

## ACUTE APPENDICITIS: COMPUTED TOMOGRAPHY FINDINGS – AN ICONOGRAPHIC ESSAY\*

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**Abstract** Acute appendicitis is the most important cause of abdominal pain requiring surgical intervention in the Western world. The early diagnosis of this disease is of paramount relevance for minimizing its morbidity. Imaging methods have represented a huge progress in the diagnosis of this entity, which used to be based essentially on clinical history, physical examination and laboratory tests results, considering that 20% to 33% of patients present with atypical symptoms. Diagnostic difficulty is higher in children, the elderly, and women in childbearing age. The main imaging methods for evaluation of acute appendicitis are ultrasound and computed tomography. The present study is aimed at describing the disease physiopathology, commenting main computed tomography technical aspects, demonstrating and illustrating tomographic findings, and describing main differential diagnoses.

*Keywords:* Acute appendicitis; Vermiform appendix; Computed tomography.

**Resumo** *Appendicite aguda: achados na tomografia computadorizada – ensaio iconográfico.*

A apendicite aguda é a causa mais comum de dor abdominal aguda que requer intervenção cirúrgica no mundo ocidental. O diagnóstico precoce é essencial para minimizar a morbidade da doença. O uso dos métodos de imagem significou grande avanço no diagnóstico desta entidade, até então avaliada apenas com base na história clínica, exame físico e dados laboratoriais, haja vista que 20% a 33% dos pacientes apresentam sintomas atípicos. O diagnóstico é mais difícil nas crianças, nos idosos e nas mulheres em idade fértil. Os principais métodos de imagem para sua avaliação são a ultra-sonografia e a tomografia computadorizada. Os objetivos deste trabalho são: descrever a fisiopatologia da doença, comentar os principais aspectos técnicos da tomografia computadorizada, demonstrar e ilustrar os achados tomográficos e citar os principais diagnósticos diferenciais.

*Unitermos:* Apendicite aguda; Apêndice vermiforme; Tomografia computadorizada.

### INTRODUCTION

Acute appendicitis is the most important cause of abdominal pain requiring surgical intervention in the Western world<sup>(1,2)</sup>. The early diagnosis of this disease is of paramount relevance for minimizing its morbidity. Imaging methods have represented a huge progress in the diagnosis of this entity, which used to be based essen-

tially on clinical history, physical examination and laboratory tests results, considering that 20% to 33% of patients present with atypical symptoms<sup>(2)</sup>.

Diagnostic difficulty is higher in children, the elderly, and women in childbearing age. The disease may occur at any age range, with higher incidence in the second decade of life<sup>(1)</sup>.

The main imaging methods for acute appendicitis evaluation are ultrasonography (US) and computed tomography (CT). Patients presenting with typical clinical and laboratory signs may be directly referred for surgery and can dispense with imaging methods<sup>(1)</sup>. However, imaging methods become essential when patients present with atypical symptoms, in retrocecal appendicitis, in obese patients, an in case of complications of the disease.

The choice between US and CT is extremely variable, depending on some factors such as preference and experience of the institution, age, sex and biotype of the patient.

Advantages of US include short acquisition time, non-invasiveness, low-cost besides not requiring preparation of the patients or contrast agent administration; however, is extremely operator-dependent<sup>(3)</sup>. Considering the lack of ionizing radiation, and the fact of representing a good method for evaluation of acute gynecological conditions, US is recommended as the initial imaging test in women of childbearing age, pregnant women and children. CT represents an excellent diagnostic alternative for all the other cases, especially obese patients and in the complications of the disease (appendix perforation).

The present study is aimed at describing the disease physiopathology; commenting main CT technical aspects; demonstrating and illustrating tomographic findings; and describing main differential diagnoses.

