Acute Appendicitis Dilemma of Diagnosis and Management

A Mohamed, N Bhat

Citation

A Mohamed, N Bhat. *Acute Appendicitis Dilemma of Diagnosis and Management*. The Internet Journal of Surgery. 2009 Volume 23 Number 2.

Abstract

Acute appendicitis is the most common cause of acute abdomen requiring surgical intervention. Although typical, uncomplicated cases of acute appendicitis are easy to diagnose and treat, diagnosis of atypical appendicitis is a difficult task and remains a clinical challenge that may test the diagnostic skills of even the most experienced surgeons. In the present review, the diagnosis of the disease is reviewed with special emphasis on difficulties and accuracy of the diagnosis.

INTRODUCTION

Since Reginald H. Filz, anatomopathologist at Harvard, first described the disease and first introduced the term appendicitis in 1886 (1), acute appendicitis remained the most common general surgical emergency seen in most hospitals (2) and the most common cause of acute abdomen requiring surgical intervention (3). In industrialized countries, individuals have a 7% lifetime risk of developing appendicitis, with the highest frequency occurring at ages from 10 to 30 years. The risk gradually decreases until age 50, when it stabilizes (4).

DIAGNOSIS

Typical uncomplicated cases of acute appendicitis are easy to diagnose and treat. Typical cases present classically with para-umbilical pain (visceral pain) migrating to the right lower quadrant of the abdomen (RLQ). Pain usually is associated with nausea, vomiting and low-grade fever.

Localized irritation and inflammation of the peritoneum results in pain with cough (Dunphy's sign), tenderness and muscle guarding on palpation in the RLQ over McBurney's point and rebound tenderness elicited by deep palpation with quick release (Blumberg sign). Unfortunately, 20-33% of the patients suspected of having acute appendicitis present with atypical findings (5-7).

DIAGNOSTIC DIFFICULTIES

Accurate and timely diagnosis of atypical cases remains clinically challenging and one of the most commonly missed problems in the emergency departments. Precaution appendectomy or misdiagnosis of presumed appendicitis is an adverse outcome that leads to unnecessary surgery (8), serious interruption of patient's daily activities and considerable waste of hospital resources (9) in addition to the recognized postoperative complications. On the other hand, delay in diagnosis may increase the morbidity and cost.

Statistics reported that 1 of 5 cases of appendicitis is misdiagnosed; however, a normal appendix is found in 15-35% of patients who have emergency appendectomy (10-12).

Variation in the position of the appendix, age of the patient and degree of inflammation make the clinical presentation of appendicitis inconsistent. Females during childbearing age present diagnostic difficulty and the incidence of misdiagnosis is increased for women of the reproductive age (13).

VARIABLE ANATOMICAL POSITIONS

The base of the appendix is fairly constant and is located at the posteromedial wall of the caecum about 2.5 cm below the ileocecal valve where the taeniae converge, whereas the position of the tip varies. It is retrocaecal in 65% of the patients, pelvic in 30%, and paracaecal or post-ileal/pre-ileal in the remaining 5%.

Inflammation of a retrocacecal appendix is difficult to diagnose. Rigidity is often absent and even on deep pressure, tenderness may be lacking (silent appendix), the reason being that the cecum distended with gas prevents the pressure exerted by the hand from reaching the appendix (14). The clue to diagnosis is hip flexion that results from irritation of the psoas muscle by the inflamed appendix. Hyperextension of the hip may induce abdominal pain

(psoas sign).

Inflammation of a pelvic appendix associated with early diarrhoea results from the contact between the inflamed appendix and the rectum. When the appendix lies entirely within the pelvis, there is usually complete absence of abdominal rigidity and often tenderness over McBurney's point is lacking as well. Rectal examination is crucial for the diagnosis. Spasm of the obturator internus muscle can be sometimes demonstrated by flexion and internal rotation of the hip (obturator sign).

Postileal appendicitis presents a great diagnostic difficulty because the pain starts in the right lower abdomen and remains there (not migratory) and is usually associated with diarrhea leading to confusion with enterocolitis.

Inflammation of a maldescended or subhepatic appendix is sometimes mistaken as acute cholecystitis.

EXTREME AGE

The highest incidence of acute appendicitis is during the second and third decade of life.

While appendicitis is uncommon in young children, it poses special difficulties in this age group because it is difficult to obtain the history and elicit clinical signs in young children, non-specific abdominal pain and mesenteric lymphadenitis are common in this age group and sometimes these are impossible to be differentiated from acute appendicitis on clinical grounds. These factors contribute to a perforation rate as high as 50% in this age group (15).

Acute appendicitis in the elderly is associated with significant morbidity (16). There is usually delay in the diagnosis because abdominal laxity may hide the clinical signs. Progression to perforation is rapid with significant increase in morbidity and mortality.

It was estimated that the perforation rate is about 50% in infancy, 10% between 10 and 40 years and 30% at 60 years of age (17).

DIAGNOSTIC ACCURACY

Accuracy of diagnosis entitles recognition and removal of the inflamed appendix prior to perforation with a minimal number of negative appendectomies.

