

# We are IntechOpen, the world's leading publisher of Open Access books Built by scientists, for scientists

5,500

Open access books available

136,000

International authors and editors

170M

Downloads

Our authors are among the

154

Countries delivered to

TOP 1%

most cited scientists

12.2%

Contributors from top 500 universities



WEB OF SCIENCE™

Selection of our books indexed in the Book Citation Index  
in Web of Science™ Core Collection (BKCI)

Interested in publishing with us?  
Contact [book.department@intechopen.com](mailto:book.department@intechopen.com)

Numbers displayed above are based on latest data collected.  
For more information visit [www.intechopen.com](http://www.intechopen.com)



---

# Clinical Approach in the Diagnosis of Acute Appendicitis

---

Alfredo Alvarado

Additional information is available at the end of the chapter

---

## Abstract

Abdominal pain is the most common reason for consultation in the emergency department, and most of the times, its cause is an episode of acute appendicitis. However, the misdiagnosis rate of acute appendicitis is high due to the unusual presentation of the symptoms. Therefore, the clinician has to be very alert in order to establish a correct diagnosis.

**Keywords:** diagnosis of acute appendicitis, clinical approach, Alvarado score

---

## 1. Introduction

The lifetime risk of appendicitis is 8.6% for males and 6.7% for females with an overall prevalence of 7% worldwide. The incidence of acute appendicitis has been declining steadily since the late 1940s, and the current annual incidence is 10 cases per 100,000 population. In Asian and African countries, the incidence of acute appendicitis is probable lower because of the dietary habits of the inhabitants of these geographic areas. Dietary fiber is thought to decrease the viscosity of feces, decrease bowel transit time, and discourage formation of fecaliths, which predispose individuals to obstructions of the appendicular lumen [1].

## 2. Epidemiology

There is a slight male preponderance of 3:2 in teenagers and young adults. In adults, the incidence of appendicitis is approximately 1.4 times greater in men than in women. However,

many studies have demonstrated a preponderance of female over male patients. The incident of primary appendectomy is approximately equal in both sexes [1].

The incidence of appendicitis gradually rises from birth, peaks in the late teen years, and gradually declines in the geriatric years. The mean age when appendicitis occurs in the pediatric population is 6–10 years. Lymphoid hyperplasia is observed more often among infants and young adults and is responsible for the increased incidence of appendicitis in those age groups. Younger children have a higher rate of perforation, with reported rates of 50–85%. The median age of appendectomy is 22 years. Although rare, neonatal and even prenatal appendicitis have been reported. Therefore, clinicians must maintain a high index of suspicion in all age groups [1]. According to Buckius et al. [2], in the USA the annual rate (per 10,000 population) of all cases of appendicitis and appendectomy increased from 7.62 in 1993 to 9.38 in 2008 and since then remained stable at 9.4 cases per 10,000. However, the ratio of simple appendectomy to complex cases has increased at extreme ages (0–9 and over 40 years). But in general, there is a trend in the percentage of complex cases that are decreasing from 33.4% in 1993 to 27% in 2008.

### 3. Etiology

The etiology of acute appendicitis is not quite clear. The main theory is that obstruction of the lumen of the appendix is the cause of acute appendicitis [3]. Fecalith, normal stool, and lymphoid hyperplasia are the main causes for obstruction. Obstruction probably plays a key role in the progression of appendicitis, but evidence for fecaliths as the most common cause of uncomplicated appendicitis is weak. Overall, fecaliths were found in 18.1% of appendicitis specimens and 28.6% of negative appendectomies. Fecaliths were associated with perforation more often than with uncomplicated appendicitis, and fecaliths are more common in pediatric cases than in adult appendicitis, independent of perforation [4].

### 4. Pathophysiology

The lumen distal to the obstruction starts to fill with mucus and acts as closed loop obstruction. This leads to distension and an increase in the intraluminal and intramural pressure. As the condition progresses, the resident bacteria in the appendix rapidly multiply [3]. Distension of the lumen of the appendix causes reflex anorexia, nausea and vomiting, and visceral pain. As the pressure of the lumen exceeds the venous pressure, the small venules and capillaries become thrombosed, but arterioles remain open, which lead to engorgement and congestion of the appendix. The inflammatory process soon involves the serosa of the appendix, hence the parietal peritoneum in the region, which causes classical right lower quadrant (RLQ) pain. Once the small arterioles are thrombosed, the area at the antimesenteric border becomes ischemic, and infarction and perforation ensue. Bacteria leak out through the dying walls, and pus forms within and around the appendix. Perforations are usually seen just beyond the obstruction rather than at the tip of the appendix [3].

## 5. Diagnosis

The diagnosis of acute appendicitis is based on the history, physical examination, and laboratory investigation, as in any other disease [5]. Graff et al. [6] found that patients whose diagnosis was initially missed by the physician had fewer signs and symptoms of appendicitis than in patients who had more signs and symptoms initially. Older patients (>40 years old) had more false-negative decisions and a higher risk of perforation or abscess. On the other hand, false-positive decisions were made for patients who had signs and symptoms similar to those of appendicitis patients. They also found no increase in the perforation or abscess rate if the hospital delay was less than 20 hours. The normal appendix rate decreased from 15% to 1.9% after implementing an observation program, with no increase in perforation rate (26.7% before and 27.5% after).

The overall accuracy for diagnosing acute appendicitis is approximately 80% with a false-negative appendectomy rate of 20%. Diagnostic accuracy varies by sex, with a range of 78–92% in males and 58–85% in female patients. The morbidity from appendectomy showed steady improvement until 1962. Since that date, there has been a statistically significant rise of morbidity reaching rates as high as 29%, but in the developing world, the rate is significantly higher [7]. Kong et al. reported a 60% perforation with a median duration from onset of symptoms of 4 days and an overall mortality of 1% [8]. Younger children have a higher rate of perforation with reported rates of 50–80%.

## 6. Medical history

The immediate history prior to the onset of pain is very important because frequently there is a history of indigestion, gastritis, or flatulence for a few days prior to the onset of pain. A history of unusual irregularity of the bowels is often obtained. Sometimes there is constipation, at other times diarrhea, especially in children [9].

Normally, appendicitis presents with highly characteristic sequence of symptoms and signs. Initially, appendicitis causes visceral pain poorly localized to the epigastrium or periumbilical region, presumably because of distension of the appendix. Anorexia, nausea, and vomiting soon follow as the pathology worsens. More advanced inflammation causes irritation of adjacent structures or the peritoneum, low-grade fever, and peritoneal pain localized in the right lower quadrant (RLQ). Pain usually occurs before vomiting, and the patient has usually not experienced similar symptoms before the present episode [10].

## 7. Family history

A careful family history should be obtained for every child in whom acute appendicitis is suspected [11]. A positive family history of acute appendicitis increases the risk by 3.18 times

in a patient with acute abdominal pain, and the chance of appendicitis is 10 times greater in a child with at least one relative with reported appendicitis [12]. Retrocecal appendicitis has been reported in members of the same family in various countries [13]. Shperber et al. reported four members of the same family operated on for acute retrocecal appendicitis. In all four cases, there was pain or tenderness in the right lower quadrant of the abdomen accompanied by fever and leukocytosis. All of these cases support the hypothesis that a hereditary factor may be involved in the pathogenesis of acute appendicitis.

Therefore, a family history of acute appendicitis is an important factor to be taken into consideration during the medical interview [14]. Ethnic and geographical variations have been reported regarding the position of the appendix, and this variable anatomy may pose a challenge during appendectomy because it may necessitate extension of a transverse incision or additional muscle splitting [15].

## 8. Physical examination

The patient usually has a low-grade fever ( $<38^{\circ}\text{C}$ ) with associated tachycardia and appears flushed and with a dry tongue and fetor oris. The patient often lies still as movement and coughing exacerbate the pain. In children the hop test has been advocated as a test to confirm appendicitis. The child is asked to hop but refuses as this causes pain [15].

Before examining the abdomen, it is well to learn from the patient the exact place where the pain started, and if have been an alteration in its location. The exact location of maximal pain should be pointed out at the time of examination. Inspection of the abdomen will reveal at a glance any abnormal local or general distension and will in some cases determine the presence of a tumor or abdominal swelling. All the hernia orifices must be inspected as a routine and special attention directed to the femoral canal, where, in a fat subject, a small hernia is easy to overlook [9].

## 9. Symptoms and clinical signs

In an international systematical review of appendicitis scores, Ying-lie [16] found that the most common features are elevated white blood count (WBC), right lower quadrant pain tenderness, combination of anorexia, nausea or vomiting, rebound tenderness, and migration of pain to the right lower quadrant. In 21 studies after 2000, polymorphonuclear leukocyte count (PMNC) was also relevant, and five studies included C-reactive protein (CRP).

Abdominal pain is the primary presenting complaint of patients with acute appendicitis. The diagnostic sequence of colicky central abdominal pain followed by vomiting with migration to the right iliac fossa is present in only 50% of patients. Loss of appetite is often a predominant feature. Constipation and nausea with profuse vomiting may indicate development of generalized peritonitis after perforation but is rarely a major feature in simple appendicitis. Male

patients with a retrocecal appendix may complain of right testicular pain, and in some cases, in children, inflammation of the right scrotal area is present [17].

Migration of pain from the epigastric region or periumbilical area to the right lower quadrant, also known as the Volkovich-Kocher sign, is an important symptom at the beginning of the disease.

Right lower quadrant tenderness is the most common clinical sign which occurs in a great majority of patients with acute appendicitis. It has an 85% sensitivity and a 90% specificity with a positive likelihood ratio of 7.3:8.0 and a negative likelihood of 0:0.26.

Rebound pain (Blumberg sign) is one of the most useful signs of acute appendicitis in children even if it is sometimes difficult to elicit it, but with some practice and patience, it is possible to obtain a positive result. It is for this reason that some clinicians have proposed similar signs to replace rebound pain. For instance, Samuel [18] in his PAS score replaced cough, percussion tenderness, and hopping tenderness for rebound pain. Elevation of temperature ( $37.3^{\circ}\text{C}$ ), not fever, is present in the early stages of acute appendicitis, and in the late stages, it will progress into fever with temperatures above  $37.7^{\circ}\text{C}$ . Usually the increase of the temperature will run parallel to leukocytosis.

