Acute appendicitis

Frances Dixon
Anjana Singh

Abstract

Acute appendicitis is inflammation of the vermiform appendix. It is the commonest general surgical emergency in children and young adults, yet its diagnosis can still confound even the most skilled surgeon due to its highly variable presentation of appendicitis, with fewer than 50% of patients exhibiting classical features. Taking a detailed history and performing a careful examination remains the cornerstone of diagnosis. Urinalysis and blood tests, particularly C-reactive protein, are useful adjuncts and are performed routinely. Radiological imaging, commonly ultrasound and computed tomography scans, also have a role when the diagnosis is unclear and/or other common conditions need to be excluded, such as gynaecological pathology in young females. Nevertheless 20% of appendices removed in UK are histologically normal. Appendicitis scoring systems may further assist in stratifying risk and increasing the accuracy of diagnosis. Recently, there has been growing interest in non-surgical management of appendicitis, particularly during the COVID-19 pandemic. Antibiotics alone have been used to successfully treat uncomplicated appendicitis (without perforation, abscess or gangrene) in the short-term, however nearly 40% of these cases eventually require appendicectomy. Surgery, usually laparoscopic appendicectomy, remains the treatment of choice for acute appendicitis and non-operative management is reserved for specific cases.

Keywords Appendicitis; appendicectomy; laparoscopy; negative appendicectomy; right iliac fossa pain

Introduction

Appendicitis is the most common general surgical emergency worldwide and is a cause of significant morbidity and mortality, particularly in the developing world. Its presentation and management is not always straightforward. The signs and symptoms are often non-specific and can mimic other pathology which adds to the complexity and challenges of making the correct diagnosis. With the aid of imaging, scoring systems and a broader range of treatment options, contemporary management of appendicitis is becoming more sophisticated and precise. In this article we examine the background, investigations, options for treatment and areas of controversy in the current management of acute appendicitis.

Frances Dixon *MBBS BSc MRCS is a Surgical Research Fellow at Milton Keynes University Hospital & Registrar in the Thames Valley Deanery, UK. Conflicts of interest: none declared.*

Anjana Singh *BSC MRCS MD FRCS is a Consultant Laparoscopic General and Colorectal Surgeon at Milton Keynes Hospital University Foundation Trust, Milton Keynes, UK. Conflicts of interest: none declared.*

The appendix

The vermiform appendix is a short, blind-ended outpouching from the caecum. It is histologically similar to the neighbouring large bowel, with an outer serosal layer of peritoneum, a muscular layer, and an inner mucosal layer with multiple mucin-secreting goblet cells. However, there is also a large amount of lymphoid tissue within the submucosa, which can become inflamed in response to infection. The location of the appendix base at the convergence of the taenia coli is anatomically consistent, but the rest of the appendix can be located anywhere from the pelvis to behind the caecum or ileum (Figure 1). The length of the appendix is usually 7–10 cm but can be up to 26 cm. Blood supply is via the appendicular artery, which lies within the free edge of the mesoappendix terminating at the tip of the appendix and is a branch of the ileocolic artery which in turn is a branch of the superior mesenteric artery. The appendix is visible from the 8th week in-utero and is part of the midgut. During embryological development the midgut rotates counter-clockwise, leading to the final position of the caecum and appendix in the right iliac fossa. Intestinal malrotation can cause the appendix to be located near the gallbladder in the right upper quadrant, or even in the left upper quadrant. Very rarely there may be congenital absence of the appendix.

It was widely thought that the appendix is a vestigial organ with no useful function, but there is increasing evidence that it may play an important role in the immune modulation of the gut.[1] It is postulated that it acts as a reservoir for beneficial bacteria and aids re-colonization of the rest of the gut, e.g. after a diarrhoeal illness such as *Clostridium difficile* infection. Interestingly, appendicectomy prior to diagnosis of ulcerative colitis can decrease the risk of requiring a colectomy, although potentially carries an increased risk of colorectal cancer in this patient population.[2]

Appendicitis is defined as inflammation of the appendix and is thought to usually occur due to obstruction of the lumen causing local infection, which is unable to drain from the appendix due to the blind-ending nature of the organ. Subsequent swelling can then lead to local ischaemia, necrosis, bacterial translocation, and potentially perforation with the development of a contained abscess or generalized peritonitis. Obstruction is most commonly due to a calcified faecolith but may also be related to hyperplasia of the lymphoid tissue (usually in response to viral infection), neoplasia, parasitic infections such as worms, or even foreign bodies. Chronic occlusion can lead to a swelling containing mucin, termed mucocoele of the appendix, which requires removal due to the small risk of underlying malignancy. Appendicitis can also occur in the absence of any luminal obstruction and the reasons for this are as yet unclear. Theories include genetic predisposition, environmental triggers and various infective agents.

