G. Maconi · G. Bianchi Porro (Eds.)

Ultrasound of the Gastrointestinal Tract

With Contributions by

G. Bianchi Porro · E. Danse · S. Daum · C. Del Vecchio Blanco · I. de Sio · M. Fraquelli · D. Geukens · O. H. Gilja · S. Greco · N. Gritzmann · K. Haruma · J. Hata · T. Hausken · J. Hoffmann · T. Kamada · H. Kusunoki · D. H. Lee · J. H. Lim · G. Maconi · N. Manabe · E. Radice · M. Sato · D. Schacherer · J. Schölmerich · T. Tanaka · L. Tarantino · L. Tibullo · S. B. Vijayaraghavan · M. Zeitz

Foreword by

A. L. Baert

With 179 Figures in 347 Separate Illustrations, 57 in Color and 24 Tables
GIOVANNI MACONI, MD
GABRIELE BIANCHI PORRO, MD, PhD
Chair of Gastroenterology
Department of Clinical Sciences
‘L. Sacco’ University Hospital
Via G. B. Grassi 74
20157 Milano
Italy

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Two to three decades ago only very few radiologists, such as F. Weill and other pioneers in the field, believed in the diagnostic potential of ultrasound for the study of the gastrointestinal tract. The main applications of ultrasound were confined to the study of solid visceral organs, the female pelvis and obstetrics. Rapid progress in computer technology and in transducer design has opened totally new horizons for ultrasound, for instance in musculoskeletal pathology, as well as in the gastrointestinal tract in children and adults.

Today ultrasound plays a major role as the primary imaging procedure in acute abdominal conditions involving the gastrointestinal tract. The indications for surgery in patients suspected of acute appendicitis have dramatically improved due to the widespread application of ultrasound.

I am very much indebted to the editors of this book, Prof. G. Maconi and Prof. G. Bianchi Porro, both internationally recognized experts in abdominal ultrasound. They developed the concept of this volume and have been very successful in involving several other distinguished ultrasound experts from both Europe and the Far East.

I would like to congratulate the editors and the authors most sincerely on this outstanding volume which provides a comprehensive overview of the use of ultrasound in acute and chronic diseases of the gastrointestinal tract.

This book will be of great value, not only for radiologists, but also for gastroenterologists, abdominal surgeons, pediatricians and oncologists. They will find it a very helpful guide in their daily clinical practice.

I am confident that it will meet with the same success among readers as previous volumes published in this series.

Leuven

Albert L. Baert
Preface

In recent decades technological advances, scientific innovations and improved skills of operators have made sonography of the gastrointestinal tract increasingly important in diagnostic work-up and medical decision-making for gastrointestinal disorders, both in acute and non-acute conditions. Thanks to its non-invasiveness, ready availability, repeatability and accuracy, ultrasonographic examination of the gastrointestinal tract is currently employed in many suspected acute and chronic inflammatory conditions, not only for purely diagnostic purposes, but also for management of well-known gastrointestinal diseases. Furthermore, given that ultrasound is usually performed as the first diagnostic imaging procedure for abdominal complaints, its role in detecting or suspecting neoplastic, infectious and inflammatory diseases of the gastrointestinal tract may become even more important in the future as an aid to selecting and driving more expensive and invasive examinations.

Despite the vast mass of scientific literature showing the importance and accuracy of ultrasound in assessing various pathologic conditions of the gastrointestinal tract, it has not yet entered into routine use in clinical practice, and indeed seems to be considered (incorrectly) as a highly specialised application of ultrasound for super-specialist sonographers. The belief that more widespread knowledge of the various applications and usefulness of ultrasound in the assessment of gastrointestinal disorders would be of value in our clinical practice prompted us in to propose this topic for Medical Radiology, Springer-Verlag’s prestigious radiological series.

In this context, this book is intended as a high-level volume prepared by authors who are specialist intestinal sonographers, regarded as authorities in their specific fields, with the intention of spreading their experience on the gastrointestinal tract to a much wider audience of sonologists. To this end, a comprehensive overview of ultrasonographic imaging of acute and chronic inflammatory gastrointestinal tract disorders, as well as specific neoplastic and infectious diseases, is provided, and the potential, usefulness and limits of gastrointestinal tract sonography are elucidated.

The topics of the volume cover not only the major gastrointestinal diseases, but also rare conditions, the aim being to help the abdominal sonographer to also interpret incidental findings related to the gastrointestinal tract and to deal with the more common problems encountered during routine abdominal investigations in patients with abdominal complaints and well-known chronic disorders. Specific technical developments and applications of ultrasound devoted to studies of the gastrointestinal tract which promise to be of increasing importance in the future, such as functional and 3D ultrasound, contrast agents and operative US, are also discussed.
The editors of this issue would like to thank the Editor-in-Chief, Prof. Albert Baert, for his valuable suggestions and assistance. A most sincere word of gratitude goes to Ursula N. Davis and Kurt Teichmann of Springer-Verlag and to Marian Shields for their constant, patient and untiring efforts in helping us to collect, edit and revise the manuscripts; their devotion deserves special recognition. We are also extremely grateful to all the authors who have contributed so remarkably in preparing their contributions. Last, but not least, special thanks go to our families for all their encouragement and support.

