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**Review Article**

# Acute appendicitis in adults

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## ABSTRACT

Acute appendicitis is one of the commonest abdominal emergency encountered by a general surgeon. Understanding the surgical pathology is pivotal in identifying the stage of disease at which the patient presents for better correlation of clinical features, laboratory and imaging reports. Various scoring systems enhance and aid this process. Imaging confirms the diagnosis. Early diagnosis is essential to prevent complications. Surgery is the mainstay of treatment. Appendicitis may present in various forms in different clinical settings. A uniform approach to presentations may not always yield good results. Though appendectomy is the mainstay of treatment yet a tailor made surgical plan needs to be developed after holistic evaluation of the patient. The article discusses the differential surgical approach based on the etiopathogenesis, diagnosis and variable clinical presentations.

**Keywords:** Acute appendicitis, Diagnosis, Scoring, Treatment

## INTRODUCTION

Acute appendicitis is one of the most common abdominal emergency managed by a general surgeon. The worldwide incidence of appendicitis is estimated to be 86 cases per 100,000 population annually.[1,2] The life time risk of developing acute appendicitis is 8.6% in males and 6.7% in females.[2] Acute appendicitis also happens to be one of the common non-obstetric emergency during pregnancy. The incidence during pregnancy is variable. It is 6.3 per 10,000 pregnancies during the antepartum period and 9.9 per 10,000 during the postpartum period.[1,2] The overall morbidity rate during the postoperative period ranges from 9-18%.[1] The mortality rate in non-perforated appendicitis is less than 1% while the mortality rate in perforated appendicitis climbs up to 5%.[2]

## ETIOPATHOGENESIS

The disease is less common in the Asian and African subcontinent due to dietary habits. Consumption of high dietary fibre leads to decrease in the viscosity of faeces, decreased bowel transit time and reduces the formation of faecoliths, which lead to obstruction and initiation of the inflammatory cascade.[2-4] The disease is more common in males with a male to female ration of 3:2 in teenagers and young adults and 1.4 times more common in males than in females in rest of the adult population. Family history seems to play role in retrocaecal type of appendicitis. Positive family history increases the chance of having appendicitis 3.18 times. Old age, three or more co morbidities and male sex is associated with a high risk of perforation.[3]

Majority of acute appendicitis are obstructive in nature. Faecoliths, lymphoid hyperplasia, foreign bodies, malignancy and parasites are the causes of obstruction. Uncommon causes of appendicitis may be foreign bodies in the lumen such as mutton bone fragments, fish bones, fruit seeds and nuts.[2] However the incidence of this type is 0.0005%.[2] Diverticulitis of the appendix can also give rise to acute inflammation. In rare circumstances appendicitis may develop while the appendix is a content of a hernia sac in less than 1% of cases. If present in an inguinal hernia

it is designated as Amyand's while if encountered in a femoral hernia sac then it is designated as De Garengeot's hernia.[5,6] Left sided appendicitis is seen in cases of situs inversus wherein a chest ray which reveals dextrocardia is diagnostic.[7]

The pathological process passes through various stages in a sequential manner.[1,2] Obstruction leads to blockage of the lumen. The secretions are unable to drain and accumulate. The appendix distends with a concomitant increase in the intraluminal pressure. There is vascular congestion due venous and lymphatic compression thereby leading to compromise in the blood supply of the appendix. Tissue ischaemia ensures with formation of multiple abscesses in the wall. This is typically called the catarrhal stage of acute appendicitis (all three layers of the wall of the appendix discernible). There is involvement of the serosal surface as well in the inflammatory process. Bacterial invasion of the luminal wall continues. The omentum gets adherent to the inflamed appendix. This is called the phlegmonous stage (layers of the appendix wall unclear). The local circulatory compromise continues leading to infarction usually at the junction of the appendix with mesoappendix as the blood supply is inadequate. The infarcted area undergoes gangrenous changes and eventually perforates (layer stratification of the wall completely lost). Perforation usually occurs at the tip. Subsequently peritonitis develops which may either be localized to the region by way of omental and intestinal adhesions or may generalized if the omentum is deficient as seen in children.[8] If untreated bacterial peritonitis will lead to septicaemia, septic shock and multiorgan failure.