History

The appendix is named ‘vermiform’ after the Latin for “worm-like”, based on its appearance. The nomenclature is credited to Andreas Vesalius in 1543. The appendix also appears in 16th century anatomical drawings by da Vinci and Eustachius.

The first published description of acute appendicitis was in 1886 by Reginald Heber Fitz, a Harvard pathologist who introduced the term ‘appendicitis’. However, the very first documented appendicectomy took place earlier in 1735 in France, performed by

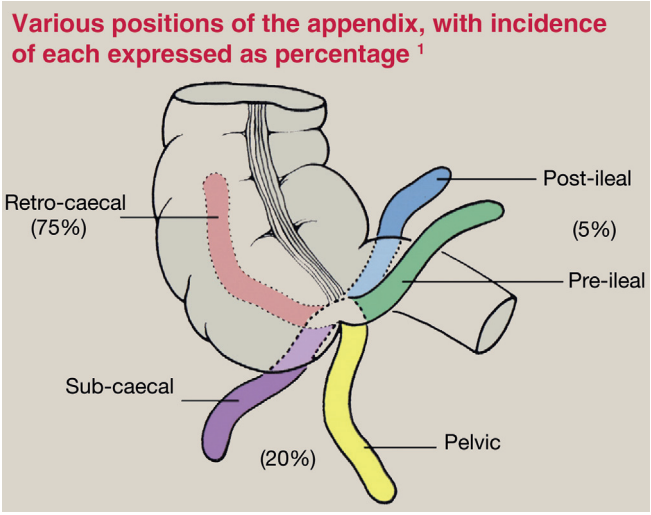

Figure 1

Claudius Amyand for a patient with a perforated appendix within the sac of an inguinal hernia (Amyand's hernia). British surgeon Lawson Tait performed the first documented appendicectomy for acute appendicitis in 1880. The technique was subsequently refined by Charles McBurney, who also described McBurney's point — two-thirds of the way from the umbilicus to the anterior superior iliac spine — theoretically the point of maximal tenderness in acute appendicitis. In the late 20th century, laparoscopic surgery started increasing in its use, and in 1980 the first laparoscopic appendicectomy was performed by a German gynaecologist called Kurt Semm. This is now the standard approach for adult appendicectomy worldwide.

Epidemiology

The lifetime risk of appendicitis is approximately 7%, with around 35,000 appendicectomies being performed per year in the UK. The incidence of appendicitis is highest in older children and young adults, but can theoretically present at any age, with a male to female ratio of 1.4:1. Young children tend to have a wider, funnel-shaped appendix, which reduces the likelihood of occlusion and therefore of developing appendicitis. In older people the lumen is often obliterated, with similar effect. Appendicitis is a global problem but there is a wide variance in incidence between countries, with an increase in incidence being recorded in newly industrialized nations. It has been hypothesized that a low dietary fibre intake predisposes to appendicitis, which may explain the higher incidence in Western countries. Global incidence tends to be lower in winter as opposed to summer, for unknown reasons.[3]

Mortality from acute appendicitis in developed countries is low, at 0.3%, but rises significantly to 1.7% after perforation and up to 5% following generalized peritonitis, demonstrating the importance of early diagnosis and treatment.[4]

Presentation

The typical symptom of appendicitis is gradual onset of central abdominal pain which then localizes to the right iliac fossa (RIF) after around 24 hours. The pain is initially transmitted by visceral sensory fibres with referral to the T10 dermatome, at the level of the umbilicus. As the inflammation worsens, local peritoneal irritation occurs in the RIF and somatic sensory nerve fibres are stimulated, leading to radiation of pain to the right lower quadrant. This pain tends to be constant, rather than the initial intermittent, colicky central abdominal pain. However, the numerous anatomical locations of the appendix mean that the presenting symptoms can vary greatly. The retro-caecal appendix is unlikely to directly irritate the peritoneum and patients may complain of right loin tenderness. Similarly, a pelvic appendix may cause groin pain or urinary symptoms including haematuria or dysuria. A retro-ileal appendix can be challenging to diagnose as the pain can be very difficult to localize and diarrhoea may feature heavily. The National Institute for Health and Care Excellence (NICE) suggest that the classic symptoms of appendicitis may only be present in 50% of cases.