## 10. Other indirect signs of rebound pain

Rovsing sign is related to the rebound tenderness test and has to do with peritoneal irritation. The cough test, described by Rostovzev, known also as the Dunphy's sign, has a near-perfect sensitivity with a specificity of 95% for the detection of acute appendicitis. The Markle test (heel drop jarring) [19], pain on walking, pain with jolts, or bumps in the road are also signs of peritoneal irritation.

## 11. Uncommon tests in acute appendicitis

Psoas sign or Obraztsova's sign or the Cope's psoas test has a very low sensitivity (16%) but a good specificity (96%) and is present in retrocecal and pelvic appendix. It is elicited with the patient in the supine position, asking the patient to lift the right thigh against the examiner's hand placed just above the knee. Alternatively, with the patient in the left lateral decubitus position, the examiner extends the patient's right leg at the hip. Increased pain with either maneuver constitutes a positive sign [15].

According to Cope [9], the irritation and reflex rigidity of the iliopsoas muscle frequently cause the patient to hold the right thigh flexed, or with a lesser degree of irritation, the pain may be felt if the right thigh be fully extended as the patient lies on the left side. This sign is often of great value. The perforated pelvic appendix is one of the most easily overlooked and therefore one of the most dangerous conditions, which may occur in the abdomen. It is at least essential to diagnose the ruptured appendicitis as soon as possible after rupture before peritonitis has

extended too far upward into the abdominal cavity. Irritation of the bladder or rectum may be signified by frequency or pain during micturition or by diarrhea or tenesmus, respectively.

Obturator sign is similar to the psoas sign. It is elicited by passively flexing the right hip and knee and internally rotating the leg at the hip, stretching the obturator muscle. Resultant right-sided abdominal pain is a positive sign, indicating irritation of the obturator muscle [15]. When the ruptured appendix is adherent to the fascia covering the obturator internus muscle, rotation of the flexed thigh will cause hypogastric pain. In performing this maneuver, it is essential that the thigh be flexed so as to relax the psoas muscle [9].

Uncommon signs are related to cutaneous hyperesthesia such as the discomfort in the “Sherren’s” triangle (umbilicus-pubic tubercle-anterior superior iliac crest) in cases of early acute appendicitis. The Massouh sign [20] is a clinical sign for acute localized appendicitis that consists of swishing two finger tips starting on the xiphoid sternum down toward the left and right iliac fossae to elicit hyperesthesia due to peritoneal irritation. A positive sign is a grimace of the patient upon a right-sided (and not left) sweep. Also, lightly touching the patient with the stethoscope creates uncomfortable sensation on the affected area. These two tests can replace the migration symptom in children who cannot communicate well.

The K-sign has been named after its region of origin, Kashmir, and is present in retrocecal and paracolic appendicitis. It is elicited by percussion and palpation of the posterior abdominal wall and is present in patients of Indian ethnicity and coexists with the psoas sign. This sign is similar to the percussion test described in the MANTRELS score included in this chapter. The K-sign can lead to an early diagnosis of acute appendicitis localized in the retrocecal and retrocolic spaces [21].

The Hamburger sign is used for the diagnosis of appendicitis. The sign is used to rule out that disease, with the physician inquiring if the patient would like to consume his favorite food. If the patient wants to eat, the clinician should consider other diagnoses than appendicitis. This sign could replace the symptom of anorexia that is 80% sensitive for appendicitis [22].

## 12. Acute appendicitis in children

Appendicitis in children is the most common abdominal disease requiring surgery in this age group. The risk of developing appendicitis during a lifetime is reported to be 8.7% for boys and 6.7% for girls. Misdiagnosis rate ranges from 28–57% in 2- to 12-year-old children and approaches to nearly 100% in children younger than 2 years [23].

According to Almaramhy [23], in neonates (birth to 30 days), the most common clinical signs are abdominal distension, vomiting, palpable mass, irritability or lethargy, and cellulitis of the abdominal wall. In infants and toddlers (less than 5 years), the prominent symptoms are vomiting, pain, fever, and diarrhea. Other common symptoms are irritability, cough or rhinitis, grunting respiration, right hip mobility restriction, pain, and limping. On physical examination, a majority of infants (87–100%) have temperature higher than 37°C and diffuse abdominal tenderness (55–92%), whereas localized right lower quadrant tenderness is observed in less than 50% of the cases. Other noticeable signs are lethargy, abdominal distension, rigidity, and

abdominal or rectal mass. The delay in the diagnosis most often results in perforation (82–92%) and bowel obstruction (82%).

In order to improve the diagnosis of acute appendicitis in children, two clinical scores have been validated. The Alvarado score (AS) [24] and the Pediatric Appendicitis Score (PAS) [18] were validated in a prospective study by Pogorelic et al. [25] finding that ROC curves gave an area under the curve (AUC) of 0.74 for the AS and 0.73 for the PAS score. They also found a negative appendectomy rate of 14.8% which in the medical literature ranges between 10 and 30%.

In other prospective validation study of the Pediatric Appendicitis score, Goldman et al. [26] found that the PAS score is valid for the diagnosis of acute appendicitis when the score was 7 or greater and for the exclusion of appendicitis when the score was 2 or lower.

In a systematic review, Ebell and Shinholser [27] found that the Alvarado score of 8 or higher rules in the diagnosis of acute appendicitis, whereas one of nine or higher rules in the diagnosis at pretest probabilities greater or equal to 40%. The Pediatric Appendicitis Score did not identify clinically useful low- or high-risk groups at typical pretest probabilities.

Bhatt et al. [28], in a prospective validation of the Pediatric Appendicitis Score in Canada, found that using the ROC curve, the AUC was 0.859. Using a cut point of 5 or less, the score was very sensitive (92.8%) but not very specific (69.3%). They concluded that the PAS is a useful tool in the evaluation of children with possible appendicitis. Scores of 4 or less help rule out appendicitis, while scores of 8 or more help predict appendicitis. Patients with a score of 6–7 may need further evaluation.

Salo et al. [29], in an evaluation of the Pediatric Appendicitis Score in younger and older children, found that younger patients showed a significant inflammation (gangrenous, perforated appendicitis, and appendiceal abscesses) in 75% of cases in comparison to 33.3% in older children. The rate of negative appendectomies was higher among younger children (15.0%) than the older children (6.9%), but not significantly different. Their conclusion was that the PAS scoring system turned out to be a weak tool in diagnosing appendicitis in children, especially in young children.

Yang et al. [30], in a prospective study to evaluate the accuracy of diagnosing appendicitis using the Alvarado score in children, found that from 105 operated patients, 93 (87.6%) were diagnosed with acute appendicitis with an erroneous rate of 12.4%. With an Alvarado score of 6 or greater, the sensitivity and specificity were 86.4 and 80%, respectively. They concluded that the Alvarado score is a noninvasive, safe diagnostic method, which is simple, reliable, and repeatable.

Chisalau et al. [31] conducted a retrospective study in 572 children that underwent surgery for acute appendicitis using the Alvarado score. They found that 16.3% had a negative appendectomy, and that almost all patients with a high score confirmed the diagnosis after surgical intervention. They concluded that the Alvarado score can be a very useful instrument for diagnosing acute appendicitis in early stages of the disease, especially when the score is below 4 or above 8.

Borges et al. [32] carried out a validation study of the Alvarado score in children and teenagers in Brazil. They found that with a cutoff point of 5 or more, a sensitivity of 92.6% and a specificity of 63.0% were obtained. With the same cutoff, the positive predictive value (PPV)

was 86.2%, and a negative predictive value was 77.8%. The rate of complicated appendicitis was high in this study. They concluded that the Alvarado score with a cutoff point of 5 or more is a valuable tool in screening children and adolescents for the diagnosis of acute appendicitis.

In an evaluation of the Alvarado score as a diagnostic tool for the diagnosis of appendicitis in children, Heineman and Drake [33] found that a cutoff of 5 appears to be fairly sensitive. They recommended imaging studies on a routine basis for children with a score of 5–7, preferably first ultrasound and only followed by CT scan, if negative, to avoid unnecessary radiation exposure.

Schneider, Kharbanda, and Bachur [34], in a study of 588 children aged 3–21 years, found that the Alvarado score of 7 or greater gave the following results: sensitivity 72%, specificity 81%, PPV 65%, and NPV 85%. This compares with the Samuel score of 6 or greater with the following results: sensitivity 82%, specificity 65%, PPV 58%, and NPV 89%. When the analysis was limited to patients younger than 10 years, the anterior figures did not change dramatically. In this group the area under the curve (AUC) was very similar, 0.83 for the Alvarado score and 0.81 for the Samuel score. In conclusion they found that the Alvarado and Samuel scores provide measurably useful diagnostic information in evaluating children with suspected appendicitis. However, neither method provides sufficiently PPV to be used in clinical practice as a sole method for determination of the need of surgery.

In a systematic review and meta-analysis that included emergency department point-of-care ultrasound (ED-POCUS) and the Pediatric Appendicitis Score (PAS), Benabbas et al. [35] studied two groups of patients: one of “undifferentiated abdominal pain” and another one of “suspected acute appendicitis.” In the first group, they included patients with history of pain migration to the right lower quadrant, cough/hop pain, and Rovsing sign pain. For the PAS of 9 or more, the Rovsing sign was the most associated one with acute appendicitis. None of the history, physical examination, laboratory tests, or PAS alone could rule out acute appendicitis in both groups. Using their test-treatment threshold model, positive ED-POCUS could rule in acute appendicitis without the use of CT and MRI, but negative ED-POCUS could not rule out acute appendicitis.

Peyvasteh et al. [36], in a study of 400 children aged less than 12 years, found that anorexia, nausea and vomiting, and rebound tenderness were significantly more common in children with positive appendectomy in contrast to patients with negative appendectomy. Sensitivity and specificity were 91.3 and 38.4%, respectively, and positive predictive value and negative predictive value were 87.7 and 51%, respectively. In children with a modified Alvarado score of more than 7, they found a positive appendectomy of 100% and a negative appendectomy of 15.8%. They concluded that the Modified Alvarado score has high sensitivity but low specificity for diagnosis of acute appendicitis. However, in their study all children with a score of 7 or more had appendicitis according to the pathology report.