## CLINICAL FEATURES

Symptoms in acute appendicitis may not vary from case to case. However signs vary significantly due to the variable location of the appendix.

Pain is the commonest symptom. Pain is usually periumbilical or epigastric in location to start with. However with time it localizes to the right iliac fossa (Volkvich-Kocher sign). The initial location of pain represents a referred pain resulting from visceral innervation of the mid gut and subsequent localized pain is caused by involvement of the parietal peritoneum as the inflammatory pathology progresses.[2]

Anorexia is very common. Patient is unwilling to have food. If the patient wants to consume a favourite food item the clinician needs to consider other differential diagnosis instead of appendicitis (Hamburger sign). Anorexia is a very common symptom in appendicitis.[2]

Vomiting is a common accompaniment of gastrointestinal infection. It is due to reflex pylorospasm.

Fever develops as the inflammatory process progresses with development of bacteraemia. Fever with chills is seen in patients who present late with complications such as abscess formation. Fever is suggestive of advancing septic process.

In a few cases of retrocaecal appendicitis, pain may be referred to the right testis or to the right hemiscrotum.[9-11]

A multitude of signs have been described for diagnosing acute appendicitis.[2]

Tenderness at the Mac Burney's point is pathognomonic in majority of cases. The only exception could be retrocaecal appendicitis. In addition to this there may be tenderness at the Lanz's and Munro's point. In pregnant women the signs may be seen higher up in the abdomen.

Tenderness in the right iliac region which is aggravated by postural change of the patient from supine to recumbent is designated as Rosenstein sign.

Blumberg's sign is pain elicited by steadily increasing pressure at the site of tenderness increases on abrupt release of the pressure (rebound tenderness)

Rovsing's sign is palpation of the left lower abdomen causing pain and discomfort in the right iliac region.

Psoas sign (Obreztsova's sign, Cope's psoas test) with the patient lying in left lateral position, extension of the right thigh will elicit pain due to the irritation caused to the right psoas muscle by the tip of an inflamed appendix.

Obturator sign is flexion and internal rotation of the right hip eliciting severe pain due to irritation of the obturator internus muscle caused by an inflamed appendix.

Markle test (heel drop jarring) elicits pain on walking or with jolts and is suggestive of peritoneal irritation.[2]

Discomfort or cutaneous hyperesthesia in the Sherren's triangle (triangle formed between the umbilicus, pubic tubercle and anterior superior iliac spine).

Massouh sign is swishing two finger tips starting on the xiphoid down towards the left and right iliac fossa will cause hyperaesthesia on the right side due to peritoneal irritation.[2]

K sign is named after the region of origin that is Kashmir.[12] It is seen in retrocaecal or paracolic postions of appendicitis. Percussion or palpation of the posterior abdominal wall co exists with psoas sign.

Symptoms and more so physical signs are difficult to interpret during pregnancy. Hence clinical examination just by itself does not suffice to even arrive at a provisional diagnosis and therefore needs imaging to confirm the diagnosis.

A retrocecal position of an acutely inflamed appendix may at times pose a clinical and diagnostic dilemma. Varied

clinical presentations need to be kept in mind while evaluating such patients.[10-13] There may be an abscess in the retrocecal and subhepatic region, retroperitoneal necrotising fasciitis, acute right sided scrotal pain and inflammation (Fournier's gangrene) and retroperitoneal abscess tricking to the right thigh.

Due to a vast variability in symptoms and signs in acute appendicitis one needs to be aware of all possibilities including anecdotal variations in presentation in order to avoid delay in the diagnosis. Delay in the diagnosis may be detrimental as the morbidity as well as mortality may rise.

## DIAGNOSIS

Meticulous evaluation of symptoms and signs can immensely help in arriving at a diagnosis of acute appendicitis especially in the adult population of patients. Various scoring systems have been developed which enable a systematic evaluation of relevant clinical features. Addition of laboratory values add to the accuracy of diagnosis. Two such scoring systems have been developed for evaluation of adults with suspected acute appendicitis.