We hope that readers will share our enthusiasm for this interesting and rapidly developing area of ultrasound.

Milan

Giovanni Maconi
Gabriele Bianchi Porro
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Acute Abdomen
Acute Appendicitis and Appendiceal Mucocele

Norbert Gritzmann

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1.1 Introduction

Appendicitis is a common disease in each period of life. Most frequently, appendicitis occurs in children and adolescents. Histologically serous, phlegmonous, ulcerous and perforated forms are differentiated. These forms usually reveal thickening and enlargement of the tubular organ, whereas chronic or neurogenic forms do not alter the size of the appendix; therefore, neither can usually be diagnosed by imaging.

1.2 Clinical Evaluation of Acute Appendicitis

The clinical assessment of the painful right lower quadrant is still the cornerstone in the diagnosis of acute appendicitis. Important signs for acute appendicitis are pain at the Mc Burney’s point, axillary–rectal difference of the temperature. In laboratory testing, signs of acute inflammation are present. The C-reactive protein (CRP) is usually elevated, and leukocytosis is often present. Clinical evaluation usually gives significant hints for pathology in the right lower quadrant; however, specificity in diagnosing acute appendicitis is limited. Of all surgically treated appendices, 30–50% do not reveal acute appendicitis at histology. The accuracy in clinical evaluation of acute appendicitis is especially low in young women and older patients (Überrüeck et al. 2004).

1.3 Diagnostic Methods

The main goal of imaging methods is to diagnose appendicitis quickly with high accuracy, non-invasive, cost-effective methods and to provide differential diagnosis without laparotomy (Puylaert 1986a).

1.3.1 Sonography

In 1986, Puylaert published a groundbreaking study on the diagnosis of acute appendicitis using sonography with the graded compression technique. Sonography is used mainly on account of widespread availability and the fact that no radiation is used. First of all, diagnosing appendicitis needs sufficient skill and expertise in the performance of gastrointestinal ultrasound. Various compression techniques are used to visualize the appendix (Lee et al. 2005).

Usually, the abdomen and the retroperitoneum are examined with the 3.5-MHz transducer. Then the caecum, which usually contains gas, is localised. Most
often the appendix originates caudal to Bauhin's valve. The position of the appendix is highly variable. Artrocaecal position or a position within the small pelvis may be found.

The appendix is a blind-ending tubular structure (Fig. 1.1). Normally the appendix is compressible with an ovoid configuration in the transverse section. The antero-posterior diameter is normally <6 mm. Compared with the terminal ileum, no peristalsis is visualised in the normal appendix. In a study by Rettenbacher et al. (1997), it was shown that the normal appendix is localised sonographically in 50–70% of cases.

Frequently, a high-resolution transducer is used to visualize the appendix during graded compression. In many cases, the appendiceal region can be seen with transabdominal 7.5-MHz transducers. The use of colour- or power Doppler may be useful; however, use of the Doppler methods is not mandatory.

Ultrasound contrast media have been used for the detection of hypervascularisation (Incesu et al. 2004). Harmonic imaging is presently the standard technique in the abdomen. The main advantage is the higher signal-to-noise ratio, but the depth of penetration is lower with this technique (Table 1.1).

Table 1.1. Sonographic signs of acute appendicitis

<table>
<thead>
<tr>
<th>Sign</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antero-posterior (a.p.) diameter of 6 mm or more</td>
<td>(see Fig. 1.2). In some cases with lymphatic hyperplasia the a.p. diameter is &gt;6 mm (Rettenbacher et al. 2001)</td>
</tr>
<tr>
<td>Round configuration in the transverse section</td>
<td>(see Fig. 1.2; Rettenbacher et al. 2003)</td>
</tr>
<tr>
<td>Missing compressibility</td>
<td>(Puyleart et al. 1986a)</td>
</tr>
<tr>
<td>Alteration of the periappendiceal fat</td>
<td>(Fig. 1.3; Noguchi et al. 2005)</td>
</tr>
<tr>
<td>Missing gas in the appendix</td>
<td>(Rettenbacher et al. 2000)</td>
</tr>
<tr>
<td>Hypervascularisation of the appendix in colour Doppler</td>
<td>(see Fig. 1.4)</td>
</tr>
<tr>
<td>Moderately enlarged lymph nodes</td>
<td></td>
</tr>
<tr>
<td>Pain directly above the appendix</td>
<td>(Puyleart et al. 1986a)</td>
</tr>
<tr>
<td>Faecolith in the appendix, with obstruction (see Fig. 1.5)</td>
<td></td>
</tr>
<tr>
<td>Localised effusion</td>
<td></td>
</tr>
</tbody>
</table>

Fig. 1.1a–c. Normal appendix. a Transverse section. b Longitudinal section. c Longitudinal section with a variable amount of air within the tip (asterisk)
In difficult patients and in women, also a transrectal or transvaginal approach may visualise appendiceal region and appendicitis (Figs. 1.2–1.6).

