Grading system for acute appendicitis using CT scan: imagenological characterization and its surgical and anatomopathological correlation.

Poster No.: C-1597
Congress: ECR 2018
Type: Educational Exhibit
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Keywords: Obstruction / Occlusion, Inflammation, Acute, Contrast agent-oral, Contrast agent-intravenous, Image manipulation / Reconstruction, CT-High Resolution, CT, Gastrointestinal tract, Emergency, Abdomen
DOI: 10.1594/ecr2018/C-1597

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Learning objectives

1. Describe the frequency of presentation of the different stages of acute appendiceal disease.

2. Identify the key characteristics of CT images for the diagnosis of the different stages of acute appendicitis and their surgical and anatomopathological correlation.
Background

Acute appendicitis is the most common cause of acute surgical abdomen. It can affect all age groups, with a predilection for the population between 10 - 30 years old, and with greater risk for the male gender \[^{1,2}\].

Anatomically, the cecal appendix is a blind intestinal loop measuring between 3-20 cm in length and less than 6 mm in transverse diameter. It usually originates in the posteromedial wall of the cecum, 2-3 cm inferior to the ileocecal valve \[^{1}\]. Its position has been described as retrocecal, subcecal, pelvic and peri-ileal; the first being the most common \[^{3,4}\].

The primary pathogenic event is the intraluminal obstruction that can occur due to fecolith (appendicolith), lymphoid hyperplasia, foreign body, parasites or neo-formative processes \[^{1,5}\]. This obstruction conditions the accumulation of fluid and secretions in the lumen of the appendix, with subsequent bacterial proliferation, and inflammation of the wall and the surrounding tissues that lead to an increase in endoluminal pressure, and at the same time, generates a decrease of blood perfusion that triggers ischemia, gangrene and, finally perforation \[^{1}\].

The diagnosis of this pathology is clinical and has a variable accuracy between 71% -97%, according to the form of presentation and the experience of the attending physician \[^{6}\]. Currently, imaging techniques such as ultrasound and CT have substantially increased the precision in the diagnosis of atypical clinical pictures and are useful in the differential diagnosis of other pathologies. CT is considered the gold standard technique for the diagnosis of this entity with a high sensitivity (87-99%) and specificity (92-99%) \[^{2,5,6}\] as well as a high positive (96%) and negative predictive value (95%) \[^{3}\].

The main findings found in CT during an appendiceal process can be divided into 3 categories \[^{1,5-8}\]:

1. Appendicular changes
   a. Diameter> 6 mm
   b. Presence of appendicolith
   c. Thickening of the cecum wall> 2 mm
   d. Reinforcement of the wall after intravenous contrast
e. Submucosal edema or stratification which configures the sign of the “target”.

F. Alteration of perpendicularly fat

g. Liquid collection or periappendiceal abscess

h. Intraluminal gas

2. Apical cecal changes

a. Cecal focal thickening

b. Arrowhead sign

3. Inflammatory changes in the lower right quadrant of the abdomen

a. Distal focal thickening of the ileal wall

b. Focal thickening of the sigmoid wall

c. Locoregional adenopathies

d. Extraluminal gas

e. Visualization of abscess

F. Extraluminal appendicolith

An important aspect of the diagnosis of acute appendicitis is the identification of any associated complication, such as perforation. This occurs in 19-35% of cases and is associated with an increase in morbidity and mortality before and after surgery [1,7]. Is because of this that preoperative identification is important to select an appropriate therapeutic approach.
Findings and procedure details

Materials and methods

A descriptive cross-sectional study was carried out, designed by the department of radiology of the Sanatorio Finochietto. The population was defined as all patients with a clinical diagnosis of appendicitis who had CT of the abdomen and pelvis as an imaging study, and were taken to the operating room for treatment with subsequent anatomopathological (AP) evaluation from January 2016 to April 2017 (n = 37), excluding 3 patients for not having an AP report (n = 34). All the data were written in the patient's medical records. Authorization was requested from the corresponding sanitary authorities, ensuring the complete confidentiality of patient data.

We included 34 patients in the study with clinical and imaging diagnosis of acute appendicitis: 50% of the female gender and 50% of the male gender. All patients were adults since the care center does not attend pediatric patients. The average age was 38 years and the age distribution is shown in Fig. 1 on page 8.

Computed tomography was performed with Multislice equipment of 16 rows of detectors, with axial acquisition in supine position and cranial-caudal direction of the abdomen and pelvis, with subsequent multiplanar reconstructions. Intravenous non-ionic iodine contrast (320 mg/dl) was administered, except in case of contraindication. The images were acquired in portal venous phase with a delay of 70 seconds. In general, oral contrast was used, except in cases that the specialist in general surgery contraindicated. All patients signed informed consent for intravenous contrast administration.

The studies were interpreted by the Staff of Radiological Physicians of the Sanatorium. Subsequently, the findings were categorized according to the anatomopathological grading of appendicitis and its visual and imaging correlation by tomography, selecting the most representative images of each group, as detailed below:\[2,5,9,10]\:

- Edematous or congestive Appendicitis: occurs due to obstruction of the appendiceal lumen, and accumulation of mucous secretion with distension of the appendix. This leads to an increase in intraluminal pressure, with venous obstruction, bacterial accumulation and reaction of the lymphoid tissue, which infiltrates the superficial layers. Macroscopically it translates into edema and congestion of the serosa. Images shows the appendix with liquid content greater than 6 mm in diameter, thickened wall (> 2
mm) with reinforcement after intravenous contrast, minimal stranding of periappendiceal fat (Fig. 2 on page 8).