### PHYSIOPATHOLOGY

The adult appendix is a long diverticulum, measuring 10 cm in length, arising

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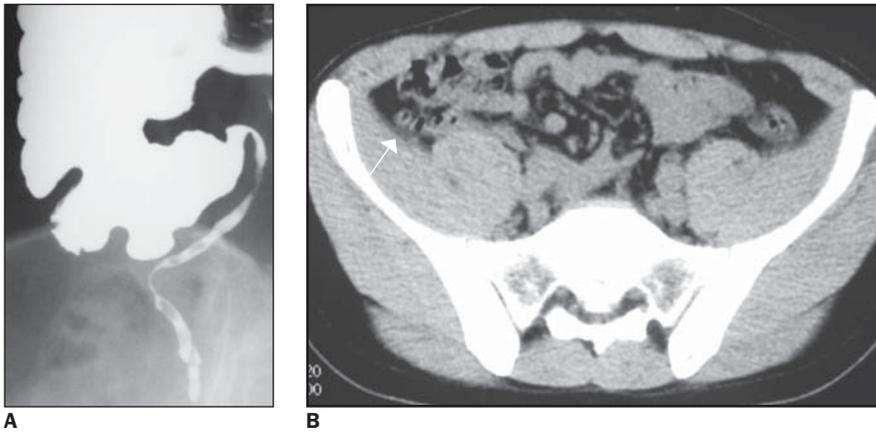
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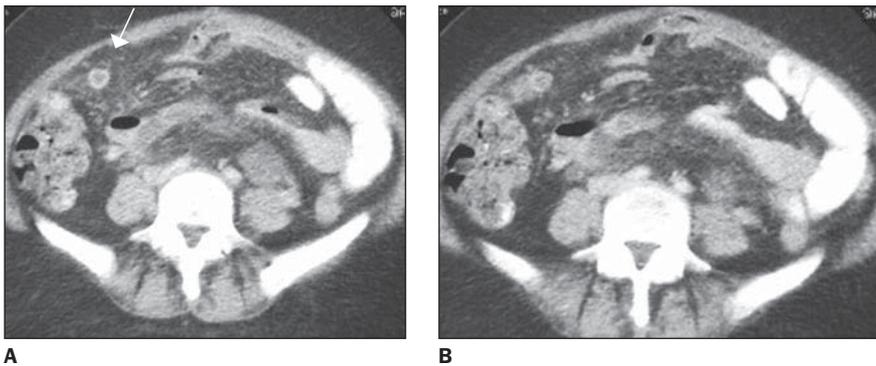
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**Figure 1.** Normal appendix. Opaque enema (A) and computed tomography (B – arrow).



**Figure 2.** Computed tomography. Signs of appendicitis (parietal thickening and increase in the mesenteric fat density) in the right flank, located more anteriorly than usual (arrow).

from the medial posterior wall of the cecum, about 3 cm below the ileocecal valve. The base is at a constant location, whereas the position of the tip of the appendix varies and may occupy several regions inside the abdominal cavity (Figure 2), including the pelvic region<sup>(1)</sup>, the left iliac fossa, or even inside the inguinal canal. Clinical presentation is highly influenced by this wide variation in the topography of the appendix<sup>(1)</sup>.

Obstruction of the appendiceal lumen due to the presence of fecalith (the most frequent one), lymphoid hyperplasia, foreign body or tumor<sup>(1)</sup>. Appendicolith, a calcified fecalith, is less frequent but is associated with perforation and abscess formation<sup>(1,2)</sup>. The obstruction of the lumen there is secretion accumulation leading to an increase in the intraluminal pressure, and determining stimulation of afferent visceral fibers between T8 and T10, with periumbilical epigastric pain as a consequence<sup>(1)</sup>.

This pain is not intense and usually poorly localized, with 2–5-hour duration. Anorexia, nausea and emesis may be present in this phase. The gradual increase in the intraluminal pressure exceeds the pressure of capillary perfusion, determining appendiceal walls ischemia, with loss of the epithelial integrity and bacterial mural invasion<sup>(1,2)</sup>. Then, the pain migrates into the appendiceal region, generally in the right iliac fossa, and may be associated with signs of peritoneal irritation (positive sudden decompression). Fever is low or absent; the presence of high fever suggests perforation<sup>(1)</sup>.