Many studies investigate the accuracy of clinical diagnosis, and the role of imaging techniques and laparoscopy in improving the diagnostic accuracy of the disease with conflicting results.

CLINICAL DIAGNOSIS

Despite technologic advances, the diagnosis of appendicitis is still based primarily on the patient's history and the physical examination (15). It has been estimated that the accuracy of the clinical diagnosis of acute appendicitis is lying between 76% and 92%, with values correlating with the surgeon's experience (18).

Over the years various clinical scoring systems (some of them computer assisted) have been used, and, although their clinical benefits have varied, most reports describe some improvement in clinical performance with their use. The greatest beneficiaries may be junior staff, whose diagnostic accuracy increases from 58% to 71% (19).

Alvarado scoring system is the most famous scoring system used to help with the clinical diagnosis of acute appendicitis and is very easy to apply (20). (Table 1)

Figure 1

Table 1: Alvarado scoring system

Symptoms	**Score**
Migratory right iliac fossa pain	1
Nausea/Vomiting	1
Anorexia	1
Signs	
Tenderness in right iliac fossa	2
Rebound tenderness in right iliac fossa	1
Elevated temperature	1
Laboratory findings	
Leucocytosis	2
Shift to the left of neutrophils	1
Total	**10**

The score is based on three symptoms, three signs and one investigation as shown in Table 1. The classic Alvarado Score included left shift of neutrophil maturation (score 1) yielding a total score of 10, but Kalan et al. (18) omitted this parameter which is not routinely available in many laboratories, and produced a modified score. Patients with a score of 1-4 are considered unlikely to have acute appendicitis, those with a score of 5-6 have a possible diagnosis of acute appendicitis, not convincing enough to have urgent surgery, and those with score of 7-9 are regarded as probably having acute appendicitis.

Application of Alvarado scoring system in diagnosis of acute appendicitis can provide a high degree of positive predictive value and thus diagnostic accuracy. The positive predictive value of Alvarado score is reported as high as 85.3%, 87.5% and 87.4% in many studies (20-22).

The accuracy of clinical diagnosis of suspected cases of acute appendicitis can further be improved by repeated clinical examination and adoption of what is called active observation. Patients under active observation are kept fasting and re-evaluated for progression or regression of their symptoms and signs by repeated clinical examination every 2-3 hours (preferably by the same physician) and repeated estimation of while blood count and C-reactive protein.

Active observation confirms intraperitoneal pathology which requires surgical intervention or further investigation in a small group of patients. It also excludes those found to have medical illness, e.g., UTI. In 30-40% of patients, a firm diagnosis is not possible; those patients can benefit from a further period of active observation with or without further investigation depending on whether the symptoms are persisting or improving. Active observation results in a substantial fall in negative appendicectomy rate (9) and is widely considered as safe and effective approach to the management of patients with equivocal features of acute appendicitis (23).

LABORATORY INVESTIGATIONS

The white blood cell (WBC) count is elevated (more than 10 $x10^9$ per L) in 80 percent of all cases of acute appendicitis (24). Unfortunately, the WBC is elevated in up to 70 percent of patients with other causes of right lower quadrant pain (25). Thus, an elevated WBC has a low predictive value. Serial WBC measurements (over 4 to 8 hours) in suspected cases may increase the specificity, as the WBC count often increases in acute appendicitis (15). In addition, 95 percent of patients have neutrophilia (26).

Many studies evaluated the role of C-reactive protein in diagnosis of acute appendicitis with conflicting results. Although the predictive value of high C-reactive protein in patients with acute appendicitis is low, current literature would suggest that a normal pre-operative CRP level is not likely to be associated with acute appendicitis.

An elevated C-reactive protein level in combination with an elevated WBC count and neutrophilia are highly sensitive (97 to 100 percent). Therefore, if all three of these findings are absent, the chance of appendicitis is low (27).

ULTRASOUND

Graded compression Sonography is relatively inexpensive, rapid, non-invasive, and requires no patient preparation or contrast material administration. Unfortunately, graded compression sonography is operator-dependent and requires a high level of skill and expertise. Sonography is also a dynamic investigation, and photographs of sonographic images cannot be reliably re-evaluated (28).

An inflamed appendix appears on ultrasound as a non-compressible tubular structure, more than 6 mm in diameter, with a thickened wall (figures 1&2).

Ultrasonography may significantly improve the diagnostic accuracy in patients with suspected acute appendicitis and should be performed in some patients in whom the clinical diagnosis is equivocal. The overall sensitivity, specificity and accuracy of ultrasonography in the diagnosis of acute appendicitis were 78%, 92% and 87%, respectively (29).

Another limitation of ultrasound in the diagnosis of acute appendicitis is the fact that patients cannot be safely be sent home after a negative result unless there are good clinical grounds for their discharge (2).