- Phlegmonous or Suppurated Appendicitis: The mucosa presents small ulcerations, with greater bacterial growth, mucus-purulent exudate and infiltration of neutrophils and eosinophils in all the tunics. The serosa is intensely congested, edematous, reddish in color and with fibrino-purulent exudate on its surface; although there is still no perforation of the wall, extension of the intraluminal content can occur towards the free cavity. CT shows an appendix with a liquid content greater than 6 mm in diameter, a wall with greater thickening without much reinforcement due to edema, and an important stranding of periappendiceal fat, as well as incipient inflammatory changes of adjacent organs (Fig. 3 on page 9, Fig. 4 on page 9).

- Gangrenous or Necrotized appendicitis: When the phlegmonous process is too intense, anoxia of the tissues is produced, this in addition to the increased anaerobic bacterial growth, and the obstruction of the arterial blood flow, finally leads to a complete necrosis of the organ. The surface of the appendix presents areas colored purple, grayish green or dark red, with micro perforations, increase of the peritoneal fluid, which can be dimly purulent, and with a fecaloid odor. CT showed greater appendiceal diameter, intraluminal and periappendiceal liquid content, greater periappendiceal fat stranding, and greater inflammatory involvement of adjacent organs (Fig. 5 on page 9, Fig. 6 on page 10).

- Complicated appendicitis (Perforated): occurs when small perforations become larger, usually on the antimesenteric border and adjacent to a fecalith, the peritoneal fluid becomes frankly purulent and foul-smelling (peritonitis). Imageologically, focal defects in the appendiceal wall, extraluminal gas, the presence of extraluminal appendicolith, periappendiceal abscess formation, and the adjacent inflammatory changes are more extensive (Fig. 7 on page 10, Fig. 8 on page 11, Fig. 9 on page 11).

Subsequently, the findings described above were compared with the surgical and the anatopathological report.

Results

The main appendiceal position found was retrocecal in 47% of the patients (Fig. 10 on page 12). Appendicoliths were found in 56% of the cases. According to the criteria established for the grades of appendiceal disease by tomography, 2 cases of edematous appendicitis, 15 cases of flegmonose, 9 cases of gangrenous and 8 cases of complicated appendicitis were identified. These findings were compared with the surgical report and visual description of the findings and later with anatopathological reports. Finding
correct correlation in 73% of the cases vs the surgical report and of 71% for the case of the pathological anatomy (Fig. 11 on page 12).

Discussion

Appendiceal disease is found in all age groups \[1,2\]. CT and ultrasound are used for its evaluation, being the latter the preferred one for the initial evaluation of the pediatric population, using CT only when the diagnosis cannot be defined, in order to avoid radiation exposure as much as possible. \[1\]. It should also be noted that CT is the gold standard for the diagnosis of this pathology, since it allows the use of multiplanar reconstructions that improve the visualization of the appendix and the identification of the different findings \[5\], which is why it was the imaging method chosen to perform the categorization of the stages of said pathology. The patients were selected from our database and therefore no additional radiation exposures were made for the interpretation of the tomograms.

Through the different tomographic findings from our population, we were able to perform the grading of this pathology, based on what is described in the literature, allowing each of the stages to be categorized with a correct correlation of more than 70% with respect to direct visualization during the surgical act and later with the anatomopathological report. It should be noted that in several of the cases the surgical act was not immediate to the obtaining of the images, which supposes an evolution in the appendiceal process, and therefore a change in the grade could have occurred by the time of surgical intervention, reducing the percentage of correct correlation.

The differentiation of the grades of appendiceal disease through CT could provide important data to surgeons to establish a better approach for their treatment, although we must mention that the results of this study cannot be extrapolated to the pediatric population since our center of attention does not attend this age group. However, given the frequency of presentation in this population, a complementary study that includes it is suggested.
Fig. 1: Age of presentation

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Fig. 2: 1,3: Appendix with thickening of its wall (3 mm) and enhancement after the administration of IV contrast, in addition it is evidenced a 7 mm diameter and subtle stranding of periappendicular fat. 2: An appendicolith at the base of the appendix can also be witnessed.

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**Fig. 3:** 4-6: Appendiceal appendicoliths with thickening of the appendix reaching 9 and 8 mm of diameter respectively. An alteration of the adjacent and pericecal fat is also visualized.

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**Fig. 4:** 7-8: Thickening of the appendix with fat stranding.

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**Fig. 5:** 9-11: Appendicular thickening, with periappendicular fluid and important stranding of the adjacent fat. Fat stranding in the pericecal and periintestinal region as well. Figure 9: A multiple appendicoliths.

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**Fig. 6:** 12-14: Appendicoliths and marked thickening of the appendix, with periappendicular fluid and important stranding of the surrounding fat.

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Fig. 7: 15-17: Appendiceal thickening with perforation in its wall and extraluminal air. A marked alteration of the adjacent fat with free peritoneal liquid is also evidenced.

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Fig. 8: 18-20: Appendiceal perforation with extraluminal appendicolith, periappendiceal abscess formation.

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Fig. 9: 21-23: Marked inflammatory changes with appendicular perforation, pneumoperitoneum, peritoneal fluid and abscess formation in the right iliac fossa.

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Fig. 10: Appendiceal position

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Fig. 11: CT correlation with Surgical and Anatomopathological visualization

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Conclusion

The tomography is the gold standard in the diagnosis of appendiceal disease. It allows to identify the position of the appendix and the results of this study suggests it can also help defining the severity of the disease by establishing the different grades in a non-invasive way, providing valuable data to surgeons for a better therapeutic approach that can be traduced in a shorter time of action and even in lower rate of complications.
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