A thorough pain history including radiation, duration and exacerbating factors is essential. Increased pain on passing over speed bumps during the journey to hospital, likely due to exacerbation of local peritoneal irritation, has good sensitivity, though not specificity, for appendicitis.[5] Pain on walking or coughing is also similarly indicative.

Appendicitis is often associated with low-grade pyrexia but presence of a high fever may suggest perforation and widespread peritonitis. Anorexia is very common, sometimes alongside nausea and vomiting. A full menstrual and sexual history should be taken in women to assess for the possibility of an underlying gynaecological cause for the pain. Family history of bowel disorders such as cancer or inflammatory bowel disease is important. Many symptoms are non-specific and it is important to perform a full systems enquiry to distinguish appendicitis from other differential diagnoses (Table 1).

Examination

General examination may reveal flushed cheeks, coated tongue and foetor. Patients with acute appendicitis prefer to lie still; children may lie with one or both hips flexed. Very young children may need to be examined in their mother's lap initially to build rapport. Palpation at McBurney's point will elicit tenderness and guarding. Rebound tenderness can be elicited by gently tapping over the area. However, this can be distressing for children, and methods such as rocking the child's abdomen from side to side while they are lying down or asking them distend and 'suck in' their abdomen or to jump up and down by the bed are alternative ways to assess local peritonism.

Findings of a rigid abdomen on examination, i.e. generalized guarding, in the context of a typical history, indicates diffuse peritonitis due to a perforated appendix. The appendix is perforated in approximately 20% of patients at presentation.[6] There may be associated septic shock. Other diagnoses such as pancreatitis, perforated cancer and gynaecological pathology should be considered depending on patient characteristics.

Examination may reveal a palpable RIF mass, indicating an appendiceal mass or an underlying bowel cancer, both warrant further investigation. Other unusual presentations of appendiceal perforation include retroperitoneal abscess formation, liver abscess from spread of infection through the portal-venous system, entero-cutaneous fistula from abscess fistulizing to the skin,

Differential diagnoses of right iliac fossa pain according to different patient groups

Child	Adult	Additional considerations in females
Gastroenteritis	Ureteric colic	Gynaecological
Mesenteric adenitis	Gastroenteritis	• Ectopic pregnancy
Meckel's diverticulitis	Testicular torsion	• Pelvic inflammatory disease
Intussusception	Visceral perforation, e.g. peptic ulcer	• Torsion/rupture of ovarian cyst
Testicular torsion	Pancreatitis	• Endometriosis
Diabetic ketoacidosis	Inflammatory bowel disease	• Mittelschmerz
Urinary tract infection	Caecal diverticulitis	Obstetric
Pneumonia	Torted epiploic appendage	• Round ligament syndrome
Sickle cell crisis	Rectus sheath haematoma	• Pyelonephritis
Henoch–Schönlein purpura	Non-specific abdominal pain	Older adults
	Pneumonia	Intestinal obstruction
		Colon cancer
		Diverticulitis
		Mesenteric infarction
		Leaking aortic aneurysm

Table 1

small bowel obstruction and even pylephlebitis (septic portal vein thrombosis) which can mimic cholangitis.

There are several specific tests for appendicitis which can be worthwhile adjuncts to an abdominal examination:

- Rovsing's sign – palpation in the left iliac fossa causes pain in the RIF, due to stretching of irritated peritoneum
- Cope's obturator sign – flexion and internal rotation of the hip causes pain due to local irritation of the obturator muscle by an inflamed pelvic appendix
- Iliopsoas sign – flexion of the thigh against resistance causes pain due to inflammation of the psoas muscle.