### **13. Acute appendicitis in pregnancy**

Acute appendicitis is the commonest non-obstetric surgical emergency during pregnancy, and it may be associated to serious maternal and fetal complications. It occurs in about 1:500–635

pregnancies per year and is more often in the second trimester. Classically, patients describe the appearance of abdominal pain as the first symptom. It begins with periumbilical pain, which then migrates to the right lower quadrant to the extent that the inflammation progresses. Anorexia, nausea, and vomiting, if present, appear after the pain. Fever of up to 38.3°C and leukocytosis may subsequently develop. A pelvic appendix can cause sensitivity below the McBurney's point and other complaints such as an increase in urinary frequency and dysuria or rectal symptoms, such as tenderness, which can confuse the examiner and delay the diagnosis [37]. Microscopic hematuria and leukocyturia may occur when the inflamed appendix is located near the bladder or ureter, but these results are reported in less than 20% of patients. Slight increases in the total serum bilirubin have been described as a marker for perforation of the appendix (70% sensitivity and 86% specificity). C-reactive protein also rises in appendicitis, but it is a nonspecific sign of inflammation. About 80% of nonpregnant patients with appendicitis have preoperative leukocytosis of over 10,000 cells/mL with a left shift. However, mild leukocytosis may be a normal finding in pregnant women in whom the total leukocyte count can reach 16,900 cells in the third trimester, rising to levels around 29,000/mL during labor including slight left shift [37].

Aggenbach et al., in a review of records of 21 pregnant patients suspected of acute appendicitis and subjected to appendectomy, found that 71% had histologically proven appendicitis of whom 43% had non-perforated appendicitis and 29% had perforated appendicitis. The negative appendectomy rate was 29%. The most frequent symptom was pain located in the right lower quadrant (95%). Other common presenting symptoms were nausea (90%), vomiting (48%), and loss of appetite (48%). A classical history of periumbilical pain migrating to the right lower quadrant occurred in 48% of whom two turned out to have a normal appendix. Upon physical examination, right lower quadrant abdominal pain or diffuse abdominal tenderness was seen in the majority of the population, and rebound tenderness was present in 67% of cases. None of the women showed signs of involuntary guarding. Three of 15 women with histologically confirmed appendicitis developed fever (20%). Infection markers such as leukocyte count and C-reactive protein were not significantly raised in pregnant women with appendicitis compared to pregnant women with normal appendix. Of note is that an elevated C-reactive protein ( $\geq 10$  m/L) was seen in four out of nine pregnant women with non-perforated appendicitis. Three patients with perforated appendicitis generally did not look well. There was no case of fetal demise in this series of 21 patients. In this study, delay in treatment was associated with higher rate of maternal and fetal complications [38].

Tamir et al. found that perforated appendicitis occurred in 43% of patients who had symptoms exceeding 24 hours ( $p < 0.0005$ ). Therefore, establishing the diagnosis of appendicitis accurately and promptly is of utmost importance. The diagnosis of acute appendicitis during pregnancy remains based in upon the combination of history, physical examination, laboratory results, and ultrasonography [39].

Bhandari et al. [40], in a retrospective review of 56 pregnant patients and 164 nonpregnant patients who underwent open appendectomy, reported a negative appendectomy of 21.3% and a perforation rate of 25% in both groups. No maternal or fetal mortality was observed in spite of the high rate of perforation and high rate of complications.

## 14. Acute appendicitis in the old age

Acute appendicitis, the most common cause of abdominal surgical emergency, shows a different pathogenesis, clinical course, and outcome in the elderly. Age-specific factors are effective on preoperative clinical diagnosis and on the stage of this infectious disease.

Gürleyik G and Gürleyik E studied a series of elderly patients, 50 years of age or older, who were subjected to appendectomy. In a group of 109 older patients, they found that the perforation rate was significantly higher than in pediatric and adult patients. The proportion of the elderly among perforated cases was significantly increased when compared with non-perforated cases (12.9% vs. 2.9%). Postoperative morbidity was noted in 73.8% of perforated and in 11.9% of non-perforated cases with an overall morbidity of 35.9%. The mortality rate was 11.9% in patients with perforation and 1.5% in patients with non-perforated appendicitis. The overall mortality was 5.5%, and no mortality was seen in patients younger than 50 years [41].

Bush et al., in a study of 1,827 adult over 65-year-old patients, who were subjected to open or laparoscopic appendectomy in Swiss hospitals, found that a delay of 12 hours or more was associated with a significant higher frequency of perforated appendicitis (29.7%) than a delay of less than 12 hours. Perforation was associated with higher reintervention rate and increased length of hospital stay [42].

Shchatsko et al., in a retrospective chart review of patients over 65 years old and who were diagnosed with acute appendicitis, found that right lower quadrant tenderness (97.6%), left shift of neutrophils (91.5%), and leukocytosis (84.1%) were the most common symptoms on presentation. This data suggests that altering the interpretation of the Alvarado score to classify elderly patients presenting with a score of 5 or more since a high risk may lead to an earlier diagnosis [43].

Omari et al., in a study of acute appendicitis in the elderly, found that all patients were complaining of abdominal pain. However, the typical migratory pain was described only by 47% of patients, 59% in patients with non-perforated appendix, and 30% in patients with perforated appendix. Anorexia was present in 74% of all patients, but it could not differentiate perforated from non-perforated groups. Nausea and vomiting were present in 57% of patients and were more significantly in the non-perforated group. Of all patients, 41% were febrile at presentation ( $>38^{\circ}\text{C}$ ), and fever was seen more in the perforated group. Localized tenderness in the right lower abdomen was present in 84% of all patients with 91% in the non-perforated compared with 75% in the perforated group. Although rebound tenderness was found in 75% of the patients, it did not differentiate between both groups. Increased WBC count ( $>10,000/\text{mm}^3$ ) was seen in 63% of all patients at presentation. In the perforated group, 71% of patients had high WBC count associated with 94% shift to the left, compared to 57% patients associated with 61% shift to the left in the non-perforated group. There were six deaths, four in the perforated and two in the nonperforated group [44]. In this study it is interesting to observe that the variables used are exactly the same variables used in the MANTRELS score of Alvarado.

## 15. Acute appendicitis in developing countries

In developing countries, where there are no facilities to do imaging studies such as abdominal ultrasound or contrast enhanced CT examination in patients suspected of acute appendicitis, the decision to operate depends on clinical grounds.

Madiwa et al., in a retrospective study of black patients in South Africa, showed that appendicitis is twice as common in males as in females and that it occurs predominantly in young people (median age 20 years). The classical presentation of periumbilical pain (16%) was outnumbered by right iliac fossa pain (36%) and nonspecific pain (27%). The majority was perforated (43%), and appendiceal inflammation was the second commonest (37%). The negative appendectomy rate was 8.8%, with a diagnostic error of 14%. Mortality was 2% mainly from patients complicated with peritonitis [45].

Kong et al., in a retrospective study undertaken in South Africa, found that 60% of patients had a perforated appendicitis. Of 599 patients with perforation, 181 (30%) were associated with localized intraabdominal contamination, and the remaining 418 (70%) were associated with generalized intraabdominal sepsis. The median duration from onset of symptoms to first contact with the health care system was 4 days. A third (32%) of patients described a migratory pattern of abdominal pain, and the remaining two thirds (68%) had nonmigratory, nonspecific abdominal pain. Median temperature was 37.5°C; the median heart rate was 101 bpm, and the median leukocyte count was 14,500 cells/mm<sup>3</sup>. Other clinical symptoms were nausea/vomiting (79%) and anorexia (58%). They concluded that acute appendicitis in South Africa is a serious disease associated with significant morbidity and with a mortality of 1–2%. Complications associated with appendiceal perforation far exceeded those reported in the developed world. Late presentation is common, with female rural patients suffering the worse clinical outcomes. The cost to the health system is substantial [8].

Abdelahim et al., in a prospective study of adult patients with suspected appendicitis in Sudan, divided these patients in three groups: group 1 with an Alvarado score of 1–3, group 2 with a score of 4–6, and group 3 with a score of 7–10. They found that all patients with an Alvarado score of 7 or above have positive surgical appendicitis. At a cutoff point of 3, the Alvarado score was found to be accurate to rule out acute appendicitis. A negative appendectomy was found in 7.1%, all below 7 of the score, while 37% of patients had a complicated appendectomy with a score of 7 or above [46].

Markar et al. carried out a study to compare management approaches and clinical outcomes of acute appendicitis in Sri Lanka (SL) and the United Kingdom (UK). They found that ultrasound studies were more common in Sri Lanka patients and CT more common in UK patients. More patients underwent open appendectomy in SL group, and laparoscopic approach was utilized more often in the UK group (50.5% vs. 11.9%). Postoperative complications were similarly represented in both groups, but readmissions occurred with greater frequency in the UK group (16.2% vs. 0%). Histological-confirmed appendicitis was seen in a significant proportion of SL patients (93.1% vs. 79.8%). They concluded that methods such as CT do not appear to improve the diagnostic accuracy of appendicitis or prevent complications [47].

Ali and Aliyu, in a retrospective study of 1257 patients, in Nigeria, found a male-to-female ratio of 1:2 and a mean age of 32.4 years. The mean duration of illness was 72 hours. All the patients were admitted with abdominal pain, the majority with pain initially located at the right iliac fossa (38.2%), periumbilical pain (31.3%), and diffused in 27.9%. The most frequent symptoms were: vomiting 85.7%, fever 73.0%, and anorexia 49.9%. Right iliac fossa pain and tenderness were present in 88.46%. The perforation rate was high (23.47%), and the negative appendectomy was 15.9%. Mortality rate was 0.9% [48].

Arfa et al., in a prospective study of 205 patients with acute abdominal pain in the right iliac fossa, found a male-to-female ratio of 0.7:1 and a mean age of 27 years. They classified the patients in three groups: those who had an emergency appendectomy, those who had surgery after an observation period, and those discharged without appendectomy after observation. In the first group of 110 patients, 63% had a rectal temperature greater than 38°C; 44% had guarding of the RIF and 87% elevated white blood counts above 10,000 cells/mm<sup>3</sup>. At surgery, appendicitis was diagnosed in 92%. After a mean delay of 36 hours of observation, 50 patients in the second group underwent surgery: 44% had a rectal temperature above 38°C, RIF guarding in 8%, and elevated white blood count above 10,000 cells/mm<sup>3</sup> in 74%. In this group, 94% were diagnosed with appendicitis during surgery. Forty-five patients were discharged without surgery after 36 hours of observation. They concluded that pain and RIF guarding, associated with temperature greater than 38°C, and elevated WBC counts, were predictive of acute appendicitis in 96% of cases. Admission for observation of patients with atypical presentation avoided 45 unnecessary appendectomies [49].