In the absence of surgical intervention, appendicitis naturally progresses to perforation, with extension of the infection toward periappendiceal tissues. There may be a process blockage by the great omentum and/or small bowel loops, and, in some cases, a possible progress to intestinal obstruction<sup>(2)</sup>. Local or distant abscess forma-

tion may occur. The appendicolith may migrate towards other sites of the abdominal cavity, determining collections formation<sup>(1,2)</sup>.

Other possible complications are infection dissemination to the abdominal wall, ureteral obstruction, venous thrombosis (portal system) and hepatic abscesses<sup>(1,2)</sup>.

Indiscriminate use of antibiotics may change the disease progress, difficulting an early diagnosis and increasing the morbidity. A delayed surgical intervention increases the risk for complications<sup>(1,2)</sup>.

## EXAMINATION TECHNIQUE

Notwithstanding the advantages of helical CT over the conventional CT (sequential, transverse sections), with shorter acquisition time and possibility of images reconstruction with thinner slices, in our experience they present similar final results. Transverse multidetector CT followed by coronal reconstruction may improve the characterization of the appendix, but its sensitivity is the same only with the utilization of transverse sections<sup>(4)</sup>.

The images acquisition must cover the whole abdomen, from the xiphoid appendix to the pubic symphysis, since the appendix localization is highly variable and distant complications may coexist. Besides, the possibility of other differential diagnosis should be considered<sup>(3,5,6)</sup>.

In conventional CT equipment, the collimation (slice thickness) may range between 5 mm and 10 mm, possibly requiring thicker slices. We consider the evaluation of the whole abdomen with 10 mm collimation followed by thin slices (5 mm) on the right iliac fossa or on the suspicious region as sufficient. Many times, these thin slices are performed on the topography of the painful area indicated by the patients, facilitating the inflammatory process identification. In institutions where helical equipment is available, 5 mm-thick-slices are performed at 8 mm-intervals, followed by 5 mm-reconstruction, according to Lane et al.<sup>(6)</sup>.

Intravenous contrast agent is not routinely utilized<sup>(7,8)</sup>, although it may be quite useful, especially in case of complications (perforated appendicitis), in young and thin patients (with paucity of peritoneal fat), in

non-specific findings, and in the differential diagnosis of a malignant process<sup>(1)</sup>.

Retrograde contrast injection (500 ml 5% iodinated solution) by rectal via has been utilized by many authors, improving both the sensitivity and specificity of the method<sup>(4,5,9)</sup>, but, in our services, we have utilized this technique only in dubious cases, reducing costs and making the procedure faster and more comfortable for the patient. The utilization of rectal-contrast reduces the incidence of false-positive results, since intestinal loops filled with fluid may be confused with distended appendices<sup>(2)</sup>.

The utilization of oral contrast is unnecessary in the majority of cases; it is helpful only in patients with non-specific abdominal pain, or when ileal opacification is necessary to solve any doubt in the case the rectal contrast is not elucidative<sup>(6)</sup>.

Finally, the fastest protocol in the evaluation of acute appendicitis is the one suggested by Lane et al.<sup>(6)</sup>, who propose the use of non-contrast-enhanced helical CT covering the whole abdomen, with 5 mm-thick slices, 8 mm interval, and followed by 5 mm reconstruction.

### TOMOGRAPHIC FINDINGS

**Thick appendix** – Appendiceal distention is the first tomographic sign, but its identification depends on the degree of distention, amount of surrounding fat, and technical quality of the study (slice thickness). The normal appendix is visualized in 67%–100% of asymptomatic adults submitted to CT<sup>(1)</sup> with thin slices (Figure 1). An appendix is considered as thick when  $\geq 8$  mm in transverse (Figure 3). Usually, the appendix contents is liquid (Figure 4). The distention rarely exceeds 15–20 mm, since perforation generally occurs first. Higher values suggest the possibility of mucocoeles or neoplasm. In patients with paucity of peritoneal fat, rectal contrast may facilitate its identification<sup>(5,9)</sup>.