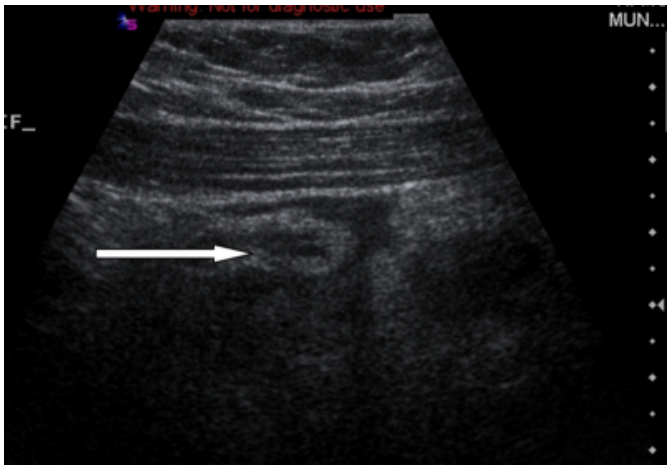
Ultrasound is helpful in young females in diagnosis of some gynecological conditions like torsion of ovarian cyst and ectopic pregnancy which may be confused with acute appendicitis.

Figure 2

Figure 1: An inflamed appendix appears on ultrasound as non-compressible tubular structure, more than 6 mm in diameter, with thickened wall and peri-appendicular inflammation

Figure 3

Figure 2: Ultrasound of the same patient as above



CONTRAST-ENHANCED CT

CT is a well-established technique in the study of acute abdominal pain and has shown high sensitivity and specificity for diagnosing and differentiating appendicitis, providing an accurate diagnosis in the early stages of disease (30).

CT is readily available, is supposed to be operator-independent, is relatively easy to perform, and has results that are easy to interpret. Helical CT has reported sensitivities of 90-100%, specificities of 91-99%, accuracies of 94-98%, positive predictive values of 92-98%, and negative predictive values of 95-100% (31-32). Studies have proven that CT without the administration of contrast material in the setting of suspicion of acute appendicitis can be as accurate as those techniques in which oral, rectal, or IV contrast medium is administered.

The typical CT finding of an inflamed appendix is a thickened wall and a non-filling appendix associated with periappendicular inflammatory fluid (figures 3&4).

CT scanning of patients with suspected appendicitis may reduce the number of patients admitted for observation and decrease the rate of negative appendectomy (33).

Figure 4

Figure 3: CT scan. The arrow points to a distended appendix with thickened walls which do not fill with colonic contrast agent, together with peri-appendicular inflammation.

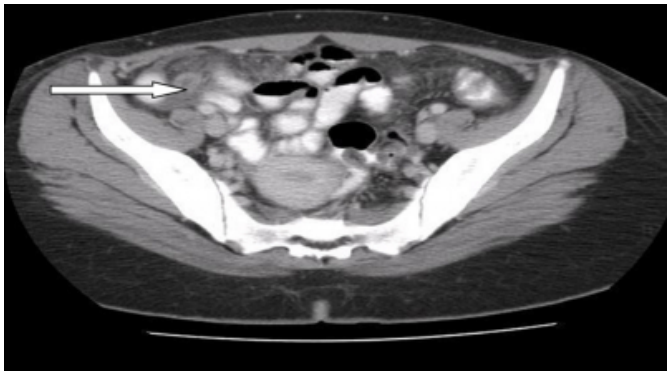


Figure 5

Figure 4: CT scan of the same patient as above, the arrow shows the appendix with the same findings.

DIAGNOSTIC LAPAROSCOPY

Several authors have advocated the use of laparoscopy as a diagnostic modality in the evaluation of a patient suspected of having acute appendicitis. Diagnostic laparoscopy should be viewed as an invasive procedure requiring general anesthesia and having a risk similar to appendectomy. For this reason, it is not preferred as a diagnostic tool. There is a lot of debate whether to remove a normal-looking appendix during diagnostic laparoscopy or to leave it. Naturally, many surgeons prefer not to come out empty-handed regardless of the gross appearance of the appendix, especially if no other pathology is identified. Many authors advocate removal of appendix regardless of the gross appearance as they believe not all normal-looking appendices are not inflamed and the

inflammation may be limited to the mucosa (endo-appendicitis); however, the routine removal of a normal appendix is not a complication-free technique even in laparoscopy. Kraemer et al. reviewed the literature for the years 1978 to 1998 to analyze the negative appendectomy rates, complication rates, the accuracy of laparoscopic appendix assessment, and the incidence of false negative diagnosis of appendicitis, at surgical and gynaecological laparoscopy. He concluded that, contrary to general opinion, there is no substantial evidence to support the assumption that the macroscopic diagnosis of appendicitis is unreliable. High rates of conflicting diagnoses of excision specimens suggest that endo-appendicitis has little clinical significance. At present, negative appendectomy rates are considerably higher for laparoscopic appendectomy than for the open approach. The role of diagnostic laparoscopy in suspected appendicitis should be reconsidered. It may be useful in particular subgroups of patients, but it is no substitute for good clinical judgement. (34). Walker et al. reported that 3.2% of the intra-operatively normal-appearing appendices demonstrated acute inflammation after pathological examination (35).