The Alvarado score was the initial system (Table 1a). It is a very lucid way of quantification of scores and has very good diagnostic accuracy. Based on the score the surgeon can arrive at a tentative diagnosis of acute appendicitis and thereafter proceed to imaging for confirming the diagnosis (Table 1b).[14,15]

**Table 1: (a) Alvarado score.**

| Symptoms/signs | Points |
|---|---|
| **Migration of pain** | 1 |
| **Anorexia** | 1 |
| **Nausea/vomiting** | 1 |
| **Right lower quadrant tenderness** | 2 |
| **Rebound pain** | 1 |
| **Temperature above 37.3ºC** | 1 |
| **Leucocytosis >10,000** | 2 |
| **PMN >75%** | 1 |
| **Total possible score** | 10 |

**Table 1: (b) Interpretation of Alvarado score.**

| Risk | Alvarado score |
|---|---|
| **High risk** | 7 or more |
| **Moderate risk** | 4 to 6 |
| **Low risk** | <4 |

Another efficient scoring system applicable to the adult population is the appendicitis inflammatory response score.[16] This score has similarity to the Alvarado score. However it gives points to the various levels of severity to four variables. These include rebound pain, leucocytosis, and percentage of polymorphonuclear neutrophils (PMN) and C-reactive protein (CRP) levels (Table 2). This makes the scoring system more elaborate in judging the severity of the inflammatory response.[17] The paediatric appendicitis is a modified system for assessing pediatric population.

**Table 2: Appendicitis inflammatory response score.**

| Symptoms/signs | Points |
|---|---|
| **Vomiting** | 1 |
| **Right iliac fossa pain** | 1 |
| **Rebound pain, light** | 1 |
| **Rebound pain, medium** | 2 |
| **Rebound pain, strong** | 3 |
| **Temperature > 38.5$^0$C** | 1 |
| **Leucocytosis 10,000 to 14,900** | 1 |
| **Leucocytosis ≥ 15,000** | 2 |
| **PMN 70-84%** | 1 |
| **PMN ≥ 85%** | 2 |
| **CRP 10-49 g/l** | 1 |
| **CRP ≥ 50 g/l** | 2 |
| **Total possible score** | 12 |

Any of the two scoring systems can be used for initial risk assessment of the patient with abdominal pain. This avoids delay in the diagnosis which can be detrimental to a successful therapeutic outcome.

## INVESTIGATIONS

Laboratory tests which are relevant and help in the diagnosis of acute appendicitis include complete blood count, CRP levels, urine examination and a urinary pregnancy test in female patients.[1,2] Raised total leucocyte count with predominant polymorphonuclear neutrophils is highly suggestive of acute bacterial inflammation and correlates with the severity of the inflammatory reaction. However in pregnant women this finding has to be interpreted cautiously as there is a physiologically raised WBC count. CRP levels confirm the presence of inflammation. Levels >1 mg/dl are present in acute appendicitis. Very high levels are seen in gangrenous appendicitis. Raised CRP with neutrophilic leucocytosis is highly suggestive of complicated acute appendicitis. A normal value of CRP has a negative predictive value of 97-100% for appendicitis.[16] Urine examination may not always be diagnostic. However it rules out urinary tract infection especially in females. Presence of RBC's in the urine may be suggestive of irritation of the ureter or bladder by a severely inflamed appendix. A urinary pregnancy test is mandatory in female patients to rule out pregnant state as a ruptured ectopic pregnancy can closely mimic appendicitis. In advanced presentations such as perforated appendix, the total bilirubin will also be raised.

Once a tentative diagnosis of acute appendicitis is made the surgeon needs to confirm the diagnosis by imaging modalities before formulating a treatment strategy. Radiological investigations undoubtedly hold a promising position and have a definitive role to play.[18]

A plain X-ray of the abdomen is commonly done in all patients presenting with abdominal pain.[19] Presence of a faecolith in the form of a radiopaque density and localized ileus in the region of the right lower abdomen are suggestive of the diagnosis. Faecal loading may be seen in patients presenting as right iliac fossa pain who are suffering from acute appendicitis. A perforated appendix will hardly give rise to gas under the diaphragm.