**Appendix wall thickening** – The normal appendiceal wall is 1–2 mm-thick. In the inflammatory process, mural thickening is present, and if intravenous contrast agent is utilized<sup>(1)</sup>, we will observe the contrast uptake on the inflamed appendix walls (Figure 5).

**Blurring of the adjacent fat** – The normal fat surrounding the appendix is homogeneous. In appendicitis, there is a blurring of this fat (Figure 3), a very frequent and significant sign found in 98% of cases<sup>(1)</sup>.

**Cecal thickening** – Also, the presence of some degree of inflammatory process is

frequent in the adjacent loops<sup>(10)</sup>, especially in the cecum (Figure 6).

**Arrow-head sign** – Characterized by an arrow-head shape, as a result of edema in the base of the appendix<sup>(11)</sup>, on rectal contrast-enhanced studies (Figure 7).

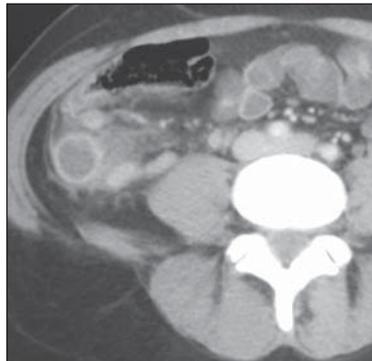
**Appendicolith** – Appendicolith does not necessarily indicate inflammation in the organ, since this finding is observed in asymptomatic adults without appendiceal distention. However, this finding gains high significance in the presence of other findings.

After appendix perforation, the appendicolith may migrate to other sites in the abdominal cavity<sup>(1)</sup>, resulting in formation of distant abscess, including during the post-operative period (Figure 8).

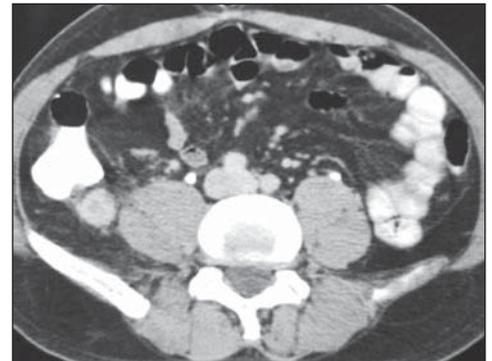
**Inflammatory mass** – In the case of an intense inflammatory process after appendiceal perforation, large, ill-define inflammatory masses may be observed in the right



**Figure 3.** Computed tomography. Male, 60-year-old patient. Acute appendicitis. Observe the degree of appendix thickening, as well as blurring of the adjacent fat.



**Figure 4.** Computed tomography. Female, 42-year-old patient. Marked liquid distention of the appendix in the right iliac fossa, with parietal thickening and blurring of adjacent fat, characterizing appendicitis.



**Figure 5.** Computed tomography. Male, 46-year-old patient. Appendicitis demonstrated by marked thickening of the appendix wall, and contrast-enhancing.



**Figure 6.** Computed tomography. Female, 50-year-old patient. Acute appendicitis. Cecal thickening (arrow), blurring of periappendicular fat and appendix thickening.

iliac fossa, determined by the blockage of the adjacent intestinal loops and omentum (Figure 9). In some cases, the appendix may be totally destroyed by infection, so its identification is unfeasible<sup>(2)</sup>.

**Free intraperitoneal fluid** – The appendix perforation results in spillage of pus into the abdominal cavity, with possible bacterial peritonitis<sup>(1)</sup> (Figure 10).

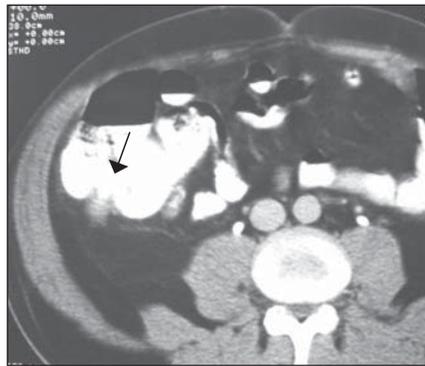
**Extraluminal air** – It may be found

within a collection or free inside the cavity (pneumoperitoneum) as a result of appendiceal perforation (Figure 11). Pneumoperitoneum pneumoperitoneum is less frequent, and, if present, is small<sup>(1)</sup>.