A genital examination should always be performed in males to exclude testicular torsion or a hernia, which can cause referred pain to the abdomen. Digital rectal examination is sometimes recommended in adults if an alternative diagnosis such as bowel obstruction is suspected, but not in children.

Mesenteric adenitis is an important differential diagnosis for RIF pain in children and an alternative source of infection must be ruled out. To this end, the cervical lymph nodes, respiratory system, ears, nose and throat must be examined. Presence of pathology does not rule out appendicitis but it may suggest a more cautious approach such as serial assessment.

Investigation

A young man with typical symptoms and signs for appendicitis can proceed straight to surgery after simple routine tests. However, there are several groups in whom diagnosis can be complex and further investigations are required.

Routine bedside tests include urinalysis and pregnancy testing. Presence of leucocytes on urinalysis may indicate inflammation of a pelvic appendix, or an alternative diagnosis such as a urinary tract infection. In females of childbearing age, urinary β-human chorionic gonadotrophin levels must be checked to rule out an ectopic pregnancy.

Blood tests including inflammatory markers and a group & screen should be taken. Normal inflammatory markers have a good negative predictive value and serial tests improve diagnostic sensitivity. Blood amylase can rule out pancreatitis.

Ultrasound (US) is often used as first line imaging for those in whom the clinical signs are equivocal or alternative pathology is suspected. It has the advantages of being safe and non-invasive, with no ionizing radiation exposure.[7] However, it is operator dependent and the appendix may not be visualized due to overlying bowel gas, making the scan non-diagnostic. Generally better views are obtained in children due to their smaller size and it can often be diagnostic. Positive US findings for appendicitis include non-compressibility, peri-appendiceal fluid, and wall thickening.

Computed tomography scanning (CT) is more diagnostically accurate than US, but involves exposure to a high dose of radiation. One study showed that a single abdominal CT with contrast is equivalent to 234 chest X-rays, and a 20-year old female who undergoes an abdominal CT scan has a 1 in 470 chance of developing a cancer related to this scan.[8] In adults over 40 years with RIF pain, a CT scan is important to rule out an obstructing cancer or alternative diagnoses such as diverticulitis. Routine CT scanning is used in the United States and many countries in mainland Europe, but its use in the UK is limited. CT with dose reduction may be considered in children but is reserved for difficult cases and seldom accessible. Positive findings of appendicitis on CT include enlarged appendiceal diameter (>6 mm), wall thickening (>2 mm), peri-appendiceal fat stranding and mural hyper-enhancement.

Magnetic resonance imaging is less widely available than CT, particularly out of hours, but lack of ionizing radiation makes it a useful imaging modality in pregnant and paediatric patients.

Scoring systems

There are as many as 26 scoring systems and risk prediction models for appendicitis but the evidence for their accuracy is

limited. They often use a combination of clinical signs, biochemical markers, and imaging findings. The most widely used is the Alvarado score, which was initially designed for use in pregnant women but has been extensively validated for the general population. A further example is the Appendicitis Inflammatory Response score, which places a larger emphasis on biochemical markers (Table 2). A recent study of UK patients presenting with RIF pain identified the Adult Appendicitis Score as having the best negative predictive value for identifying those at low risk of having appendicitis.[9]

Management

Patients with a diagnosis of acute appendicitis should be admitted and receive analgesia, appropriate fluid resuscitation and intravenous antibiotics whilst awaiting surgery. The time to progression from acute appendicitis to perforation is variable. A short in-hospital delay of 12–24 hours prior to surgery does not appear to increase the risk of perforation. However, patients should be monitored for signs of sepsis as systemic infection can quickly become life-threatening if not treated promptly. Delay beyond 48 hours increases risk of surgical site infections and other complications.[7] For unstable patients with generalized peritonitis, immediate resuscitation followed by emergency appendicectomy is required.