Furthermore, Van den Broek prospectively evaluated 109 diagnostic laparoscopies for suspected appendicitis with normal-looking appendices in 100 cases. After a median follow-up of 4.4 years, only two patients had acute appendicitis and nine had some recurrent pain He suggested that it is safe to leave a normal-looking appendix in place when a diagnostic laparoscopy for suspected appendicitis is performed, even if another diagnosis cannot be found at laparoscopy. (36) Diagnostic laparoscopy may be helpful in equivocal cases or in women of childbearing age, while therapeutic laparoscopy may be preferred in certain subsets of patients (e.g., women, obese patients, athletes) (37), but it should not be advocated as a routine diagnostic procedure to replace the classical pre-operative work-up usually performed for clinically suspected appendicitis, because it has its own morbidity and in most cases requires general anesthesia.

MANAGEMENT

SURGICAL MANAGEMENT

Appendectomy is the only curative treatment for acute appendicitis. Typical cases should be operated without unnecessary delay for time-consuming or expensive investigations.

Open appendectomy (OA) has withstood the test of time for more than a century since its introduction by McBurney (38). Since its initial description by Semm in 1983, laparoscopic appendectomy (LA) has struggled to prove its superiority over the open technique (39, 40). Recent prospective randomized trials have suggested that laparoscopic removal of an inflamed appendix may have benefits over open surgery (41, 42). Laparoscopic appendectomy has been claimed to reduce postoperative pain, length of hospitalisation, analgesic doses and surgery-associated complications (43) However, unlike laparoscopic cholecystectomy, LA has not yet gained popularity, most probably because most of the cases are dealt with by junior surgical staff on an emergency basis outside the working hours.

MEDICAL MANAGEMENT

The standard treatment for acute appendicitis is appendectomy, but in isolated environments where there are no surgical capabilities, medical management is required until surgical resources become available. Adams retrospectively reviewed 9 cases of US Navy men on a submarine who had appendicitis treated at sea with various antibiotic protocols; he found good response to treatment in all cases (44).

A Swedish multicenter study randomized 252 men aged 15-50 to surgery or antibiotic treatment alone, excluding patients with a high suspicion of major perforation or complications. The findings suggest that if there are reasons to postpone surgery, antibiotics alone are a satisfactory way to treat mild to moderate appendicitis without complications. The study concluded that acute non-perforated appendicitis can be treated successfully with antibiotics. However, there is a risk of recurrence, and this risk should be compared with the risk of complications after appendectomy (45).

Hansson et al. randomized 369 consecutive adults with presumed appendicitis to either antibiotics (202) or surgery (167) as primary treatment. Their conclusion is that antibiotics are an appropriate first-line treatment for adults with appendicitis without obvious signs of intra-abdominal perforation (46); both studies had some limitations and it seems that more studies are needed to establish the role of antibiotic as a primary treatment of non-complicated appendicitis.

APPENDICULAR MASS

An appendix mass is a common surgical clinical entity, encountered in 2-6% of patients presenting with acute

appendicitis (47, 48, 49).

Patients presenting late in the course of acute appendicitis are complicated by the development of an inflammatory mass in right iliac fossa (49). This inflammatory mass is composed of the inflamed appendix, omentum and bowel loops (figures 5&6).

At the beginning of the 20th century, Ochsner (1901) proposed non-operative management for the appendix mass (50), followed by interval appendectomy 6-8 weeks after successful conservative management as proposed by Murphy at the beginning of the 20th century (51). This approach became a traditional management of appendicular mass.

Conservative treatment (Ochsner–Sherren regimen) comprises hospitalization, intravenous fluids, antibiotics, analgesics and a strict watch on the vitals and general state of the patient. In 90-80% of the patients, the mass resolves without complications. The remaining 10-20% need emergency operation due to spreading infection (figure 5-7), which is comparatively more difficult (52, 53).

Figure 6

Figure 5: Appendicular mass (arrow).

