended surgery and resulted in a considerable number of unnecessary laparotomies and prophylactic appendectomies [3,9]. Ultrasonography is the first-line examination if appendicitis is suspected. Despite its high value, it is nevertheless still an examination that depends on an operator [1] who needs to be very experienced. In our study, the ultrasound examinations were undertaken by very well-trained senior radiologists. Ultrasound examination of the RIF does however have its limits [1], which are related to factors concerning the patient (obesity, parietal scars), to underlying conditions (intestinal gas) or to atypical location of the appendix. In our study, 93% (107 cases) of the difficulties in identifying the appendix were related to it being retrocaecal. This ectopic location of the appendix has already been described in the literature as a source of diagnostic difficulty with ultrasonography [10,11], and because of these weaknesses of ultrasound examination, some practitioners have had to resort to second-line CT [1,5]. In the absence of CT, we have sought certain usual signs that are associated with appendicular inflammation, which we have called “indirect” signs, given that the only direct sign of appendicitis in imaging is visualisation of the appendix, with a maximum external diameter greater than 6 mm or maximum parietal thickness greater than 3 mm [4]. The signs that accompany appendicular inflammation are pain in the RIF, thickening of the peritoneal fat (Fig. 2) and localised reduction in intestinal peristalsis (hypokinesia of the digestive loops). Certain less consistent signs indicate a complication of the pathology, for example an effusion of intraperitoneal fluid located in the RIF that may indicate appendicular perforation. Other cases could show an abscess filled with a variable amount of pus (Fig. 1) or an appendix mass. The first three indirect signs are those we evaluated, and with them, our study revealed the following diagnostic performance: a positive predictive

<table>
<thead>
<tr>
<th>Table 2</th>
<th>The diagnostic value of association of the three indirect signs.</th>
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<tr>
<td></td>
<td>Appendicitis</td>
</tr>
<tr>
<td>3 signs +</td>
<td>115</td>
</tr>
<tr>
<td>3 signs —</td>
<td>22</td>
</tr>
<tr>
<td>Positive predictive value: 95.8%; negative predictive value: 57.2%; sensitivity: 83.9%; specificity: 85.7%.</td>
<td></td>
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</tbody>
</table>

<table>
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<tr>
<th>Table 3</th>
<th>The diagnostic value of the association of pain and hypertrophy of the peritoneal fat.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Appendicitis</td>
</tr>
<tr>
<td>2 signs +</td>
<td>7</td>
</tr>
<tr>
<td>2 signs —</td>
<td>15</td>
</tr>
<tr>
<td>Positive predictive value: 87.5%; sensitivity: 31.8%; negative predictive value: 65.9%; specificity: 96.7%.</td>
<td></td>
</tr>
</tbody>
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<thead>
<tr>
<th>Table 4</th>
<th>The diagnostic value of the association of pain and localised hypokinesia in the digestive loops.</th>
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<tbody>
<tr>
<td></td>
<td>Appendicitis</td>
</tr>
<tr>
<td>2 signs +</td>
<td>11</td>
</tr>
<tr>
<td>2 signs —</td>
<td>11</td>
</tr>
<tr>
<td>Positive predictive value: 45.8%; sensitivity: 50%; negative predictive value: 60.7%; specificity: 56.7%.</td>
<td></td>
</tr>
</tbody>
</table>

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<tr>
<th>Table 5</th>
<th>The diagnostic value of pain in the right iliac fossa.</th>
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<tbody>
<tr>
<td></td>
<td>Appendicitis</td>
</tr>
<tr>
<td>Sign +</td>
<td>2</td>
</tr>
<tr>
<td>Sign —</td>
<td>2</td>
</tr>
<tr>
<td>Positive predictive value: 25%; sensitivity: 50%; negative predictive value: 83.3%; specificity: 62.5%.</td>
<td></td>
</tr>
</tbody>
</table>
value of 95.7%, a negative predictive value of 57.2%, sensitivity of 83.9% and specificity of 85.7%. These figures are comparable with those of large ultrasound series with visualisation of the inflamed appendix [12], at least for positive predictive value, specificity and sensitivity. If the three signs were not associated, hypertrophy of the peritoneal fat was the most specific sign (96.7%) and the sign with the highest negative predictive value was the pain caused by compression on exploration of the right iliac fossa (83.3%).

Despite the simultaneous presence of the three main signs, in five cases out of 120 (4%), a diagnostic error was made and an unnecessary laparotomy, with its corollary of prophylactic appendectomy, could not be avoided. Certain diseases such as adenitis [13] and typhoid or tuberculous ileitis are causes of diagnostic errors. We encountered one case of tuberculous adenitis and two cases of ileitis due to Salmonella typhi. In western countries, the presence of Crohn’s disease may produce these indirect signs, which is why it is wise to emphasize that, despite their importance as demonstrated in this study, these indirect signs of appendicular inflammation must be considered with a great deal of caution, and taking into account the epidemiological context, the clinical symptoms and the biological signs.

**Conclusion**

In the absence of CT or when CT cannot be performed for various reasons, if the appendix cannot be located by ultrasonography, the diagnosis of appendicitis can be directed towards finding indirect ultrasound signs, particularly in a population highly disposed to appendicitis. In our study, when these signs were associated, they had a positive predictive value of 95.7%, sensitivity of 83.9% and specificity of 85.7%. We recommended that ultrasonographers should systematically look for pain on compression, thickening of the peritoneal fat and localised hypokinesia of the digestive loops when exploring the RIP for suspected appendicitis. Of these indirect signs, the most specific is hypertrophy of the peritoneal fat, and the sign with the highest negative predictive value is pain on compression of the RIP. However, it is important to point out that in a not insignificant proportion of cases (20.3%), these indirect signs may be related to an ileocaecal pathology without being specific to appendicitis, and cannot be alleged to have the same diagnostic value as the direct signs of appendicitis.

**Disclosure of interest**

The authors declare that they have no conflicts of interest concerning this article.

**References**