Zognéreh et al., in a retrospective study to analyze clinical, paraclinical, and therapeutic aspects of acute appendicitis in Central Africa Republic, found an incidence of appendectomy in Bangui of 36 per 100,000 inhabitants. These cases of appendicitis were diagnosed essentially on clinical grounds. Leukocyte counts exceeded 10,000 cells/mm<sup>3</sup> in 30% of patients. Histological examination revealed the presence of parasites in 10 cases: *Schistosoma mansoni* eggs, seven cases; *Ascaris lumbricoides* eggs, one case; and combination of these parasites, two cases. Most of patients consulted late, a mean of 4 days, after onset of symptoms. The mortality rate was high, 3.5% partially due to lateness of consultation and because patients in tropical Africa often consult a traditional healer before resorting to modern medicine and also partially from misdiagnosis [50].

Fashima et al., in a prospective study of 250 cases of acute appendicitis in Lagos, Nigeria, found a male-to-female ratio of 1.2:1 with a mean age of 27.7 years and with the majority of cases (42.8%) occurring in the third decade of life. Abdominal pain (100%), fever (48.4%), anorexia (48%), and vomiting (47.8%) were the common symptoms. Commonly elicited signs included right iliac fossa direct tenderness (74.4%), rebound tenderness (59.2%), localized guarding (42.8%), and rectal tenderness (43.2%). The mean white cell count was not significantly elevated (mean 8.538 cell/mm<sup>3</sup>). In 63% the appendices were retrocecal with a mean length 10.4 cm. The commonest postoperative complication was wound infection (8%); overall complication rate was 13.5% and a negative appendectomy rate 13.4% [51]. (It is interesting to note the incongruency between the high incidence of rectal tenderness and the high incidence of retrocecal appendices.)

Tade, in Nigeria, carried out a prospective study of 100 consecutive patients who presented to the emergency department with right iliac fossa pain and suspected diagnosis of acute appendicitis. These patients were assessed using the Alvarado score. He found a male-to-female ratio of 1.7:1 and a mean age of 34 years. Of the 100 patients under the study, 38 had appendectomy, and four of these had a normal appendix (19.5%), and seven patients had a perforated appendix (18.4%). Forty-four patients had scores less than 5; they were admitted, and none of them required surgery. Twenty-four patients had appendicitis. The specificity and positive predictive value reached 100% with a score of 10. Sensitivity and negative predictive values reached 100% at scores below 5, indicating that these patients did not have appendicitis [52].

Giiti et al. performed a cross-sectional study in northwest Tanzania, involving 199 patients undergoing appendectomy. In this group they found that 26 patients (13.1%) were HIV-seropositive with a significant older age (mean 38.4 years) than the HIV seronegative population (mean 25.3 years). Leukocytosis was present in 87% of seronegative patients as compared to 34% in seropositive patients. Peritonitis was significantly more frequent among HIV-positives (34% vs. 2%). Also, 11.5% of HIV patients developed surgical site infections, as compared to 0.6% in the HIV-negative group [53].

## 16. Differential diagnosis in acute appendicitis

In general, when the diagnosis of acute appendicitis is not clear, the clinician has to take into consideration other diagnostic possibilities, and the best form to do it is to assess the patient according to the anatomical location of the pain or tenderness. In this case, the abdomen is divided into four quadrants [54].

If the pain or tenderness is localized in the right upper quadrant, the most probable causes are cholecystitis, biliary colic, cholangitis, hepatitis, hepatic abscess, pancreatitis, peptic ulcer, retrocecal appendicitis, appendicitis during pregnancy, intestinal obstruction, inflammatory bowel disease, and pneumonia.

If the pain is localized in the left upper quadrant, the most probable causes are gastritis, peptic ulcer, pancreatitis, splenomegaly, splenic rupture, intestinal obstruction, inflammatory bowel disease, diverticulitis of the splenic flexure, appendicitis, pneumonia, myocardial ischemia or infarction, and pericarditis.

If the pain is localized in the right lower quadrant, the most probable causes are appendicitis, stump appendicitis, inflammatory bowel disease, diverticulitis (cecal, Merkel's), mesenteric adenitis, intestinal obstruction, hernia, ectopic pregnancy, salpingitis, ovarian cyst, mittelschmerz, nephrolithiasis, pyelonephritis, and ureteral calculus.

If the pain is localized in the left lower quadrant, the most probable causes are colon diverticulitis, appendicitis, intestinal obstruction, inflammatory bowel disease, ischemic colitis, hernia, ectopic pregnancy, salpingitis, ovarian torsion, ruptured ovarian cyst, mittelschmerz, nephrolithiasis, pyelonephritis, and ureteral calculus.

Other probable causes of abdominal pain or tenderness are pneumonia, myocardial ischemia or infarction, pericarditis, gastritis, peptic ulcer, enteritis, colitis, mesenteric thrombosis or ischemia, ruptured abdominal aorta or aneurism, typhoid enteritis, abdominal tuberculosis, parasitic infections, cystitis, epiploic appendagitis, intussusception of the appendix, abdominal cystic lymphangioma, dengue fever, localized pseudomembranous colitis, hemorrhagic omental torsion, and herpes zoster (initial stage).

## 17. Effect of time on risk of perforation in acute appendicitis

Papaziogas et al. carried out a study to quantify the role of time between symptoms' onset and surgery on the changing risk of appendicitis perforation and to evaluate the possible factors leading to the operation. The relative risk of perforation was calculated according to the "time-table method." Time was divided into intervals, initially 12 hours and, later on, 24 hours. They found that 18 of 169 patients had perforated appendicitis. The time from symptom onset to the first examination was longer for patients with perforation than without ( $p = 0.047$ ). On the other hand, the time from initial examination in the emergency department to the operating room showed no statistical difference between patients with rupture and those without. The risk of perforation was negligible within the first 12 hours of untreated symptoms but increased to 8% within the first 24 hours. Their conclusion was that surgeons should be mindful of delaying surgery beyond 24 hours of symptom onset in patients with assumed appendicitis [55].

Bickell et al. found that for patients with untreated symptoms beyond 36 hours, the risk of rupture rose to and remained steady at 5% for each ensuing period of 12 hours. They also found that patients sent for CT scan experienced longer times to operation (18.6 vs. 7.1 hours) [56].

Andersson mentioned that many studies have shown an association with higher proportion of negative appendectomies in patients with short delay. Early identification and treatment of perforated appendicitis is therefore important. In patients with equivocal diagnosis, active observation is a time-proven, safe, and simple management which gives an improved diagnostic accuracy [57].

## 18. Basic laboratory tests

The basic laboratory tests that are needed in the early diagnosis of acute appendicitis are just a few. These tests are available in the majority of the health facilities and do not take too much time to obtain the results. They are complete blood count (CBC) that includes a white blood count (WBC) with a differential count. The WBC is a good inflammatory marker that measures the quantitative changes of an inflammatory process and usually run parallel with the increasing temperature. The urinalysis determines if there is excessive number of red cells that could be related to an episode of ureteral calculus. It also may show acetonuria which may be related to anorexia and fasting state. In women of childbearing age, a pregnancy test used is in order

to rule out pregnancy. C-reactive protein (CRP) can be used in the late stages of acute appendicitis to confirm complicated appendicitis such as gangrene or perforation of the appendix.

## 19. Imaging studies

Under certain circumstances, imaging studies may be needed to achieve a correct diagnosis. Sometimes, the clinical presentation of the symptoms is atypical, and the signs and laboratory tests are inconclusive in the diagnosis of acute appendicitis, and in these cases, some imaging studies could be helpful.

Diagnosis of acute appendicitis is usually clinical and straightforward, and extensive investigations are unnecessary. However, a plain X-ray of the abdomen may help in the diagnosis particularly in young children, women of childbearing age, the elderly, and patients with systematic disease or who are immunosuppressed, in whom negative appendectomy and perforation rates are high [58].

The role of plain radiographs in the diagnosis of acute appendicitis has been reviewed in different studies. Many findings have been taken as evidence of appendiceal inflammation, including the presence of a fecalith, dilated sentinel loop of the ileum, ileal or cecal air-fluid levels on the erect film, widened preperitoneal fat line, haziness in the right lower quadrant, and blurring of the right psoas outline. Although plain radiographic findings on the erect or supine plain abdominal films may have an ancillary role in the diagnosis of acute appendicitis, they are neither sufficiently sensitive nor specific. Despite this, the role of plain abdominal radiographs will not become obsolete given the pragmatic difficulties in getting a CT scan as a first-line image and the risk of much greater radiation dose that a CT scan carries [59].

Aydin et al. found that plain abdominal X-ray in children provides useful information in the diagnosis of acute appendicitis and concluded that this test is an important tool not just for exclusion of other causes of pain but also for detection of appendicitis. Careful assessment of plain abdominal films in suspected appendicitis is encouraged in the case of unavailability out of hours of more widely accepted modalities (US, CT). In some cases, unnecessary delay of surgical intervention with a poor outcome may be prevented [60].

Petroianu et al. described the association and relevance of the image of fecal loading in the cecum, detected by plain abdominal X-ray, in patients with acute appendicitis. They studied 170 patients of both sexes who were admitted to the hospital with acute pain in the right flank. One group had plain abdominal X-rays done before surgical treatment, and another group had abdominal plain X-rays done before the surgical procedure and also the following day. They found that the radiographic sign of fecal loading in the cecum of patients with abdominal pain is associated with acute appendicitis. The image usually becomes undetectable shortly after appendix removal. The radiographic sign was present in all pediatric patients, including a 5-day-old premature newborn with perforated appendicitis. Only five of 170 patients without the radiographic sign presented acute appendicitis. This sign strongly supports the diagnosis of acute appendicitis when associated with indicative physical examination and laboratory findings [61].

## 20. Ultrasound studies

Acute appendicitis remains a clinical diagnosis, but when this diagnosis is uncertain, ultrasound (US) has been proven to be a helpful imaging modality in patient evaluation especially in children with suspicion of appendicitis. Graded compression US is the least expensive and less invasive method and has been reported to have an accuracy of 70–95%.