In equivocal cases, in the absence of sepsis, antibiotics should not be administered as they may mask diagnosis by partial treatment of any intra-abdominal pathology. Also if the symptoms resolve, it is unclear whether this is attributable to the antibiotics or due to natural improvement of the underlying condition. In these cases, a "watch & wait" policy can be employed. If the patient is systemically well and has a good support system at home, they may be suitable for ambulatory management, and can often be discharged with appropriate safety-netting. They should be reviewed the following day in an ambulatory clinic, either for imaging such as US or for serial examination and repeat blood tests. This "active observation" approach is recommended by the Royal College of Surgeons of England (RCS) for suitable patients, and is also supported by the National Institute for Health & Care Excellence (NICE).[7]

There is emerging interest in determining whether antibiotics alone are an appropriate alternative treatment for uncomplicated appendicitis. The regimen typically involves intravenous antibiotics administered for 1–3 days followed by oral antibiotics for up to 10 days with prompt surgical intervention in case of clinical deterioration. Antibiotics alone are reported to be successful in treating 44%–85% of patients in the short-term, with a lower complications rate than the surgical group.[4] However, there was a 20% readmission rate and all eventually required appendicectomy. A meta-analysis from 2019 showed no difference in length of stay or complication-free treatment between the antibiotic and appendicectomy group.[10] Absence from work was shorter in the former, but again, a significant proportion (37.4%) required appendicectomy within one year following conservative management. There are also concerns regarding missed neoplasms. The need for 'rescue appendicectomy' was elegantly demonstrated by the famous case of Leonid Rogozov, the sole physician posted to an Antarctic base. He developed appendicitis that was unresponsive to antibiotics, and eventually ended up removing his own appendix with the help of a mirror and 2 untrained assistants (Figure 2). Current NICE as well as European and American guidance continues to advocate appendicectomy as the treatment of choice for uncomplicated appendicitis.[7] Patients who elect for non-surgical management must be clearly counselled on the risks and benefits. This is an area of ongoing research and controversy but may be useful for patients who are high risk for surgery, e.g. those with multiple comorbidities, or for situations when surgery is unavailable.

Three widely known and validated appendicitis scoring systems and their scoring methods

		Alvarado[b]	Appendicitis Inflammatory Response Score[b]	Adult Appendicitis Score
Symptoms	Gender			1
	Time from onset			1
	Anorexia	1		
	Nausea/vomiting	1	1	
	RIF pain		1	2
	Migratory pain	1		2
Signs	RIF tenderness	2		2–4
	Guarding/rebound	1	1–3	2–4
Vitals	Pyrexia	1	1	
Bloods	White cell count (x 10^9)	2	1–2 (>15)[a]	1–3 (>14)[a]
	Proportion of neutrophils (%)	1	1–2 (>85%)[a]	2–4 (>83)[a]
	CRP (mg/l)		1–2 (>50)[a]	1–5 (25–83)[a]
	CRP (mg/ml) (symptoms >24 h)			1–2 (12–152)[a]
Appendicitis risk	Low risk (total score)	0–4	0–4	0–10
	High risk (total score)	7–10	9–12	>16

CRP, C-reactive protein; RIF, right iliac fossa.
[a] Numbers in brackets indicate values required to achieve the highest score.
[b] Score can be used in children or adults with suspected appendicitis.

Table 2

During the COVID-19 pandemic the use of conservative treatment with antibiotics increased in both adults and children with appendicitis worldwide, likely as part of the global trend to reduce surgery and reserve hospital space for those with COVID.[11] Interestingly, there was a reduction in the number of adult appendicitis cases presenting to hospitals during this time, but higher rates of complicated appendicitis, perhaps indicating late presentation or a reluctance to attend hospital, a trend which has been reflected in numerous other diseases during the pandemic. A further impact of COVID on appendicitis treatment can be seen in a case series of open appendicectomy performed under spinal anaesthesia. Although this technique is used in the developing world it is rarely used in the United Kingdom, but was adopted as a mechanism to reduce aerosolization from both intubation and laparoscopy. This technique was shown to be safe and feasible but has not been more widely adopted post-pandemic.[12]

The majority of appendicectomies in the UK are now performed laparoscopically. Laparoscopic surgery confers benefits of shorter length of stay, fewer wound complications and quicker return to normal function than open surgery. Further advantages are a lower risk of both short- and long-term adhesive small bowel obstruction. Intra-abdominal abscess is slightly more common after laparoscopic appendicectomy in adults, although this effect is not seen in children.[4] Laparoscopic surgery historically takes longer than open but this difference is reducing as surgeons become more skilled at it. In fact, many surgeons now believe there are very few situations when open appendicectomy is preferable; surgical expertise, local resources and stability of the patient are the primary determinants.