Ultrasonography (USG) of the abdomen is first line investigation for diagnosis of acute appendicitis.[20] It has high sensitivity of 85%. A normal appendix is usually not picked up by USG. However when inflamed it enlarges in size rendering it visible on USG. A non-compressible tubular structure with diameter greater than 6 mm is diagnostic. Presence of periappendiceal or pericaecal fluid may be a usual accompaniment. However the findings may not always be so distinct. The challenge is in diagnosing cases where symptoms don't match with abdominal signs. If studied in detail the findings on USG are: hypertrophy of the appendicular wall, disturbance of the normal layered structure, destruction of the wall, purulent fluid or faecoliths within the appendicular lumen, high periappendicular echoes suggest the aggregation of omentum and other soft tissues like the small intestine what is classically described as an appendicular lump and periappendicular accumulation of fluid suggests an abscess formation secondary to a perforation in most cases.

The Kojima classification of appendicitis is based on the following USG criteria: high echo bands representing the submucosal layer, presence or absence of an appendix and length of the shorter diameter of the appendix.[2]

Based on these USG criteria one can identify the pathological stage of appendicitis (Table 3).

**Table 3: Correlation of pathological stage of acute appendicitis with USG findings.**

| Type | Pathological diagnosis | Layer structure of the appendicular wall | Submucosal layer |
|---|---|---|---|
| **I** | Catarrhal | Clear | No hypertrophy |
| **II** | Phlegmonous | Indistinct | Hypertrophied |
| **III** | Gangrenous | Disrupted | Indistinct and partly lost |

USG is essential investigation for diagnosing appendicitis in pregnant women. A graded compression ultrasound is more sensitive and specific. However the diagnostic efficacy decreases after 35 weeks of gestational age due to technical difficulties. The sensitivity is 18% and specificity is 99% in pregnant women. Hence MRI scores over USG in diagnosing appendicitis during pregnancy.

Computed tomography (CT) is the investigation of choice wherein USG is inconclusive.[21,22] Findings on CT are: hypertrophy of the appendiceal wall, enlargement of the appendix (diameter >6 mm), appendix mass, periappendiceal abscess formation, presence of faecolith, increased density of the periappendiceal adipose tissue and fluid filled pouch of Douglas.

CT can reveal an enlarged appendix but cannot reveal the structure of the appendiceal wall unlike USG. Hence USG is superior to CT for assessing the severity of appendicitis depending upon mural changes in the inflamed appendix.

MRI is the first line imaging modality for pregnant patients of any gestational age with suspected appendicitis.[23,24] It has sensitivity of 100% and specificity of 98%. There is no increased risk to the foetus. However gadolinium enhanced MRI in pregnancy is associated with increased risk of rheumatological, inflammatory and infiltrative skin conditions since birth. Still births and neonatal deaths have also been reported.

## DISCUSSION

Early diagnosis is pivotal for good outcomes. Delay in diagnosis can lead to increased morbidity and even mortality. Hence treatment should commence immediately after a confirmation of diagnosis. The initial treatment is supportive. It comprises of rehydrating the patient, administration of antibiotics and analgesia. Once the patient is hemodynamically stabilised by way of reduced tachycardia, stable blood pressure and improved urine output can one contemplate surgical intervention. Associated co-morbidities if present should be optimised as far as possible.

After the initial resuscitative measures are completed a clinical reassessment is essential. Depending on the duration of symptoms and the interval between onset of symptoms and presentation to hospital, the surgeon needs to ascertain whether surgery is feasible or not. This is dictated by the absence or presence of a lump or features of peritonitis.

If patient presents early that is before the formation of a lump then surgery is the mainstay of treatment. Open appendectomy (OA) or laparoscopic appendectomy (LA) is the treatment of choice.[23,24] It is a matter of experience or availability of expertise which dictates the approach. It is important that irrespective of the approach, the pathology has to be removed without any residual disease thereby having extremely low morbidity and no mortality at all.

Mac Burney's grid iron incision continues to be the standard open approach for appendectomy for established cases. However if one anticipates operative difficulties or in female patients then a right lower para median or lower midline approach is justified. Inversion of the stump which once upon a time was a standard practice is no longer done.

The inverted stump may serve as an apex for intussusception. Covering the stump with omentum prior to closure of the incision is a safe practice at it reduces significantly the chances of postoperative adhesions.