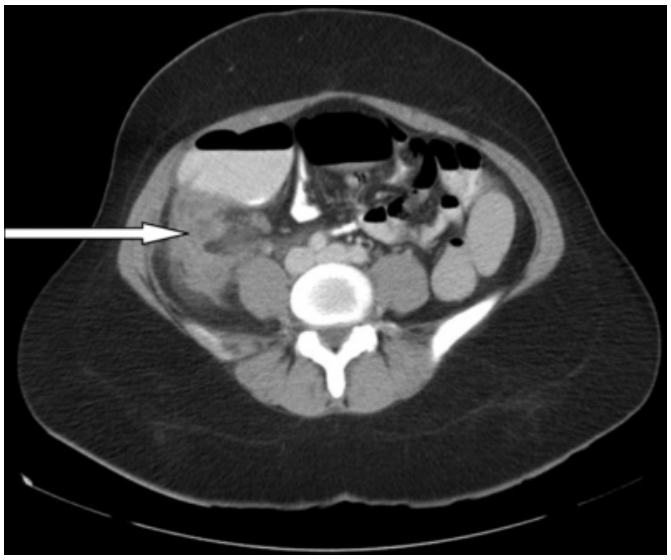


Figure 7

Figure 6: Appendicular mass lignifying to form an appendicular abscess

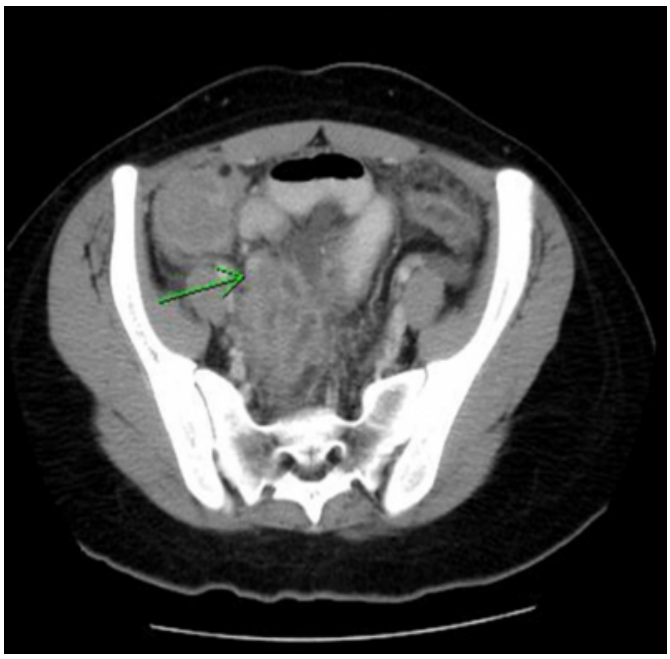
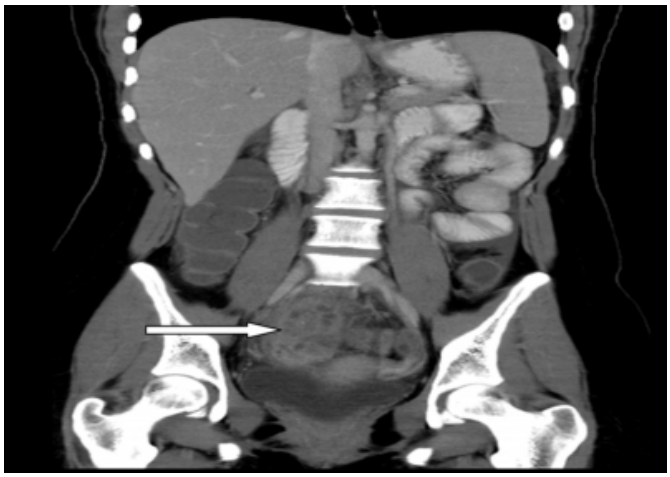


Figure 8

Figure 7: CT scan of the same patient as above (coronal view)



Advocates of initial conservative approach claim a lower rate of complications compared to early operative approach (54, 55). In the recent years, the treatment of the appendicular mass took a turn from the traditional approach of initial conservative treatment followed by interval appendectomy to immediate appendectomy (56, 57). However, this change is not widely accepted and a large number of surgeons still continue to adopt the same traditional conservative approach (58). It is obvious thqt controversy exists as to the best approach towards this

problem and the opinion is divided about the management of appendicular masses.

Many studies showed that early surgical intervention is known to be an effective alternate to conservative therapy for a long time as it considerably reduces the total hospital stay and obviates the need for a second admission (59). At present, there is no agreed consensus on the management of appendiceal masses. There is a need to develop a protocol for the management of this common problem (60).

The value of interval appendicectomy has been increasingly questionable. The principal reasons for justifying interval appendicectomy are firstly to prevent recurrence of acute appendicitis and secondly to avoid misdiagnosing an alternative pathology such as a malignancy (61).

Kaminski et al. (2005) identified 1012 patients over a 13-year period with an appendix mass that had successful initial non-operative treatment. Eight hundred and sixty-four did not have interval appendicectomy performed. Thirty-nine of the 864 (5%) had a recurrence at a mean follow-up of 48 months. The mean time to recurrence was 10±15 months. They concluded that interval appendicectomy was not justified as the vast majority (95%) of patients successfully managed conservatively will not develop a recurrence (62, 63).

Willemsen et al. studied 233 patients who had interval appendectomy after successful initial conservative management of an appendicular mass. He found that histological examination of resection specimen showed a normal appendix without signs of previous inflammation in 30% of cases. In addition, complications due to interval appendectomy were seen in 18% of patients, including sepsis, bowel perforation, small bowel ileus, and various wound abscesses. He concluded that interval appendectomy seems unnecessary in patients who respond well to initial conservative treatment (64).

The incidence of misdiagnosing an appendix mass varies between 0% and 10%. Following non-operative management of an appendix mass, most authors consider further investigations as mandatory (65, 66, and 67). CT has been shown to be effective in diagnosing alternative pathologies that had clinically been diagnosed as an appendix mass (68).

Ahmed et al. review recent literature on interval appendicectomy; they concluded that interval appendicectomy is unnecessary in the majority of patients presenting with an appendix mass; 86-95% of the patients with an appendix mass whose symptoms resolve following conservative management will not experience a recurrence. If recurrence does occur it is likely to occur within one year and is usually associated with a milder clinical course amenable to both operative and non-operative approaches (63).