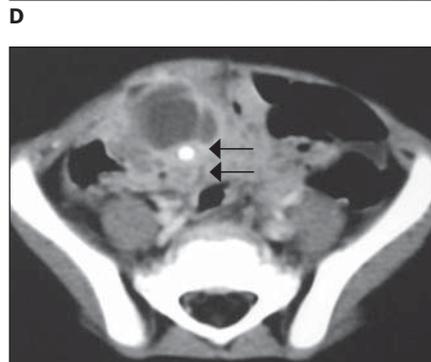
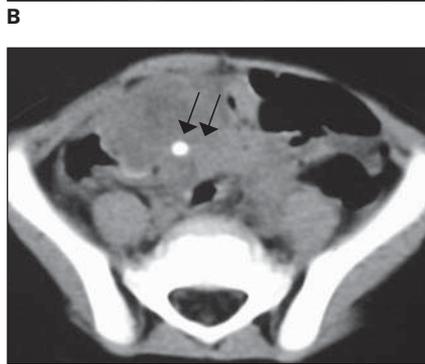
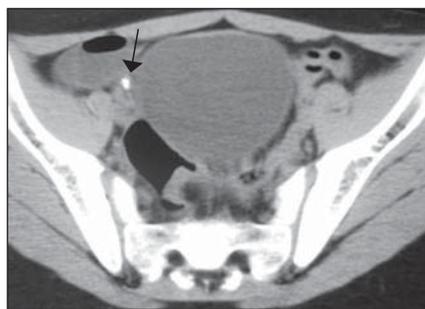
**COMPLICATIONS**

Complications occur as a result from delayed diagnosis and appendix perforation<sup>(1,2)</sup>, disseminating the infectious process into the peritoneal cavity. Main complications are the following:

**Abscess** – A frequent complication, occurring in the appendix or in other sites inside the abdominal cavity, characterized by fluid collection, marginal enhancement after intravenous contrast administration, and many times blocked by adjacent intestinal loops (Figure 12).