LA has certain distinct benefits over the open procedure.[25] In female patients a variety of adnexal pathologies can closely mimic acute appendicitis and pose both a clinical as well as imaging dilemma.[26] Laparoscopic approach allows confirmation of diagnosis. The standard three port technique enables successful appendectomy in majority of patients. Extensive adhesions obscuring anatomical identification as seen in complicated appendicitis and adhesions due to previous lower abdominal surgery are indications for conversion. The other advantages of LA are decreased incidence of surgical site infections, pain, incisional hernias and short hospital stay.[27-29]

Other forms of minimal access surgery are single incision laparoscopic surgery (SILS) and natural orifice transluminal endoscopic surgery (NOTES).[30,31] However lack of expertise and evidence to support these methods have led to decreased utilisation of these methods.

In patients who present late with the formation of a lump or phlegmon, conservative approach is advisable. This comprises of intravenous antibiotics and fluids till the inflammatory process settles followed by an interval appendectomy. This reduces the chances of damaging the adherent bowel and a faecal fistula.

15-25% of patients undergo appendectomy for a non-inflamed appendix during the course of surgery for suspected appendicitis.[32] This is described as negative or white appendectomy. The logic underlying this concept is that leaving behind a normal appendix will have a chance of developing appendicitis at a later date or an appendicular malignancy could be missed.[33] However with the advent of excellent imaging modalities and laparoscopic technology the incidence of negative appendectomy should be as low as possible.

Perforated appendix may present with localized peritonitis or generalized peritonitis. Localized peritonitis is in the form of an abscess. An appendicular abscess needs individualized treatment. Besides supportive therapy, invasive intervention does become necessary. USG guided aspiration of the abscess cavity is the mainstay of treatment. However, if the cavity is large with significant features of sepsis then an extra peritoneal drainage is necessary.

Generalized peritonitis will require a formal laparotomy. The inflamed and perforated appendix can be dealt with meticulously. More surgical options can be exercised in case of friability of the caecum such as Z stitch. This has the added advantage of clearing the peritoneal cavity of pus and administering a rigorous saline lavage. Adequate drainage of the peritoneal cavity is mandatory to prevent the formation of residual abscesses. This can be done even by laparoscopic approach. But drainage may at times be inadequate leading to residual abscess formation.

Appendicular involvement in ulcerative colitis (UC) may clinically closely simulate routine appendicitis.[34] However the histologic appearance is similar to involved colon during a UC flare with chronic inflammatory changes and characteristic crypt abscesses. Therefore patients of UC who present with right lower quadrant pain and have features suggestive of appendicitis on CT should not be subjected to appendectomy. Instead they should be started on antibiotics as a part of conservative approach followed by colonoscopy after attaining a quiescent state or remission.

Similarly, patients of abdominal tuberculosis with lump in the right iliac fossa presenting with features suggestive of acute appendicitis should be managed conservatively. Appendectomy performed in these patients can lead to the formation of an intractable faecal fistula.[35]

Surgical management of appendicitis during pregnancy is a great challenge. If surgery is contemplated the surgeon needs to evaluate the duration of pregnancy or the size of the gravid uterus and identify the location of the caecum and appendix ether by USG or by MRI. This will enable precise choice of the incision. If expertise is available then a laparoscopic approach may be contemplated.[28] However a calculated risk to the pregnancy always remains which has to be explained to the patient.

An inflamed appendix in an inguinal or femoral hernia sac is the biggest challenge to the surgeon. Appendectomy can safely be performed through the groin incision. However prosthetic repair of the hernia needs to be avoided as the chances of the prosthesis getting infected is extremely high despite all aseptic precautions being taken.[5,6]

It is good surgical practice to open a specimen of appendix at the time of surgery. This has twofold purpose viz. confirmation of the inflammatory pathology and ruling out the presence of a tumour. The commonest tumour of the appendix is a carcinoid. Adenocarcinoma of the appendix is rare. As majority of appendectomies are done as emergency procedures at odd hours, it is advisable to complete the surgery. In the event of a tumour being found intraoperatively the surgeon should await the histological diagnosis. This should be followed by staging of the tumour. A definitive surgery should be performed at a later date.