SUMMARY

Acute appendicitis remains the most common general surgical emergency seen in most hospitals and the most common cause of acute abdomen requiring surgical intervention. Typical uncomplicated cases of acute appendicitis are easy to diagnose and to treat. Diagnosis of atypical appendicitis is a difficult task and remains a clinical challenge that may test the diagnostic skills of even the most experienced surgeons. Difficulties of diagnosis of atypical cases result from variation of the anatomical position of the appendix, appendicitis occurring at extremes of age and in females during child bearing age.

Despite technologic advances, the diagnosis of appendicitis is still based primarily on the patient's history and the physical examination. Diagnostic accuracy can be improved by using various clinical scoring systems. The Alvarado scoring system is the most famous scoring system used to help with the clinical diagnosis of acute appendicitis and is very easy to apply. The positive predictive value of Alvarado score is reported as high as 85.3%, 87.5%, and 87.4% in many studies. Accuracy of diagnosis can also be improved by adoption of an active observation policy.

Laboratory investigations including WBCC and serum reactive proteins help in supporting the diagnosis of acute appendicitis rather than excluding it.

Ultrasonography may significantly improve the diagnostic accuracy in patients with suspected acute appendicitis and should be performed in some patients in whom the clinical diagnosis is equivocal. The overall sensitivity, specificity and accuracy of ultrasonography in the diagnosis of acute appendicitis were 78%, 92% and 87%, respectively.

CT scanning of patients with suspected appendicitis may reduce the number of patients admitted for observation and decrease the rate of negative appendectomy. Helical CT has reported sensitivities of 90-100%, specificities of 91-99%, accuracies of 94-98%, positive predictive values of 92-98%, and negative predictive values of 95-100%.

There is a lot of controversy associated with laparoscopy as

a diagnostic modality in the evaluation of a patient suspected of having acute appendicitis, including the question whether to remove a normal looking appendix during diagnostic laparoscopy or to leave it.

Appendectomy is the only curative treatment for acute appendicitis. Many studies claimed that laparoscopic appendectomy, compared with open surgery, reduces postoperative pain, length of hospitalisation, analgesic doses and surgery-associated complications.

Medical treatment of acute appendicitis may be helpful in isolated environments where there are no surgical capabilities until surgical resources become available. Although some studies indicated that antibiotics are an appropriate first-line treatment for adults with appendicitis without obvious signs of intra-abdominal perforation, more studies are needed to establish the role of antibiotic as a primary treatment of non-complicated appendicitis.

In the recent years the treatment of an appendicular mass took a turn from the traditional approach of initial conservative treatment to immediate appendectomy. Many studies showed that early surgical intervention is known to be an effective alternate to conservative therapy as it considerably reduces the total hospital stay and obviates the need for a second admission.

The value of interval appendicectomy has been increasingly questionable and there is strong evidence from various studies that there are no needs for interval appendicetomy after successful conservative management of an appendicular mass.