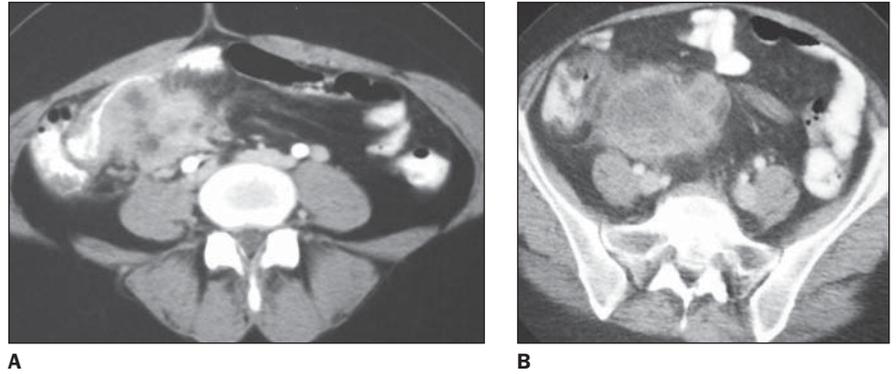


**Figure 7.** Computed tomography. Male, 60-year-old patient. Acute appendicitis. Arrow head sign (arrow).

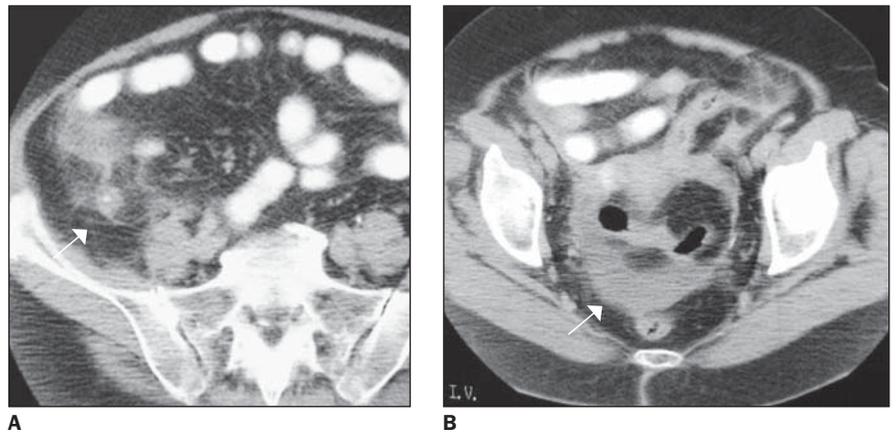


**Figure 8.** Computed tomography. Appendicoliths. **A:** Normal appendix with appendicoliths in an asymptomatic patient (arrow). **B,C,D:** Early phase of appendicitis with appendicoliths. In this case, although the appendix thickness is only 6 mm, other positive signs such as liquid distention of the appendix, presence of appendicolith, and compatible US results, have allowed the presurgical diagnosis. **D:** Photo of the surgical specimen. **E,F,G:** Appendicular abscess recognized by the presence of appendicolith in a three-year-old child using antibiotics for two weeks (double arrows).

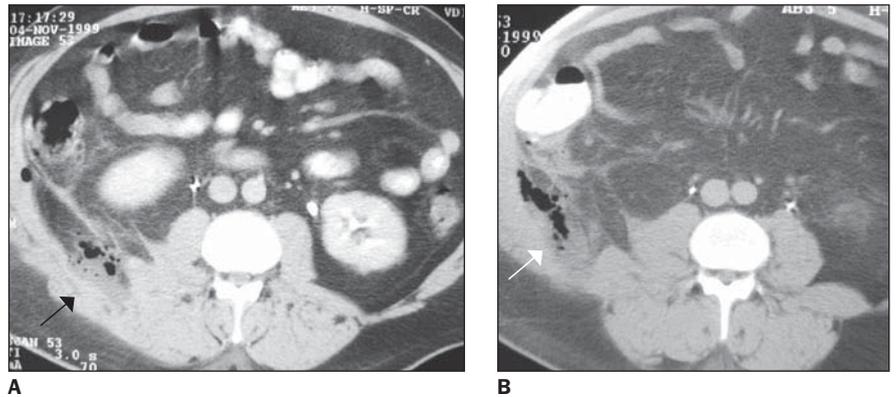
**Figure 9.** Computed tomography. Female, 34-year-old patient. Inflammatory mass in the right iliac fossa. Appendicitis. Differential diagnosis with Crohn's disease, ileocecal tuberculosis and neoplastic process.



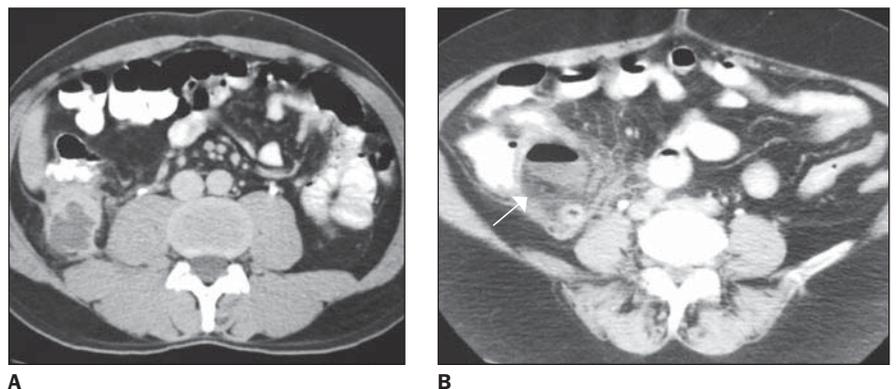
**Figure 10.** Computed tomography. Female, 71-year-old patient. Appendicitis with free intraperitoneal fluid suggesting peritonitis confirmed at the surgery (arrows).