Toprak et al., in a study to investigate the integration of ultrasound (US) findings with the Alvarado score in diagnosing or excluding acute appendicitis, found that the diagnostic accuracy of US was as follows: sensitivity 93.1%, specificity 92.2%, positive predictive value 92.6%, negative predictive value 93.6%, and accuracy 92.6%. They also found that all patients with an Alvarado score greater than or equal to 7 had appendicitis proven by surgery and pathology. In the case of non-visualization of the appendix without a high Alvarado score, appendicitis can safely be ruled out. CT scan may be useful in children with moderate scores and equivocal findings [62].

The problem with ultrasound is that it was found to have an extremely variable accuracy in the diagnosis of acute appendicitis with a sensitivity range from 44 to 100% and a specificity range of 47 to 99%. Radiologist-operated ultrasound had inferior sensitivity and inferior positive predictive values when compared with a CT scan, though it was significant faster to perform and avoided the administration of contrast materials [63]. For this reason, “a first pass” approach using US first and then CT, if US is not diagnostic, would be desirable in some institutions [64–66]. Chiang found that clinical evaluation is still paramount to the management of patients with suspected acute appendicitis before considering medical imaging like ultrasonography or computed tomography [67]. Nevertheless, in cases of clinical doubt, ultrasonography may improve the diagnosis and reduce the negative laparotomy rate and can also be helpful in detecting periappendicular abscesses or gynecological diseases [68].

## 21. Computed tomography

In recent years, the routine use of computed tomography in the diagnosis of acute appendicitis has been highly controversial due to concerns related to the hazards of ionizing radiation and also about its overutilization in clear-cut clinical presentations. The use of CT scans of the abdomen exposes the patients to high dose of radiation which may be the equivalent of 400 chest X-rays, and this certainly will increase the risk for development of cancer or leukemia [69–71]. In a prospective randomized study of clinical assessment versus computed tomography for the diagnosis of acute appendicitis, Hong et al. found that clinical assessment, unaided by CT scan, reliably identify patients who needed operation for acute appendicitis, and they undergo surgery sooner, so the routine use of abdominal-pelvic CT is not warranted and computed tomography should not be considered the standard of care for the diagnosis of acute appendicitis [72].

Petrosian found that the overall negative appendectomy rate in patients with CT scan was similar to that in those without (6% for both groups) and that therefore preoperative CT scans did not decrease the negative appendectomy rate [73]. In another study, Lee found that neither CT nor US improves the diagnostic accuracy or the negative appendectomy rate; in fact, they may delay surgical consultation and appendectomy [74]. Using the Alvarado score to decide the need to perform a CT scan in cases of suspected acute appendicitis in the ED settings, McKay found that with a score of 4 to 6, an adjunctive CT scan would be recommended to confirm the diagnosis. If the Alvarado score is 7 or higher, a surgical consultation should be obtained. A computed tomography would be necessary in patients with an Alvarado score of 3 or lower [75]. In another study to compare the Alvarado and CT scan in the evaluation of suspected appendicitis, Tan revealed that CT scans are unnecessary in those patients with an AS of 9 or 10 and recommended that an evaluation by CT scan is of value mainly in patients with an Alvarado score of 6 or less in males and 8 or less in females [76].

## 22. Magnetic resonance imaging

In a systematic review and meta-analysis of diagnostic performance of MRI for evaluation of acute appendicitis, Duke et al. found that this test has a high accuracy for the diagnosis for a wide range of patients and may be acceptable for use as first-line diagnostic test [77].

Inci et al., in a study to assess the diagnostic value of unenhanced magnetic resonance imaging (MRI) in the diagnosis of acute appendicitis and compare with Alvarado scores and histological results, found that MRI is a valuable technique for detecting acute appendicitis even in the cases with low Alvarado scores [78].

Konrad et al. found that the sensitivity and specificity of MRI for acute appendicitis were 100 and 98%, respectively, as compared to 18 and 99%, respectively, with US. They suggested that at certain institutions, MRI may be considered a first-line imaging modality for pregnant patients of any gestational age with suspected appendicitis [79].

In a retrospective study designed to determine the utility of appendix MRI in evaluation of pediatric patients with right lower quadrant pain and inconclusive appendix sonography findings, Herliczek et al. found that the sensitivity and specificity of MRI for acute appendicitis in children with inconclusive findings were 100 and 96%, respectively. The positive predictive value for the examination was 83%, the negative predictive value was 100%, and the overall test accuracy was 97%. This proves that MRI may supplant CT as a secondary modality to follow inconclusive appendix sonography [80].

In relation to the safety of the use of MRI during the first trimester of pregnancy, Ray et al. found that there is no increased risk of harm to the fetus or to young children. However, Gadolinium-enhanced MRI in pregnancy was associated with increased risk of a broad set of rheumatological, inflammatory, or infiltrative skin conditions from birth and also for stillbirth or neonatal death [81].

### 23. Diagnostic laparoscopy

Diagnostic laparoscopy for suspected appendicitis is recommended for young women, the elderly, or other patients with unclear pathology because of its broader diagnostic ability and for obese patients due technical difficulties during open laparotomy. In one study the Alvarado score combined with selective laparoscopy gave a rate of 0% cases of negative appendectomy so this approach was recommended for widespread use in the management of suspected acute appendicitis [82].

The difficulty with laparoscopy for the diagnosis of acute appendicitis is that the negative appendectomy rate is higher than open appendectomy because of the absence of tactile feedback. Kraemer et al. found that the negative rates were 22% for laparoscopic appendectomy and 15% for open appendectomy. The role of diagnostic laparoscopy may be useful in a particular subgroup of patients but is not a substitute for good clinical judgment. Furthermore, it is not always necessary to perform an incidental appendectomy [83]. This statement is in conflict with the conclusion of Greason et al. who advised that incidental laparoscopic appendectomy is the preferred treatment option [84].

Strong et al. [85], in a multicenter study, suggested that surgeon's judgment of the intraoperative macroscopic appearance of the appendix is inaccurate and does not improve with seniority and therefore supports removal at the time of surgery. In this study 3326 patients underwent an appendectomy. Documentation of the histopathological specimen was missing in 134 cases, and 34 had no surgeon opinion recorded, leaving 3138 patients for final analysis. Of these patients, 60.5% underwent totally laparoscopic procedures, 32.6% open procedures and 7.0% laparoscopic converted laparoscopic procedures. The authors found that when surgeons assessed an appendix as normal ( $n = 496$ ), subsequent histological assessment revealed pathology in 138 cases (27.8%). This included 114 patients with appendicitis and 24 patients with other diagnoses (11 worm infestations, five fibrous infiltrations, four carcinoid tumors, two cases of pelvic inflammatory disease within the appendix, one colorectal polyp, and one cecal diverticulum affecting the appendix). On the other hand, where the appendix was judged to be inflamed intraoperatively ( $n = 2642$ ), pathological assessment revealed a normal appendix in 254 (9.6%). There was overall disagreement in 392 cases (12.5%), leading to only moderate agreement (Kappa 0.571).

Diagnostic laparoscopy and appendectomy for children with chronic right iliac fossa pain have been studied by Charlesworth and Mahomed. Their conclusion was that the literature supports laparoscopic appendectomy in all patients presenting with chronic right iliac fossa pain following negative radiological and serological investigations. Symptomatic improvement can be expected to be 88% immediately and up to 100% in the long term. However, in their study five normal appendices were removed out of 16 children that were subjected to diagnostic laparoscopy and appendectomy [86]. I think that in these cases, it could be a good idea to remove the distal third of the appendix and send it for a frozen section for histological examination during the procedure. In such a way, some of these cases could be spared from a negative appendectomy.

## 24. Unusual cases of acute appendicitis

### 24.1. Retrocecal appendix

Several unusual cases of acute appendicitis have been found in the medical literature mostly related to abnormal position of the appendix and ethnic variations. Although there is no significant association between retrocecal appendix and perforation [87–89], several cases of serious complications of retrocecal appendicitis have been reported.

Kim et al. [90] described the clinical presentation and computed tomographic features of ascending retrocecal appendicitis. The patients presented with right lower quadrant pain (49%), right flank pain (24%), right upper abdominal pain (18%), and periumbilical pain (15%). Inflamed ascending retrocecal appendices were visualized completely in 70%, partially in 21%, and not detected in 9%. Perforation of the appendix with formation of an abscess was present in 49%, and appendicoliths were found in 33%.

Ong et al. [91] from Singapore reported four cases of patients with retrocecal appendicitis who presented with right upper quadrant abdominal pain. Ultrasound examination showed subhepatic collections in two patients and normal findings in the other two. Computed tomography identified correctly retrocecal appendicitis and inflammation in the retroperitoneum in all cases. In addition, abscesses in the retrocecal space (two cases) and subhepatic collections (two cases) were also demonstrated. Emergency appendectomy was performed in two patients, interval appendectomy in one, and hemicolectomy in another. Surgical findings confirmed the presence of appendicitis and its retroperitoneal extensions.

A case of retroperitoneal necrotizing soft tissue infection after appendicitis was reported by Carmignani et al. [92] where a 17-year-old boy presented to the hospital in acute septic shock after 9 days with symptoms of back pain, fever, and decrease appetite. According to the patient's mother, his pain was originally attributed to chiropractic problems which contributed to the delayed diagnosis. The patient had an acute abdomen and was immediately taken to the operating room for an exploratory laparotomy which revealed an inflamed and perforated retrocecal appendix with diffuse retroperitoneal necrotizing soft tissue infection. An appendectomy was performed, and the patient was resuscitated, stabilized, and transferred to the ICU the same evening. After stabilization the patient was taken to the operating room again for an exploratory laparotomy. At exploration, wide spread necrotizing infection was found involving the anterior abdominal wall, retroperitoneum, and scrotum. Extensive debridement was performed. Subsequently, he remained for utmost 3 months in the hospital for closure of his abdominal wound by plastic surgery team. This initially required debridement with placement of a xenograft and a foam, polyethylene, dressing. The patient's abdominal wound was later closed with a split-thickness graft. The patient's condition continued to progress satisfactorily, and he was discharged.