If severe complications, such as significant perforation (Fig. 1.7) or abscess formation (Fig. 1.8), are present, the appendix often cannot be visualized as the origin of the inflammation. In these cases, computed tomography (CT) should be performed in order to completely delineate the inflammation and to visualise a safe path for a transabdominal drainage; however, the drainage can be performed under US guidance.

The accuracy of sonography in diagnosing appendicitis varies between 70 and 95% depending on the study (Chan et al. 2005; Kessler et al. 2004; Lee et al. 2005; Puylaert et al. 1986a; Rettenbacher et al. 2002; van Breda Vriesman et al. 2003). In the present author’s opinion, accuracies over 90% can be achieved if sonography is performed by an experienced team (Gritzmann et al. 2002).

It is generally accepted that sonography should be performed in clinically, questionable cases, in order to reduce the high rate of false-negative appendectomies; however, in clinically, highly suspicious cases the incidence of acute appendicitis was only about...
Therefore, it was advocated that sonography be performed in all cases with pain in the right lower quadrant (Rettenbacher et al. 2002).

An acute appendicitis can be excluded if the normal appendix can be completely displayed and/or a differential diagnosis that explains the clinical findings can be found.

### 1.3.2 Computed Tomography

In the United States, CT is the preferred method in the evaluation of acute appendicitis (Rao et al. 1997); however, CT involves significant radiation doses to the patients.
Computed tomography can be performed only in the region of the painful right lower quadrant if it is preceded by sonography. This is a way to reduce radiation, particularly in young patients. Modern multidetector scanners can visualise the abdomen at low doses using modes with a high spatial resolution. The main advantage of CT is that operator dependency is lower than with sonography. Furthermore, the normal appendix can be seen in a higher percentage than with sonography. In European institutions, CT is often used as a problem-solving investigation if sonography fails to give a clear diagnosis (van Breda Vriesman et al. 2003). After oral application of water-soluble contrast media, perithyptic abscesses or bowel loop abscesses are usually better revealed by CT (see Fig. 1.6).

1.3.3 Magnetic Resonance

Magnetic resonance imaging (MRI) is also used to diagnose acute appendicitis (Hörmann et al. 1998; Birchard et al. 2005). With fast sequences the lower abdomen can be imaged within seconds (i.e., HASTE sequence). The prompt availability is a prerequisite for diagnosing acute appendicitis. Accuracy is reported to be comparable to that of CT (Hörmann et al. 1998); however, its relatively high cost enables only MRI as a problem-solving investigation. In the future, this may change; however, up to now, MRI is not a primary standard imaging modality in the diagnosis of acute appendicitis.

1.4 Differential Diagnosis

The differential diagnosis can be divided into intestinal (Table 1.2), gynaecological, urological and diseases of other compartments (mainly abdominal wall, psoas muscle, gallbladder, pancreas) (Abu-Yousef 2001).

1.4.1 Intestinal Differential Diagnosis

Most often, infectious ileocaecitis is found (Puylaert 1986b; Tarantino et al. 2003). Sonographically, the caecum and/or the terminal ileum are moderately thickened. The caecum shows hyperausturation. Often, enlarged painful regional lymph nodes are found. The most frequent microbes are *Yersinia*, *Campylobacter* or *Salmonella* (Puylaert et al. 1988). The appendix can be reactively enlarged by these diseases.

When examining children, in the event of a painful lower quadrant, invagination of the small bowel has to be considered. The sonographic picture is typical. A double-layer intussusception can be visualised. With adults, tumours causing invagination have to be excluded. Furthermore, complications of a Meckel’s diverticulum (inflammation, bleeding) have to be taken into account (Baldisserotto et al. 2003). Another differential diagnosis when examining children is a volvulus (Patino and Munden 2004). In this condition, the mesenteric vessels show a whirlpool sign.

In adults, diverticulitis of the ascending colon or caecum is an important conservatively managed disease (Macheiner et al. 1999, Wada et al. 1990). Also diverticulitis of the sigmoid colon can be right sided or project on the right side (Hollerweger et al. 2001). Diverticula on the right side are usually true diverticula, which are often large.

Furthermore, a (perforated) tumour of the colon should be considered.

Crohn’s disease is a frequent transmural chronic inflammation of the bowel. Usually, segmental thickening of the small bowel is seen. Also other parts of the bowel, appendix included (Fig. 1.9), can be involved. Due to the transmural inflammation, the surrounding fat is frequently affected. Fistulas are often found. In chronic forms, fibrous stenosis is frequently present with dilation of the oral segments.