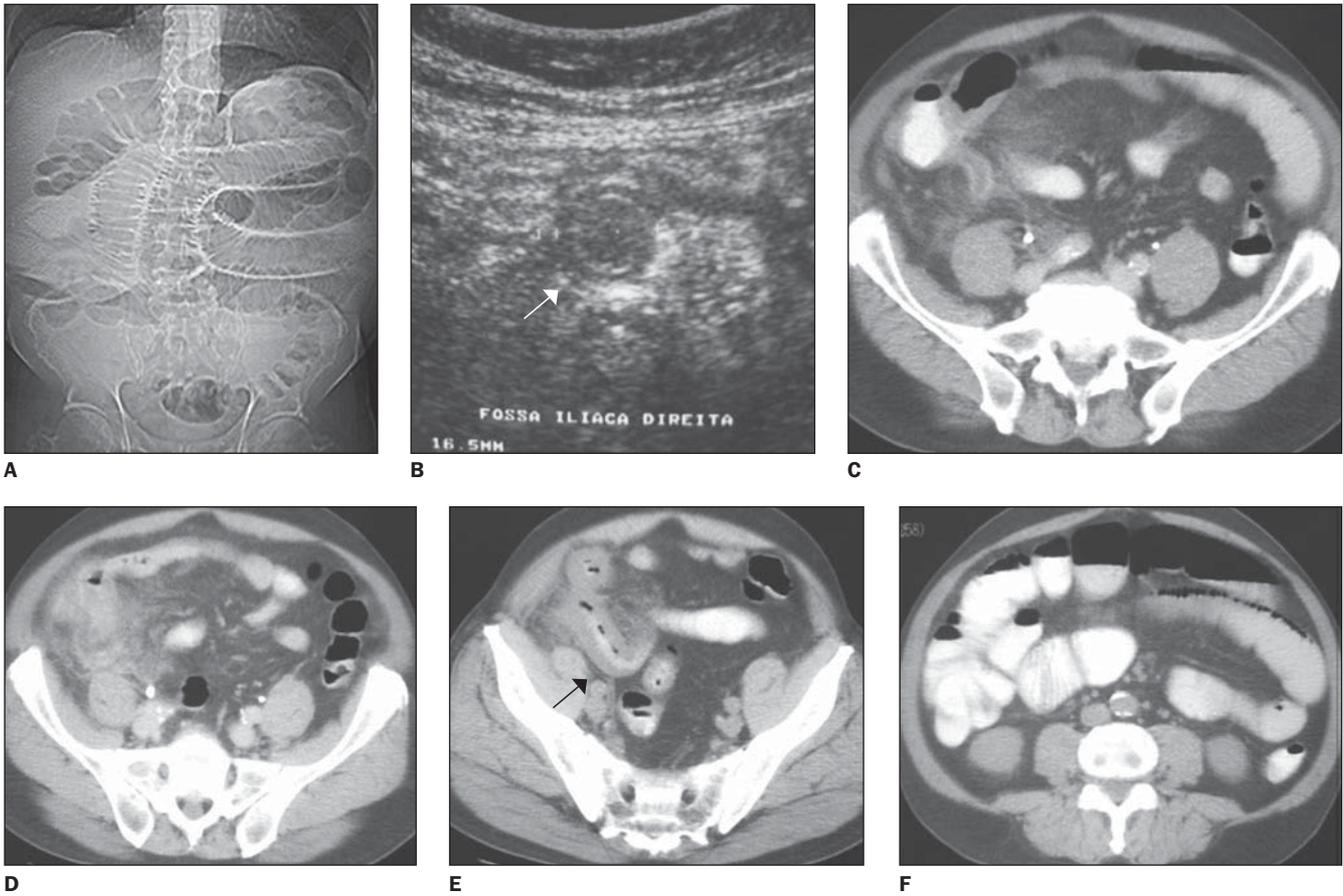


**Figure 11.** Computed tomography. Male, 59-year-old patient. Appendicitis complicated with wall abscess characterized by extraluminal air (arrows) surgically confirmed. The appendix has been completely destroyed by the infection, with unfeasible localization by means of CT.