One case of acute appendicitis mimicking acute scrotum was reported by Buzatti et al. [93] in a young male who presented with diffuse abdominal pain of 4-day duration, accompanied by fever and anorexia. On physical examination the scrotum was red and swollen, and there was tenderness by direct percussion of the lower abdomen. The skin around the scrotum, mainly in

the groin and hypogastric area, was also red suggesting evolution of a Fournier syndrome. A white blood cell count was elevated ( $18.000 \text{ cells/mm}^3$ ), and C-reactive protein was about 260. Intensive care support and antibiotic therapy were immediately started. An ultrasonography of the scrotum was performed, which showed the vascularization of both testicles preserved, and an abscess in the right hemiscrotum and the presence of edema in the subcutaneous and the muscular fascia of the abdominal wall and inguinal region. An abdominal ultrasound demonstrated free liquid in the pelvis but did not find the appendix. The scrotal abscess was drained, and the left hemiscrotum cavity was also explored finding no pus or necrosis inside. Afterward a laparotomy was performed and a retrocecal appendix was found with diffuse peritonitis. Appendectomy was performed followed by abdominal cavity wash. The patient developed infectious complications and survived. Pathological examination confirmed an acute perforated appendicitis.

Hsieh et al. [94] reported two cases of retroperitoneal abscess resulting from perforated acute appendicitis and identified 22 more cases. In this series, they found that none of the patients presented with classical symptoms of acute appendicitis at the onset of the disease and less than half reported abdominal pain. The average interval between the onset of symptoms and diagnosis was 16 days, and the most effective tool was computed tomography. The mortality rate was 16.7%, and all deaths were caused by profound sepsis.

Sharma [95] described a case of retrocecal appendicitis in a 6-year-old boy who presented with a thigh abscess. He presented with a positive psoas sign and feculent discharge in the right thigh. Laparotomy revealed a perforated retrocecal appendix with surrounding collection communicating to the thigh. Appendectomy with drainage of the retroperitoneal and thigh collections under adequate antibiotic coverage resulted in a satisfactory recovery.

## 24.2. Stump appendicitis

Stump appendicitis is defined as the development of obstruction and inflammation of the residual appendix after appendectomy. In a 60-year literature review of stump appendicitis, Subramanian and Liang [96] found that stump appendicitis is an underreported and poorly defined condition. Their conclusion was that appendicitis warrants early detection in patients with abdominal pain, nausea, and vomiting. A prior history of appendectomy can delay the diagnosis which could lead to perforation that requires extensive resection.

Roberts et al. [97] identified 48 cases of stump appendicitis in the English medical literature and found that the presenting symptoms are basically indistinguishable from those of primary appendicitis. They found three cases of stump appendicitis in their institution that were diagnosed ranging from 2 months to 20 years after the initial appendectomy. In their review, they found perforation of the appendix in 60% of patients. Besides the possibility of stump appendicitis, there is the possibility of a duplicate appendix which is a rare developmental abnormality. In the review of these 48 cases, one can see that there is a difference among the length of the stumps removed. The average length of the stumps left after the initial operation was 2.7 cm for an open appendectomy vs. 4.2 cm for a laparoscopic appendectomy which

indicates that there is certain difficulty to identify the cecal appendiceal junction during the laparoscopic appendectomy.

Geraci et al. [98] reported a case of a 54-year-old appendicectomized woman who presented with a recent history of periumbilical abdominal pain radiating to the right side and right iliac fossa, in the absence of fever, vomiting, or other symptoms. Elective colonoscopy revealed an appendicular orifice clogged by a big fecalith with surrounding hyperemic mucosa. A CT scan confirmed the diagnosis of stump appendicitis. After 30 days of therapy with metronidazole and mesalazine, the patient was submitted to surgery and appendectomy was performed obtaining a specimen of 24 mm stump appendicitis.

Bu-Ali et al. [99] reported a case of stump appendicitis after laparoscopic appendectomy which was diagnosed preoperatively with a CT scan. This case was of an 18-year-old male who presented with a 1-week history of lower abdominal pain, nausea, and vomiting. He had a history of laparoscopic appendectomy for acute appendicitis. On physical examination, he had tenderness and guarding in the lower abdomen. A CT scan showed free pelvic fluid with a tubular structure of about 2.5 cm in length and 0.78 cm in diameter located posteriorly to the ileocecal junction. Laparoscopic exploration confirmed the findings. A residual appendicular stump was found and dissected from adhesions and removed. Histopathology showed a residual appendix with residual neutrophilic infiltration associated with multifocal hemorrhagic necrosis. The postoperative was uneventful.

Tang et al. [100] reported three cases of stump appendicitis in children who presented with right lower quadrant abdominal pain and a history of appendectomy. Ramirez et al. [101] reported a case of stump appendicitis in a 2-year-old child admitted to the emergency room due to vomiting, abdominal pain, and fever. The patient had a history of peritonitis associated with perforated appendicitis 6 months before. At this time, he had an emergency laparotomy due to hemodynamic deterioration and worsening of abdominal pain. During the operation, peritonitis, stump appendicitis with perforation, and incidental Meckel's diverticulum was found. This required removal of the stump and the Meckel's diverticulum and intestinal resection with an end-to-end anastomosis. Patient received antibiotic therapy and underwent a laparostomy with subsequent peritoneal lavages in the ICU. He was discharged in good general condition 14 days after surgery.

### **24.3. Left-sided appendicitis**

Congenital anatomical abnormalities resulting in left-sided appendicitis are usually caused by situs inversus and midgut malrotation. Several cases have been reported in different parts of the world, some of them starting with diffused abdominal pain and then localizing into the left upper quadrant or in the left lower quadrant. Akbulut et al. [102] gave an overview of the literature on left-sided appendicitis associated with situs inversus totalis and midgut malrotation. They found that the diagnosis was made preoperatively in 51.5% of the cases and intraoperatively in 19% of cases. Pain location was present in the left lower quadrant in 62% of cases, right lower quadrant (14.7%), bilateral lower quadrant (7.3%), pelvic region (2%), left upper quadrant (7.3%), and periumbilical area (6.3%).

Singla et al. [103] reported a case of left-sided acute appendicitis in an elderly male with asymptomatic midgut rotation. Their conclusion was that imaging offers significant advantage for timely and definitive management.

#### **24.4. Abdominal wall hernias and acute appendicitis**

Amyand's hernia is a rare form of an inguinal hernia (less than 1% inguinal hernias) which occurs when the appendix is included in the hernia sac and becomes incarcerated. Claudius Amyand was a French surgeon who performed the first successful appendectomy in 1735. He found a perforated appendix with a pin within an inguinal hernia sac, and since then a few similar cases have been reported in the medical literature. Perforated appendix and periappendicular abscess formation within an inguinal sac is an extremely rare condition.

Unver et al. [104] presented a case of left-sided Amyand's hernia in which a 32-year-old male presented with an irreducible inguinal mass with pain for 3 days accompanied by nausea and vomiting. He had a Lichtenstein hernioplasty 3 years before for a left inguinal hernia. An abdominal CT scan showed a mobile cecum that switched to the left side of the abdomen, with coexisting inflammatory echogenic findings and a left-sided inguinal hernia sac including an appendix vermiformis. The patient underwent an emergency abdominal exploration finding that the cecum was mobile and shifted to the left side. The appendix was found incarcerated in the left inguinal sac. The appendix was removed, and the internal ring was repaired with primary sutures.

The presence of an appendix within a femoral hernia sac is a rare condition and is known as a De Garengeot hernia, after a French surgeon who first described it in the literature in 1731. This type of hernia is reported to account for 0.5–3.3% of all femoral hernias.

Ebisawa et al. [105] reported a case of De Garengeot hernia in which a 90-year-old female presented with a 3-day history of right inguinal swelling and inguinal pain. On physical examination there was an egg-sized mass located slightly lower than the inguinal ligament that showed signs of inflammation and was painful on direct compression. There were no complaints of abdominal pain, nausea, or vomiting. Laboratory tests revealed a slight elevation of CRP (0.49 mg/dL). Abdominal X-ray showed no gas-fluid levels and no signs of small intestine dilatation. Pelvic CT scan revealed a small round mass beside the femoral artery and vein with air-fluid levels and small amount of ascites in the pelvic cavity. The patient was taken to the operating room, and the inguinal ligament was transected. The hernial sac revealed a congested and inflamed appendix. Appendectomy was performed through the hernial sac. There was no evidence of perforation or abscess, so a hernioplasty was completed with synthetic mesh. Histopathological examination revealed a gangrenous appendicitis. The patient was discharged 7 days later with no complications. Because of the rarity and lack of typical symptoms associated with acute appendicitis, achieving preoperative diagnosis is very difficult.

## **25. Conclusion**

Diagnosis of acute appendicitis is basically made on clinical grounds where the experience and common sense of the physician are extremely important. The main purpose of this approach is

to make a timely and accurate diagnosis within the first 24 hours after the initiation of symptoms in order to prevent serious complications such as gangrene and perforation of the appendix.