References

1. Fitz RH: Postoperative inflammation of vermiform appendix with special reference to its easy diagnosis and treatment. AMJ Medication Sci; 1886; 92:321-346
2. Douglas CD, MacPherson NE, Davidson DM, Gani JS: Randomized controlled trial of ultrasonography in diagnosis of acute appendicitis incorporating Alvarado's Score. BMJ; 2000; 321:919
3. Pesonen E, Ikonen J, Juhola M, Eskelinen M: Parameter for a knowledge base for acute appendicitis: Methods Inf Med; 1994; 33:220-226
4. Addiss DG, Shaffer N, Fowler BS, Tauxe RV: The epidemiology of appendicitis and appendectomy in the United States. Am J Epidemiol; 1990; 132: 910-925
5. Lewis FR, Holcroft JW, Boey J, Dumphy JE: Appendicitis: A critical review of diagnosis and treatment in 1000 cases. Arch Surg; 1975; 110:677-84
6. Berry J Jr, Malt RA: Appendicitis near its centenary. Ann Surg; 1984; 200:567-75
7. Khairy G: Acute appendicitis. Is removal of a normal appendix still existing and can we reduce its rate? Saudi J Gastroenterol; 2009; 15:167-70
8. Flum DR, Morris A, Koepsell T, Dellinger EP: Has misdiagnosis of appendicitis decreased over time? JAMA; 2001; 286:1748-1753
9. Jones PF: Suspected acute appendicitis: trend in management over 30 years. Br J Surg; 2001; 88:1570-7
10. Koch A, Marusch F, Schmidt U, Gastinger I, Lippert H: Appendicitis in the last decade of the 20 th century. Zentralbl Chir 2002; 127:290-6
11. Bisard D, Rosenfield JC, Estrada F, Reed JF: Institutioning a clinical guideline practice to decrease the rate of normal appendectomies. Am Surg; 2003; 69:796-8
12. Rettenbacher T, Hollerweger A, Greitzmann N, Gotwald T, Schwamberger K, Ulmer H: Appendicitis: Should diagnostic imaging be performed if the clinical presentation is highly suggestive of the disease. Gastroenterolgy 2002; 123:992-8
13. Marcia LM, David Z, Darshani N, Melinda AM, Clifford Y: Negative appendectomy rate: Influence of CT scans. Am Surg; 2005; 71:803-8
14. Mann CV: Appendix. In: Short Practice of Surgery, 22nd ed. Russel and WS Williams, 1995: 832-6
15. Hardin DM Jr: Acute appendicitis: review and update. Am Fam Physician; 1999; 60(7):2027-34.
16. Lee JF, Leow CK, Lau WY: Appendicitis in the elderly. Aust N Z J Surg; 2000; 70:593-6.
17. Koepsell TD, Inui TS, Farewell VT: Factors affecting perforation in acute appendicitis. Surg Gynecol Obstet;1981; 153:508-10
18. Shakhatreh HS: The accuracy of C-reactive protein in the diagnosis of acute appendicitis compared with that of clinical diagnosis. Med Arh; 2000; 54:109-10
19. McAdam WA, Brock BM, Armitage T, Davenport P, Chan M, de Dombal FT: Twelve years' experience of computer-aided diagnosis in a district general hospital. Ann R Coll Surg Engl; 1990; 72:140-6.
20. Malik KA, Khan A, Waheed I: Evaluation of the Alvarado score in diagnosis of acute appendicitis. J Coll Physicians Surg; 2000; 10:392-4.
21. Kalan M, Talbot D, Cunliffe WJ, Rich AJ: Evaluation of the modified Alvarado score in the diagnosis of acute appendicitis: a prospective study. Ann R Coll Surg Engl; 1994; 76:418-9
22. Owe TD, Williams H, Stiff G, Jenkinson LR, Rees BI: Evaluation of the Alvarado score in acute appendicitis. J R Soc Med; 1992; 85:87-8
23. Senbanjo RO: Management of patients with equivocal signs of appendicitis. J R Coll Surg Edinb; 1997; 42:85-8.
24. Elangovan S: Clinical and laboratory findings in acute appendicitis in the elderly. J Am Board Fam Pract; 1996; 9:75-8
25. Calder JD, Gajraj H: Recent advances in the diagnosis and treatment of acute appendicitis. Br J Hosp Med 1995; 54:129-33
26. Liu CD, McFadden DW: Acute abdomen and appendix. In: Greenfield LJ, eds. Surgery: scientific principles and practice. 2d ed. Philadelphia: Lippincott-Raven, 1997:1246-61
27. Graffeo CS, Counselman FL: Appendicitis. Emerg Med Clin North Am; 1996; 14:653-71
28. Poortman P, Lohle PN, Schoemaker CM, Oostvogel HJ, Teepen HJ, Zwinderman KA, Hamming JF. Comparison of CT and sonography in the diagnosis of acute appendicitis: a blinded prospective study. AJR Am J Roentgenol; 2003; 181:1355-9
29. Skaane P, Amland PF, Nordshus T, Solheim K: Ultrasonography in patients with suspected acute appendicitis: a prospective study. Br J Radiol; 1990; 63:787-93