**Figure 12.** Computed tomography. Acute appendicitis complicated with abscess in the right iliac fossa. Two different cases, the second (B) with gaseous content (arrow).





**Figure 13.** Male, 64-year-old patient. **A:** Digital radiogram **B:** Ultrasound (arrow). **C-F:** Classical findings of acute appendicitis besides signs of intestinal obstruction characterized by dilatation of small bowel loops and mural thickening of the terminal ileum (arrow).

**Venous thrombosis** – Severe complication resulting from infectious process dissemination to the portal system. Also, hepatic abscesses may be observed.

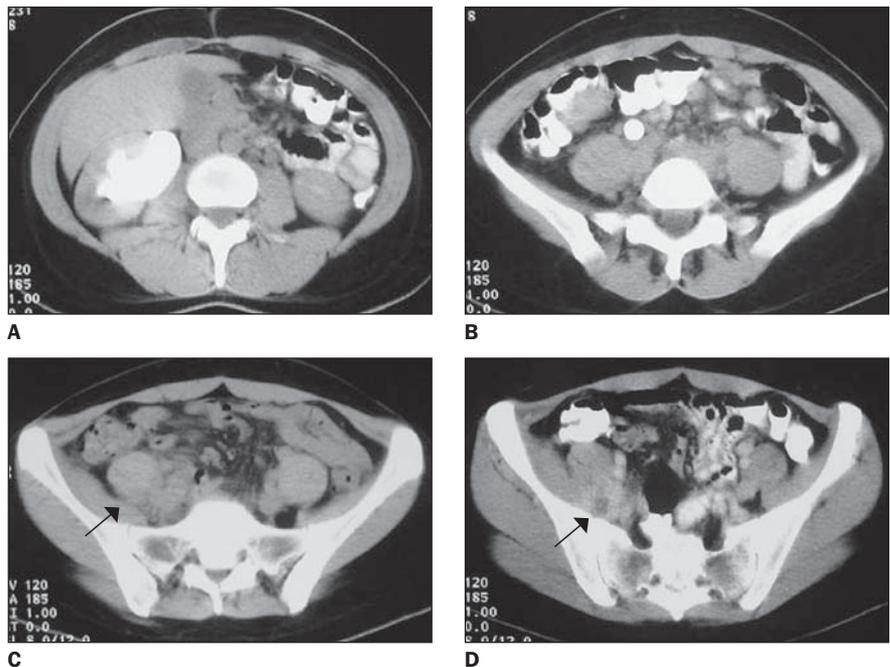
**Intestinal obstruction** – Initially, the blockage determined by the intestinal loops determines a regional ileum, however, as the disease progresses, obstruction may occur as a result from inflammatory process and ischemia (Figure 13).

**Sepsis** – Extremely severe complication detectable by clinical diagnosis, resulting from intracavitary abscesses or diffuse peritonitis, with consequent systemic dissemination of the infectious process and high mortality.

**Ureteral obstruction** – The inflammatory process may determine ureteral obstruction at right (Figure 14).

**DIFFERENTIAL DIAGNOSIS**

Main differential diagnoses are<sup>(2,4,6)</sup>: diverticulitis, epiploic appendagitis, typhi-



**Figure 14.** Computed tomography. Female, 27-year-old patient. Investigation for renal colic. Obstructive uropathy associated with signs of an inflammatory process in the retroperitoneum (arrows), with upper ureteral obstruction. Acute appendicitis confirmed at surgery.

litis, omental infarct, Crohn's disease, colitis, acute cholelithiasis/cholecystitis, ureteral calculus/pyelonephritis, pelvic inflammatory disease/ovarian cyst, mesenteric lymphadenopathy, neoplasm.

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