## Author details

Alfredo Alvarado<sup>1,2,3,4,5\*</sup>

\*Address all correspondence to: [alfredoalvara@hotmail.com](mailto:alfredoalvara@hotmail.com)

- 1 Alma mater: Universidad Nacional de Colombia, Bogotá, Colombia
- 2 Certified by the American Board of Surgery and the American Board of Emergency Medicine, Miami, FL, USA
- 3 International College of Surgeons, Chicago, IL, USA
- 4 Society of Laparoscopic Surgeons, Chicago, USA
- 5 American College of Emergency Physicians, Irving TX, USA

## References

- [1] Craig S, Brenner BE. Appendicitis: Practice essentials, backgrounds, anatomy. Medscape. Jan 19, 2017
- [2] Buckius MT, McGrath B, Monk J, Grim R, Bell T, Ahuja V. Journal of Surgical Research. 2012;**175**:185-190
- [3] Wagensteen OH, Dennis C. Experimental proof of the obstructive origin of appendicitis in man. Annals of Surgery. 1939;**110**:629-647
- [4] Singh JP, Mariadson JG. Role of the fecalith in modern-day appendicitis. Annals of the Royal College of Surgeons of England. 2013 Jan;**95**(1):48-51
- [5] Peterson MC, Holbrook JH, Von Hales D, Smith NL, Stacker LV. Contributions of the history, physical examination, and laboratory investigation. The Western Journal of Medicine. 1992 Feb;**156**(2):163-165
- [6] Graff L, Russel J, Seashore J, et al. False-negative and false- positive errors in abdominal pain evaluation: Failure to diagnose acute appendicitis and unnecessary surgery. Academic Emergency Medicine. 2000 Nov;**7**(11)
- [7] Sedlack JD. The rising morbidity of appendectomy for acute appendicitis. Welcome to Appendicitis.pro.Google (direct Web citation)
- [8] Kong VY, Sartorius B, Clarke DL. Acute appendicitis in the developing world is a morbid disease. Annals of the Royal College of Surgeons of England. 2015;**00**:1-6

- [9] Cope Z. *The Early Diagnosis of the Acute Abdomen*. Ely House, London: Oxford University Press; 1968
- [10] Wagner J, McKinney WP, Carpenter JL. Does this adult patient have appendicitis? The rational clinical examination. American Medical Association. Chapter 5. 2009. p. 54
- [11] Gauderer MW, Crane MM, Green HA, Decou JM, Abrams RS. Acute appendicitis in children: The importance of family history. *Journal of Pediatric Surgery*. 2001 Aug;**36**(8): 1214-1217
- [12] Ergul E. Importance of family history and genetics for the prediction of acute appendicitis. *The Internet Journal of Surgery*. 2006;**10**(1)
- [13] Shperber Y, Halevy A, Oland J, Orda R. Familial retrocecal appendicitis. *Journal of the Royal Society of Medicine*. 1966 Jul;**79**:405-406
- [14] Alary FS, Gutierrez I, Perez JG. Familial history aggregation on acute appendicitis. *BMJ Case Reports*. 19 Oct, 2017. p. 1-3
- [15] Humes DH, Simpson J. Clinical presentation of acute appendicitis: Clinical signs, laboratory findings, clinical scores, Alvarado score and derivative scores. *Imaging of Acute Appendicitis in Adults and Children*. Medical Radiology. Springer-Verlag Berlin Heidelberg; 2011
- [16] Ying-Lie O. Contribution of Clinical Features in Appendicitis Scores: An International Systematic Review. *Albinusdreef 2*, 2333 ZA Leiden, Netherlands: Leiden University Medical Center. Jan 2012
- [17] Petroianu A. Diagnosis of acute appendicitis. *International Journal of Surgery*. 2012;**10**: 115-119
- [18] Samuel M. Pediatric appendicitis score. *Journal of Pediatric Surgery*. 2002;**37**:877-881
- [19] Markle GB. A simple test for intraperitoneal inflammation. *The American Journal of Surgery*. 1973;**125**:721
- [20] Massouh sign. Wikipedia (Published Online)
- [21] Wani I. K-sign in retrocecal appendicitis: A case review series. *Cases Journal*. 2009;**2**:157 (Published Online)
- [22] Hamburger sign. Wikipedia (Published Online)
- [23] Almaramhy HH. Acute appendicitis in young children less than 5 years: Review article. *Italian Journal of Pediatrics*. 2017;**43**:15
- [24] Alvarado A. A practical score for the early diagnosis of acute appendicitis. *Annals of Emergency Medicine*. 1986;**15**(5):557-564
- [25] Pogorelic Z, Rak S, Mrklic I, Juric I. Prospective validation of Alvarado score and pediatric appendicitis score for the diagnosis of acute appendicitis in children. *Pediatric Emergency Care*. 2015;**31**:164-168

- [26] Goldman RD, Carter S, Stephen D, Antoon R, Mounstephen W, Langer JC. Prospective validation of the pediatric appendicitis score. *The Journal of Pediatrics*. 2008;**153**:278-282
- [27] Ebell MH, Shinholser JA. What are the most clinically useful cutoffs for the Alvarado and pediatric appendicitis scores? A systematic review. *Annals of Emergency Medicine*. 2014 Oct;**64**(4):365-362
- [28] Bhatt M, Joseph L, Ducharme FM, Dougherty G. Prospective validation of the pediatric appendicitis score in Canadian pediatric emergency department. *Academic Emergency Medicine*. 2009 Jul;**16**(7):591-596
- [29] Salo M, Friman G, Stenstrom P, Ohlson B, Arnbjornson E. Appendicitis in children: Evaluation of the pediatric appendicitis score in younger and older children. *Surgery Research and Practice, Hindawi Publishing Corporation*; 2014:6. Article: 438076
- [30] Yang ES, Yoon SK, Kim EY, Rho YI, Park SK, Moon KR. Usefulness of Alvarado scoring system for the diagnosis of acute appendicitis in children. *Korean Journal of Pediatric Gastroenterology and Nutrition*. 2004 Mar;**7**(1):1-7
- [31] Chisalau V, Tica C, Chirila S, Ionescu C. *ARS Medical Tomitana*. 2017;**3**(23):115-129
- [32] Borges PS, Lima M, Falbo Neto GH. The Alvarado score validation in diagnosing acute appendicitis in children and teenagers at the Instituto Materno Infantil de Pernambuco. *Rev Bras Saude Mater infant*. 2003;**3**(4):439-445
- [33] Heineman J. An evaluation of the Alvarado score as a diagnostic tool for appendicitis in children. *BestBets*. April 2013 (Published Online)
- [34] Schneider C, Kharbanda A, Bachur R. Evaluating appendicitis scoring systems using prospective pediatric cohort. *Annals of Emergency Medicine*. 2007 Jun;**49**(6):778-784
- [35] Benabbas R, Hanna M, Shah J, Sinert R. Diagnostic accuracy of history, physical examination, laboratory tests, and point of care ultrasound for pediatric acute appendicitis in the emergency department: A systematic review and meta-analysis. *Academic Emergency Medicine*. 2017;**24**(5):523-551
- [36] Peyvasteh M, Askarpour S, Javaherizadeh H, Besharati S. Modified Alvarado score in children with diagnosis of appendicitis. *Arquivos Brasileiros de Cirurgia Digestiva*. 2017;**30**(1):51-52
- [37] Franca-Neto AH, do Amorin MM, Virgolino-Nobrega BMS. Acute appendicitis in pregnancy: Literature review. *Revista Da Associacao Medica Brasileira*. 2015 Mac/Apr;**61**(2): 1-14
- [38] Aggenbach L, Zeeman GG, Cantineau AEP, et al. Impact of appendicitis during pregnancy: No delay in accurate diagnosis and treatment. *International Journal of Surgery*. 2015;**15**:84-89
- [39] Tamir IL, Bongard FS, Klein SR. Acute appendicitis in the pregnant patient. *The American Journal of Surgery*. 1990 Dec;**160**(6):571-575

- [40] Bhandari TR, Shahi S, Acharya S. Acute appendicitis in the developing world. *International Scholarly Research Notices*. 2017;**2017**:2636759
- [41] Gurleyik G, Gurleyik E. Age related clinical features in older patients with acute appendicitis. *European Journal of Emergency Medicine*. 2003 Sep;**10**(3):200-203
- [42] Busch M, Gutzwiller FS, Aellig S, et al. In-hospital delay increases the risk of perforation in adults with acute appendicitis. *World Journal of Surgery*. 2011 Jul;**35**(7):1626-1633
- [43] Shchatsko A, Brown R, Reid T, et al. The utility of the Alvarado score in the diagnosis of acute appendicitis in the elderly. *The American Journal of Surgery*. 2017 July;**83**(7):793-798
- [44] Omari AH, Khammash MR, Qasaimeh GR, et al. Acute appendicitis in the elderly: Risks factors of perforation. *World Journal of Emergency Surgery*;**214**, 9:6
- [45] Madiba TE, Haffejee, Mbete DL, et al. Appendicitis among African patients at king Edward VIII hospital, Durban, South Africa: A review. *East African Medical Journal*. 1998 Feb;**75**(2):81-84
- [46] Abdelahim M, Khair R, Elsiddig K. The validity of the Alvarado score in diagnosis of acute appendicitis among Sudanese patients. *Surgery: Current Research*. 2016;**6**:1
- [47] Markar SR, Pinto D, Penna M, et al. A comparative international study on the management of acute appendicitis between a developed country and a middle-income country. *International Journal of Surgery*. 2014;**12**(4):357-360
- [48] Ali N, Aliyu S. Appendicitis and its surgical management experience at the university of Maidiguri teaching hospital Nigeria. *Nigerian Journal of Medicine*. 2012 Apr-Jun;**21**(2): 223-226
- [49] Arfa N, Gharbi L, Marsaoui L, et al. Value of admission for observation in the management of acute abdominal right iliac fossa pain. Prospective study of 205 cases. *La Presse Médicale*. 2006 Mar;**35**(3):393-398
- [50] Zoguereh DD, Lemaitre X, Ikoli JF, et al. Acute appendicitis at the National University Hospital in Bangui, Central African Republic: Epidemiologic, clinical, paraclinical and therapeutic aspects. *Sante* 2001 Apr-Jun;**11**(2):117-125
- [51] Ib F, Adesanya AA, Atoyebi OA, et al. Acute appendicitis in Lagos: A review of 250 cases. *The Nigerian Postgraduate Medical Journal*. 2009 Dec;**16**(4):268-273
- [52] Tade AO. Evaluation of Alvarado score as an admission criterion in patients with suspected diagnosis of acute appendicitis. *West African Journal of Medicine*. 2007;**26**(3):210-212
- [53] Giiti GC, Mazig HD, Heulkelbach H, Mahalu W. HIV, appendectomy and postoperative complications at a reference hospital in Northwest Tanzania: Cross-sectional study. *AIDS Research and Therapy*. 2010 Dec 29;**7**:47
- [54] Hardy A, Butler B, Crandall M. The evaluation of the acute abdomen. In: Moore LJ et al. editors. *Common Problems in Acute Care Surgery*. New York; Springer Science+Business Media; 2013