Laparoscopy can be diagnostic as well as therapeutic and is therefore useful in equivocal cases. It enables examination of the intra-abdominal organs and can aid diagnosis of alternative causes for presenting symptoms, such as ovarian pathology or Meckel's diverticulum. All organs should be examined systematically and the findings recorded with intraoperative photographs, particularly if the appendix appears grossly normal. When no alternative pathology is identified, the general consensus amongst UK surgeons is to remove a normal-looking appendix. Up to 30% have microscopic inflammation on histology, and non-removal could lead to non-resolution of symptoms[13] and in the case of open appendicectomy, cause confusion due to the presence of an appendicectomy scar.

Figure 2 Leonid Rogozov performing an auto-appendicectomy in 1961. (From Rogozov L. Auto-appendectomy in the Antarctic, a case report. Rogozov, Brit Med J 2009; 339: 1421–2. With permission from BMJ Publishing Group Limited.).

All appendiceal specimens should be sent for histology as underlying malignancy can be a cause of appendicitis. Neoplasms such as neuroendocrine tumour, adenocarcinoma and mucinous cystadenomas occur in less than 1% of routine appendicectomies and 10%–29% of interval appendicectomies for perforated appendicitis.[14] These patients may require further investigation, monitoring or even more extensive surgery.

Management of patients who present with an appendiceal mass or abscess is different to uncomplicated appendicitis. Often these patients will have a longer duration of symptoms and may even find that their pain has improved over time. This is generally due to omental wrapping of a contained perforation, leading to a mass in the RIF. Operating on this population carries a high risk of conversion to right hemicolectomy. Therefore, the preferred option is to confirm the diagnosis on imaging and to treat conservatively with intravenous antibiotics for 48–72 hours followed by oral antibiotics for 7 days. It can be useful to mark the outline of the mass and perform serial examinations to ensure response to antibiotics. If there are signs of sepsis and drainable collection on imaging then image-guided drainage is an option. Repeat imaging is often required to follow the progress of the phlegmon. The patient should be reviewed in an outpatient clinic and an interval appendicectomy planned for approximately 6 weeks later. Those over 40 years of age should be offered a colonoscopy prior to interval appendicectomy.[14] A proportion of patients will re-present in the intervening period and require acute intervention. Indications for acute intervention include increasing abdominal pain, increasing size of mass, and any symptoms of systemic infection such as tachycardia or pyrexia.

Appendicectomy

Patients must be counselled regarding the risks, benefits and alternatives of appendicectomy and consented preoperatively. The most common complication following appendicectomy is wound infection and can occur in 5%–10% of cases. Other complications include bleeding, damage to surrounding structures, postoperative ileus, abscess or collection, and incisional hernias. Some surgeons also consent for bowel resection, anastomotic leak and stoma. It was thought that perforated appendicitis could have a detrimental effect on fertility in females but this has not been borne out in studies.[4]

Both open and laparoscopic appendicectomy are performed under general anaesthesia with the patient in supine position. Prophylactic antibiotics are administered to prevent wound infection and intra-abdominal abscess. Once intra-abdominal access is achieved, the patient is placed in the Trendelenburg position (head down) with a tilt to the left. This allows access to the caecum and appendix without overlying small bowel loops.

Surgical technique – open appendicectomy

There are several possible incisions for an open appendicectomy (Figure 3). The Lanz incision is most commonly used – a transverse incision centred on McBurney's point. It allows good access to the caecal pole and appendix, and gives an aesthetically pleasing scar as it lies within Langer's lines of skin tension. It can