With more appendectomies being done laparoscopically the incidence of stump appendicitis is increasing proportionately.[36,37] Stump appendicitis is defined as the development of obstruction and inflammation of the residual appendix after appendectomy. As this is a poorly defined condition it has always been under reported. The presentation is indistinguishable from acute appendicitis. The patient may present with this condition as early as from 2 months to 20 years after appendectomy. The length

of the residual stump is responsible for developing this condition. Traditional recommendation of the stump length was 5 mm to prevent stump appendicitis. However most recent recommendation is that it should be less than 3 mm long. This is specifically pertinent to laparoscopic approach. A single endoloop is sufficient. There is no need to apply two endoloops as the residual stump length increases significantly.[37] A CT will reveal the following findings in stump appendicitis: remnant of appendicular lumen, luminal dilatation, pericaecal inflammatory reaction and abscess formation.

Stump appendicitis also has a high propensity to perforate to extent of 60%.[37] Duplication of the appendix is a rare condition which could closely mimic stump appendicitis. Treatment is completion appendectomy either open or laparoscopically.[36]

## CONCLUSION

An elaborate history and meticulous physical examination is pivotal for early diagnosis of acute appendicitis in adults. Scoring systems are a useful adjunct to diagnosis. Imaging modalities and laboratory investigations help in ascertaining the clinical diagnosis. Surgery is the mainstay of treatment. However, the therapeutic approach will vary depending upon the stage at which the patient presents. Awareness of therapeutic strategies in situations with concomitant conditions is necessary to prevent untoward complications.

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## REFERENCES

1. Petroianu A. Diagnosis of acute appendicitis. Int J Surg. 2012;10:115-9.
2. Alfredo A. Clinical approach in the diagnosis of acute appendicitis, current issues in the diagnostics and treatment of acute appendicitis. 2018. Available at: https://www.intechopen.com/books/current-issues-in-the-diagnostics-and-treatment-of-acute-appendicitis/clinical-approach-in-the-diagnosis-of-acute-appendicitis. Accessed on 01 June 2020.
3. Gurleyik G, Gurleyik E. Age related clinical features in older patients with acute appendicitis. Eur J Emerg Med. 2003;10(3):200-3.
4. Petroianu A, Alberti L, Zac RI. Assessment of the persistence of fecal loading in the cecum in presence of acute appendicitis. Int J Surg. 2007;5:11-6.
5. Vagholkar K, Pawanarkar A, Vagholkar S, Pathan K. Amyand's hernia: a need for greater surgical awareness. Int J Adv Med. 2016;3:145-7.
6. Vagholkar K, Pawanarkar A, Vagholkar S, Pathan K, Pathan S. De Garengeot's hernia: a surgical surprise. Int Surg J. 2016;3:471-2.
7. Singla A, Rajaratman J, Singla AA. Unusual presentation of left sided appendicitis in elderly male with asymptomatic midgut rotation. Int J Surg Case Rep. 2015;17:42-4.
8. Almaramhy HH. Acute appendicitis in young children less than 5 years: review article. Ital J Pediatr. 2017;43:15.
9. Buzatti KC, Goncalvez MV, Da Silva R, Rodrigues BP. Acute appendicitis mimicking acute scrotum: a rare complication of a common abdominal inflammatory disease. J Coloproctol. 2018;1:65-9.
10. Carmignani CP, Ismail S, Ganz J, Kalan MMH. Retroperitoneal necrotizing soft tissue infection after appendicitis. Surgical Rounds. 2005:283-4.
11. Sharma SB, Gupta V, Sarma SC. Acute appendicitis presenting as thigh abscess in a child: a case report. Pediatr Surg Int. 2005;21(4):298-300.
12. Wani I. K-sign in retrocecal appendicitis: a case review series. Cases J. 2009;2:157.
13. Tamir IL, Bongard FS, Klein SR. Acute appendicitis in the pregnant patient. Am J Surg. 1990;160(6):571-5.
14. Alvarado A. A practical score for the early diagnosis of acute appendicitis. Annals of Emergence Medicine. 1986;15(5):557-64.
15. Tade AO. Evaluation of Alvarado score as an admission criterion in patients with suspected diagnosis of acute appendicitis. West Af J Med. 2007;26(3):210-12.
16. Scott AJ, Mason SE, Arunakirinathan M, Reissis Y, Kinross JM, Smith JJ. Risk stratification by the appendicitis inflammatory response score to guide decision-making in patients with suspected appendicitis. Br J Surg. 2015;102(5):563-72.
17. Kollár D, McCartan DP, Bourke M, Cross KS, Dowdall J. Predicting acute appendicitis? A comparison of the Alvarado score, the appendicitis inflammatory response score and clinical assessment. World J Surg. 2015;39(1):104-9.
18. Debnath J, George RA, Ravikumar R. Imaging in acute appendicitis: what, when, and why. Med J Armed Forces India. 2017;73:74-9.
19. Bin Ismail HM, Malik A. Will plain abdominal x-ray become obsolete?. Open J Radiol. 2017;2(2):32-7.
20. John H, Neff U, Kelemen N. Appendicitis diagnosis today: clinical and ultrasound deductions. World J Surg. 1993;17:243-9.
21. 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.
22. Ong EMW, Venkatesh K. Ascending retrocecal appendicitis presenting with right upper abdominal pain: utility of computed tomography. World J Gastroenterol. 2009;15(28):3576-9.