- [55] Papaziogas B, Tsiaousis P, Koutelidakis, et al. Effect of time on risk of perforation in acute appendicitis. *Acta Chirurgica Belgica*. 2009 Jan-Feb;**109**(1):75-80
- [56] Bickell NA, Aufses AH, Rojas M, Bodian C. How time affects the risk of rupture in appendicitis. *Journal of the American College of Surgeons*. 2008 Mar;**202**(3):401-406
- [57] Andersson RE. Does delay of diagnosis and treatment in appendicitis cause perforation? *World Journal of Surgery*. 2016;**40**:1315-1317
- [58] Rodrigues G, Kannaiyan L, Gopashetty M, et al. Plain X-ray in acute appendicitis. *Internet Journal of Radiology*. 2003;**3**(2):1-4
- [59] Bin Ismail HM, Malik A. Will plain abdominal X-ray become obsolete? *Open Journal of Radiology*. 2017;**2**(2):32-27
- [60] Aydin D, Turan C, Yurtseven A, et al. Integration of radiological findings and a clinical score in pediatric patients. *Pediatrics International*. 2017 Dec;**60**(2):173-178. DOI: 1111/ped.13471
- [61] Petroianu A, Alberti L, Zac RI. Assessment of the persistence of fecal loading in the cecum in presence of acute appendicitis. *International Journal of Surgery*. 2007;**5**:11-16
- [62] Toprak H, Kilinkaslan H, Ahmad IC, et al. Integration of ultrasound findings with Alvarado score in children with suspected appendicitis. *Pediatrics International*. 2014;**56**:95-99
- [63] Pinto F, Pinto A, Russo A, et al. Accuracy of ultrasonography in the diagnosis of acute appendicitis in adult patients: Review ultrasound. *Critical Ultrasound Journal*. 2013;**5** (Suppl 1):52
- [64] Reich B, Zalut T, Weiner S. An international evaluation of ultrasound vs computed tomography in the diagnosis of appendicitis. *International Journal of Emergency Medicine*. 2011;**4**:68
- [65] Mostbeck G, Adam EJ, Nielsen MB, et al. How to diagnose acute appendicitis: Ultrasound first. *Insights imaging*. 2016 Apr;**7**(2):255-263
- [66] Debnath J, George RA, Ravikumar R. Imaging in acute appendicitis: What, when, and why. *Medical Journal Armed Forces India*. 2017;**73**:74-79
- [67] Chiang DT, Tan EI, Birks D. To have or not to have. Should computed tomography and ultrasonography be implemented as a routine in patients with suspected appendicitis in a regional hospital? *Annals of the Royal College of Surgeons of England*. 2008;**90**:17-21
- [68] John H, Neff U, Kelemen N. Appendicitis diagnosis today. Clinical and ultrasound deductions. *World Journal of Surgery*. 1993;**17**:243-249
- [69] Mettler FA et al. Effective doses in radiology and diagnostic nuclear medicine: A catalog. *Radiology*. 2008;**24**(1):254-263
- [70] Guite KM, Hinshaw LH, Ranallo FN, et al. Ionizing radiation in abdominal CT: Unindicated multiphase scans are an important source of medically unnecessary exposure. *Journal of the American College of Radiology*. 2011;**8**:756-761

- [71] Markar SR, Karthikesalingan A, Cunningham J, et al. Increase use of preoperative imaging and laparoscopy has no impact on clinical outcomes in patients undergoing appendectomy. *Annals of the Royal College of Surgeons of England*. 2011;**93**:620-623
- [72] Hong JJ, Cohn SM, Ekeh P, et al. A prospective randomized study of clinical assessment versus computed tomography for the diagnosis of acute appendicitis. *Surgical Infections*. 2003;**4**(3):231-239
- [73] Petrosian M, Estrada J, Chan S, et al. CT scan in patients with suspected appendicitis: Clinical implications for the acute care surgeon. *European Surgical Research*. 2008;**40**(2):211-210
- [74] Lee SL, Walsh AJ, Ho HS. Computed tomography and ultrasonography do not improve and may delay the diagnosis and treatment of acute appendicitis. *Archives of Surgery*. 2001;**136**:556-562
- [75] McKay R, Shepherd J. The use of the clinical score system by Alvarado in the decision to perform computed tomography for acute appendicitis in the ED. *American Journal of Emergency Medicine*. 2007;**25**(50):489-493
- [76] Tan WJ, Acharyya S, Goh YV, et al. Prospective comparison of the Alvarado score and CT scan in the evaluation of suspected appendicitis: A proposed algorithm to guide CT use. *Journal of the American College of Surgeons*. 2015;**220**:218-224
- [77] Duke E, Kalb B, Arif-Tiwari, et al. A systematic review and meta-analysis of diagnostic performance of MRI for evaluation of acute appendicitis. *American Journal of Roentgenology*. 2016;**206**(3)
- [78] Inci E, Hocaoglu E, Aydin S, et al. Efficiency of unenhanced MRI in the diagnosis of acute appendicitis: Comparison with Alvarado scoring system and histopathological results. *European Journal of Radiology*. 2011;**80**(2):253-258
- [79] Konrad J, Grand D, Lourenco A. MRI: First-line imaging modality for pregnant patients with suspected appendicitis. *Abdominal Imaging*. 2015 Oct;**40**(8):3359-3364
- [80] Herliczek TW, Swenson DW, Mayo-Smith WW. Utility of MRI after inconclusive ultrasound in pediatric patients with suspected appendicitis: Retrospective review of 60 consecutive patients. *American Journal of Roentgenology*. 2013;**200**:968-973
- [81] Ray JG, Vermeulen MJ, Bharatha A, et al. Association between MRI exposure during pregnancy and fetal and childhood outcomes. *JAMA*. 2016 Sep 6;**316**(9):952-961
- [82] Borgstein PJ, Gordijn RV, Eijsbouts QA, Cuesta MA. Acute appendicitis, a clear-cut case for men a guessing game in young women. A prospective study on the role of laparoscopy. *Surgical Endoscopy*. 1997;**11**(9):923-927
- [83] Kraemer M, Ohman C, Leoppert R, Yang O. Macroscopic assessment of the appendix at diagnostic laparoscopic is reliable. *Surgical Endoscopy*. 2000 Jul;**14**(7):625-633

- [84] Greason KL, Rappold JG, Liberman MA. Incidental laparoscopic appendectomy for acute right lower quadrant abdominal pain. Its time has come. *Surgical Endoscopy*. 1998 Mar;**12**(3):223-225
- [85] Strong S, Blencowe N, Bhangu A. How good are surgeons at identifying appendicitis? Results from a multi-Centre cohort study. *International Journal of Surgery*. 2015;**15**:107-112
- [86] Charlesworth P, Mahomed A. Diagnostic laparoscopy and appendectomy for children with chronic right iliac fossa pain: An aggregate analysis. *Journal of Population and Social Studies*:1
- [87] Shen GK, Wong R, Daller J, et al. Does the retrocecal position of the vermiform appendix alter the clinical course of acute appendicitis? A prospective analysis. *Archives of Surgery*. 1991 May;**126**(5):569-570
- [88] Herscu G, Kong A, Russell D, et al. Retrocecal appendix location and perforation at presentation. *The American Journal of Surgery*. 2006 Oct;**72**(10):890-893
- [89] Oruc M, Muminagic S, Denjalic A, et al. Retrocaecal appendix position: Findings during the classic appendectomy. *Medical Archives*. 1912 Jun;**66**(3):190-193
- [90] Kim S, Lim HK, Lee JY, et al. Ascending retrocecal appendicitis: Clinical and computed tomographic findings. *Journal of Computer Assisted Tomography*. 2006 Sep-Oct;**30**(5):772-776
- [91] Ong EMW, Venkatesh K. Ascending retrocecal appendicitis presenting with right upper abdominal pain: Utility of computed tomography. *World Journal of Gastroenterology*. 2009 Jul 28;**15**(28):3576-3579
- [92] Carmignani CP, Ismail S, Ganz J, Kalan MMH. Retroperitoneal necrotizing soft tissue infection after appendicitis. *Surgical Rounds*. 2005 June:283-284
- [93] Buzatti KC, Goncalvez MV, Da Silva R, Rodrigues BP. Acute appendicitis mimicking acute scrotum: A rare complication of a common abdominal inflammatory disease. *Journal of Coloproctology*. 2018;(1):65-69
- [94] Hsieh CH, Wang JC, Yang HR, et al. Retroperitoneal abscess resulting from perforated acute appendicitis: Analysis of its management and outcome. *Surgery Today*. 2007;**37**:762-767
- [95] Sharma SB, Gupta V, Sarma SC. Acute appendicitis presenting as thigh abscess in a child: A case report. *Pediatric Surgery International*. 2005 Apr;**21**(4):298-300
- [96] Subramanian A, Liang MK. A 60-year literature review of stump appendicitis: The need for a critical view. *American Journal of Surgery*. 2012 Apr;**203**(4):503-507
- [97] Roberts KE, Starker LF, Andrew J, et al. Stump appendicitis: a surgeon's dilemma. *Journal of the Society of Laparoendoscopic Surgeons*. 2011;**15**:373-378
- [98] Geraci G, Di Carlo G, Cudia B, Modica G. Stump appendicitis. A case report. *International Journal of Surgery Case Reports*. 2016;**20**:21-23

- [99] Bu-Ali O, Al-Bashir M, Samir HA, Abu-Sidan FM. Stump appendicitis after laparoscopic appendectomy: Case report. *Ulusal Travma ve Acil Cerrahi Dergisi*. 2011 May;17(3):267-268
- [100] Tang XB, Qu RB, Wang WL. Stump appendicitis in children. *Journal of Pediatric Surgery*. 2011;6(1):233-236
- [101] Ramirez AG, Fierro F, Holguin DA, Mendez M. Stump appendicitis in a 2-year-old patient. *Case Report and Literature Review*. 2017 Jan;3(1)
- [102] Akbulut S, Ulku A, Senol A, et al. Left-sided appendicitis: Review of 95 published cases and a case report. *World Journal of Gastroenterology*. 2010 November 28;16(44):5598-5602
- [103] Singla A, Rajaratman J, Singla AA. Unusual presentation of left sided appendicitis in elderly male with asymptomatic midgut rotation. *International Journal of Surgery Case Reports*. 2015;17:42-44
- [104] Unver M, Ozturk S, Karaman K, Turgut E. Left sided Amyand's hernia. *World Journal of Gastrointestinal Surgery*. 2013 Oct 27;5(10):285-286
- [105] Ebisawa K, Yamzaki S, Kimura Y, et al. Acute appendicitis in an incarcerated femoral hernia: A case of De Garendeot hernia. *Case Reports in Gastroenterology*. 2009 Sep-Dec;3(3):313-317