30. Pinto Leite N, Pereira JM, Cunha R, Pinto P, Sirlin C: CT evaluation of appendicitis and its complications: imaging techniques and key diagnostic findings. AJR; 2005; 185:406-17
31. Jacobs JE, Birnbaum BA, Macari M, Megibow AJ, Israel G, Maki DD, Aguiar AM, Langlotz CP: Acute appendicitis: comparison of helical CT diagnosis focused technique with oral contrast material versus nonfocused technique with oral and intravenous contrast material. Radiology; 2001; 220:683-90
32. Stroman DL, Bayouth CV, Kuhn JA: The role of computed tomography, in the diagnosis of acute appendicitis. Am J Surg; 1999; 178:485-489
33. Wilson EB, Cole JC, Nipper ML, Cooney DR, Smith RW: Computed tomography and ultrasonography in the diagnosis of appendicitis: when are they indicated? Arch Surg; 2001; 136:670-5
34. Kraemer M, Ohmann C, Leppert R, Yang Q. Macroscopic assessment of the appendix at diagnostic laparoscopy is reliable. Surg Endosc; 2000; 14:625-33
35. Walker SJ, West CR, Colmer MR. Acute appendicitis: does removal of a normal appendix matter, what is the value of diagnostic accuracy and is surgical delay important? Ann R Coll Surg Engl; 1995; 77:358-63
36. Van den Broek WT, Bijnen AB, de Ruiter P, Gouma DJ. A normal appendix found during diagnostic laparoscopy should not be removed. Br J Surg; 2001; 88:251-4
37. Geis WP, Miller CE: Laparoscopic appendectomy for acute appendicitis: rationale and technical aspects. Contemp Surg; 1992; 40:13-9
38. McBurney C: The incision made in the abdominal wall in case of appendicitis with a description of a new method of operating. Ann Surg; 1894; 20-38.
39. Semm K: Endoscopic appendectomy. Endoscopy; 1983; 15(2):59-64
40. Gangal HT, Gangal MH: Laparoscopic appendicectomy. Endoscopy; 1987; 19(3):127-9
41. Attwood SEA, Hill ADK, Murphy PG: A prospective randomized trial of laparoscopic versus open appendectomy. Surgery; 1992; 112; 497-501
42. McAnena OJ, Austin 0, O'Connell PR: Laparoscopic versus open appendicectomy: a prospective evaluation. BrJ Surg; 1992; 79: 574-5
43. Cuschieri: A: Appendectomy laparoscopic or open? Surg Endosc; 1997; 11: 319-320
44. Adams ML: The medical management of appendicitis in a nonsurgical environment: a retrospective case review. Mil Med; 1990; 8:345-7
45. Styrud J, Eriksson S, Nilsson I, Ahlberg G, Haapaniemi S, Neovius G, Rex L, Badume I, Granström L: Appendectomy versus antibiotic treatment in acute appendicitis. A prospective multicenter randomized controlled trial. World J Surg; 2006; 30:1033-7
46. Hansson J, Körner U, Khorram-Manesh A, Solberg A, Lundholm K: Randomized clinical trial of antibiotic therapy versus appendicectomy as primary treatment of acute appendicitis in unselected patients. Br J Surg; 2009; 96:473-81
47. Bradley EL, Isaacs J: Appendiceal Abscess Revisited. Arch Surg; 1978; 113:130-2
48. Jordan JS, Kovalcik PJ, Schwab CW: Appendicitis with a palpable mass. Ann Surg; 1981; 193:227-9
49. Arnbjornsson E: Management of appendiceal abscess. Curr Surg; 1984; 41: 4-9
50. Ochsner AJ: The cause of diffuse peritonitis complicating appendicitis, and its prevention. JAMA; 1901; 26: 1747-54
51. Murphy JB: Two thousand operations for appendicitis. Am J Med Sci; 1904; 128: 187-197
52. Foran B, Berne TV, Rosoff L: Management of the appendiceal mass. Arch Surg; 1978; 113:1144-5
53. Janik JS, Ein SH, Shandling B, Simpson JS, Stephens CA. Nonsurgical management of appendiceal mass in late presenting children; J Pediatr Surg; 1980; 15:574-6
54. Tingstedt B, Bexe-Lindskog E, Ekelund M, Andersson R: Management of appendiceal masses. Eur J Surg; 2002; 168(11):579-82
55. Arshad M, Aziz LA, Qasim M, Talpur KA: Early appendicectomy in appendicular mass: a Liaquat University Hospital experience. J Ayub Med Coll Abbottabad; 2008; 20:70-2
56. Price MR, Haase GM, Sartorelli KH, Meagher DP Jr: Recurrent appendicitis after initial conservative management of appendiceal abscess. J Pediatr Surg; 1996; 31:291-4.
57. Garg P, Dass BK, Bansal AR, Chitkara N. Comparative evaluation of conservative management versus early surgical intervention in appendicular mass--a clinical study. J Indian Med Assoc; 1997; 95:179-80, 196
58. Erdogan D, Karaman I, Narci A, Karaman A, Cavuşoğlu YH, Aslan MK, Cakmak O: Comparison of two methods for the management of appendicular mass in children. Pediatr Surg Int; 2005; 21(2):81-3
59. Jordan JS, Kovalcik PJ, Schwab CW. Appendicitis with a palpable mass. Ann Surg; 1981; 193:227-9
60. Ahmed I, Deakin D, Parsons SL: Appendix mass: do we know how to treat it? Ann R Coll Surg Engl; 2005; 87:191-195
61. Thomas DR: Conservative management of the appendix mass. Surgery; 1973; 73:677-80
62. Kaminski A, Liu IL, Applebaum H, Lee SL, Haigh PI: Routine interval appendectomy is not justified after initial nonoperative treatment of acute appendicitis. Arch Surg; 2005; 140:897-901
63. Deakin DE, Ahmed I: Interval appendicectomy after resolution of adult inflammatory appendix mass--is it necessary? Surgeon; 2007; 5(1):45-50
64. Willemsen PJ, Hoorntje LE, Eddes EH, Ploeg RJ: The need for interval appendectomy after resolution of an appendiceal mass questioned. Dig Surg; 2002; 19:216-222
65. Verwaal VJ, Wobbes T, Goris RJA: Is there still a place for interval appendicectomy? Dig Surg; 1993; 10:285-8
66. Yamini D, Vargas H, Bongard F, Klein S, Stamos MJ: Perforated appendicitis: Is it truly a surgical urgency? Am Surg; 1998; 64:970-5
67. Bagi P, Dueholm S: Nonoperative management of the ultrasonically evaluated appendiceal mass. Surgery; 1987; 101: 602-5
68. Oliak D, Sinow R, French S, Vikram VM, Stamos MJ: Computed tomography scanning for the diagnosis of perforated appendicitis. Am Surg; 1999; 65: 959-64

Author Information

Abbas AR Mohamed, MBBS, FRCSI, FICS
Consultant General and Laparoscopic Surgeon, Department of Surgical Specialties, King Fahad Medical City

Nadeem Ahmad Bhat, MBBS, MRCSed.
Assistant Consultant General Surgeon, Department of Surgical Specialties, King Fahad Medical City