23. Konrad J, Grand D, Lourenco A. MRI: first-line imaging modality for pregnant patients with suspected appendicitis. Abdominal Imaging. 2015;40(8):3359-64.
24. Lim SG, Ahn EJ, Kim SY, Chung IY, Park JM, Park SH, Choi KW. A clinical comparison of laparoscopic versus open appendectomy for complicated appendicitis. J Korean Soc Coloproctol. 2011;27:293-7.
25. Markar SR, Venkat-Raman V, Ho A, Karthikesalingam A, Kinross J, Evans J, Bloom I. Laparoscopic versus open appendicectomy in obese patients. Int J Surg. 2011;9:451-5.
26. Cariati A, Brignole E, Tonelli E, Filippi M, Guasone F, De Negri A, Novello L, Risso C, Noceti A, Giberto M, Giua R. Laparoscopic or open appendectomy: critical review of the literature and personal experience. G Chir. 2001;22:353-7.
27. Navez B, Therasse A. Should every patient undergoing laparoscopy for clinical diagnosis of appendicitis have an appendicectomy?. Acta Chir Belg. 2003;103:87-9.
28. Vettoretto N, Agresta F. A brief review of laparoscopic appendectomy: the issues and the evidence. Tech Coloproctol. 2011;15:1-6.
29. Pearl J, Price R, Richardson W, Fanelli R. Guidelines for diagnosis, treatment, and use of laparoscopy for surgical problems during pregnancy. Surg Endosc. 2011;25:3479-92.
30. Asarias JR, Schlussel AT, Cafasso DE, Carlson TL, Kasprenski MC, Washington EN, Lustik MB, Yamamura MS, Matayoshi EZ, Zagorski SM. Incidence of postoperative intraabdominal abscesses in open versus laparoscopic appendectomies. Surg Endosc. 2011;25:2678-83.
31. Gill RS, Shi X, Al-Adra DP, Birch DW, Karmali S. Single incision appendectomy is comparable to conventional laparoscopic appendectomy: a systematic review and pooled analysis. Surg Laparosc Endosc Percutan Tech. 2012;22:319-27.
32. Huang C, Huang RX, Qiu ZJ. Natural orifice transluminal endoscopic surgery: new minimally invasive surgery come of age. World J Gastroenterol. 2011;17:4382-8.
33. Jaunoo SS, Hale AL, Masters JP, Jaunoo SR. An international survey of opinion regarding investigation of possible appendicitis and laparoscopic management of a macroscopically normal appendix. Ann R Coll Surg Engl. 2012;94:476-80.
34. Van Vlodrop V, Pattyn P, Ceelen W. Management of the 'normal' appendix during surgery for right fossa syndrome: proposed clinical algorithm. Acta Chir Belg. 2007;107:8-11.
35. Jahadi MR, Shaw ML. The pathology of the appendix in ulcerative colitis. Dis Colon Rectum. 1976;19:345-9.
36. Subramanian A, Liang MK. A 60-year literature review of stump appendicitis: the need for a critical view. Am J Surg. 2012;203(4):503-7.
37. Bu-Ali O, Al-Bashir M, Samir HA, Abu-Sidan FM. Stump appendicitis after laparoscopic appendectomy: casereport. Ulusal Travmave Acil Cerrahi Dergisi. 2011;17(3):267-8.


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