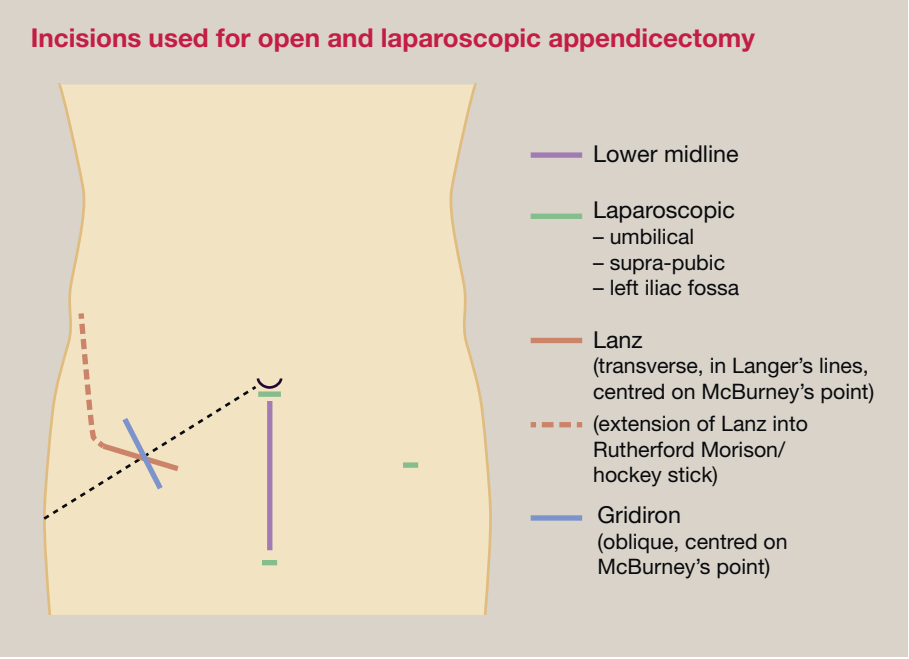

Figure 3

be converted to the longer muscle-cutting Rutherford Morison/hockey stick incision if improved access is required. Occasionally a lower midline laparotomy is used if access is likely to be difficult, e.g. an obese patient.

Once the skin is divided, the external oblique aponeuroses is incised, followed by blunt dissection of the internal oblique and transversus abdominis. The exposed transversalis fascia and peritoneum is then lifted between clips to exclude any underlying bowel prior to dividing and entering the abdominal cavity. The appendix can be identified by following the taenia coli to its base. Blunt dissection is often necessary to free local adhesions and the appendix can then be delivered into the wound. The mesoappendix is clamped, divided and ligated. The base of the appendix is crushed in artery forceps, which are then reapplied slightly distal to the crushed base, and a suture tied around the crushed portion to ligate the base. The appendix can now be divided. The stump may be buried with a purse-string suture in the caecum but this does not appear to confer any benefit and many surgeons now consider it superfluous.[15]

Next the right iliac fossa and pelvis is inspected and washed out if there is contamination. Alternatively, a swab on a stick may be used to 'mop' the peritoneal cavity clean of any residual pus after suctioning. This has the advantage of not spilling pus into clean areas, which might occur when washing through a small incision. An abdominal drain may be used if there is an abscess cavity. The abdominal wall is then closed in layers.

Surgical technique – laparoscopic appendicectomy

Pneumoperitoneum is usually established via a port placed just below the umbilicus, using an open Hasson's technique. This involves incision of the skin followed by dissection along the umbilical stalk (cicatrix) to its base where it meets the fascia which is then incised and access to the peritoneal cavity obtained. A 10 mm port is inserted and pneumoperitoneum established at 10–12 mmHg. A typical arrangement would be to use the umbilical port for the camera and place two further 5 mm ports, one in the left iliac fossa and one supra-pubically, as per Figure 3. This placement allows triangulation to the right iliac fossa and minimizes instrument clashing. Ports should be inserted under direct vision to avoid damage to vessels or intra-abdominal structures. The patient's bladder must be empty to reduce the possibility of bladder injury during suprapubic port insertion. The patient should void immediately preoperatively, or alternatively a urinary catheter can be inserted.

Once the set-up is complete, a diagnostic laparoscopy is performed. If the appendix is adherent locally or is retro-caecal, additional dissection may be required to free it. The appendix is then lifted using forceps, exposing the mesoappendix. As with open surgery, a window can be made near the appendix base and the mesoappendix divided and removed alongside the appendix. The mesoappendix can alternatively be dissected off the appendix from tip to base and left behind intra-abdominally, but this can be difficult if the mesoappendix is grossly inflamed. It is generally desirable to remove the mesoappendix with the appendix in case of incidental finding of a tumour, as sampling the nodes in the mesoappendix can be prognostically important. Once the appendix is free the base is ligated, using two loop ligatures, and the appendix divided between them. If there is a perforation close to the base of the appendix a stapler may be preferred as a looped suture may cut through oedematous tissue. To reduce contamination, the appendix is removed using a retrieval bag, via the umbilical port. Washout is performed as necessary and then working ports are removed under direct vision. The larger umbilical port site should be closed primarily to reduce the incidence of incisional hernias, and the skin closed at all port sites.

Other surgical techniques for appendicectomy include single incision laparoscopic surgery (SILS) and the more experimental

natural orifice transluminal endoscopic surgery (NOTES). Both increase the complexity of the procedure and currently offer no advantage over the standard techniques.

Postoperative recovery is generally rapid, particularly with laparoscopic appendicectomy, and discharge within 24 hours postoperatively is the usual target for uncomplicated cases. Upon discharge, patients should be counselled to seek medical advice if they are not feeling back to normal within a few days. Patients with perforated appendicitis should receive intravenous antibiotics for 2–3 days followed by oral antibiotics.

Commonest postoperative complications include wound infection, intra-abdominal collection, and postoperative ileus, with overall rates of 10%, 5% and 2%, respectively.[15] Radiological imaging is useful in diagnosing postoperative collections and the latter may be treated with percutaneous drainage or surgical washout as appropriate. Stump appendicitis is related to incomplete appendicectomy that leaves an excessively long stump after surgery and is a rare complication. To minimize this, the surgeon should ensure that the base of the appendix is identified at its junction with the caecum and ligated. Treatment is resection of the stump. Faecal fistulae are rare and usually respond to conservative management.

Negative appendicectomy

This is defined as the removal of a normal appendix. The UK has a much higher negative appendicectomy rate than most countries – 20% compared to 6.2%.[9] This may in part be attributable to low rates of CT scanning in the UK.[7] Laparoscopy provides a higher probability of making a specific diagnosis when compared to open surgery, and a lower rate of removal of normal appendices. However, there is still a high rate of removal of normal appendices with either type of surgery especially in women.[16] Since surgery has associated risks, removal of an entirely normal-looking appendix is becoming increasingly controversial. There is a 10% complication rate following negative appendicectomy and patients should be fully counselled prior to surgery. It has been proposed that increasing the use of scoring systems to identify patients at low risk for appendicitis can prevent this population from ever progressing to surgery.[9]

Special groups

Pregnancy: Acute appendicitis is the most common general surgical problem encountered during pregnancy. The pregnant uterus causes displacement of other intra-abdominal organs, leading to atypical presentations. In the third trimester the pain may localize to right lumbar region or even right upper quadrant as the appendix migrates cephalad with the growing uterus. There are also numerous physiological changes that may confound blood tests, for example mild leucocytosis is normal in pregnancy. Fetal loss occurs in 3%–5% of cases of uncomplicated appendicitis but in 20% if perforation occurs, so early diagnosis and prompt treatment is vital.[15] Imaging can reduce delays in diagnosis and also incidence of negative appendicectomy. Open appendicectomy is the preferred treatment due to concerns that laparoscopy increases the risk of fetal loss, however this is contended. With open surgery, the incision should be horizontal and cross the point of maximal tenderness. When laparoscopy is performed, insufflation pressures should be kept low to minimize risks. From the second trimester patients should be positioned in a slight left lateral position during the operation.

Children often present later and are more likely to have a perforated appendicitis. In young children particularly, the omentum is less effective at containing the inflammation, so increasing the likelihood of generalized peritonitis following perforation of appendix.[17]

Older adults tend to have diminished inflammatory response resulting in less marked findings on history and clinical examination. They may delay seeking medical care and have higher rate of perforation and mortality. Because of the higher incidence of colonic neoplasms, patients over 40 should have a CT scan or alternatively a colonoscopy post-discharge.

Immunocompromised people: This population is increasingly seen in surgical practice. They are susceptible to infection and their immune response is attenuated due to immunosuppression either from the underlying condition or medication. They may not exhibit typical symptoms and signs of appendicitis which can complicate and delay diagnosis. CT can be helpful to differentiate. A broader range of differential diagnosis includes opportunistic bacterial, viral and fungal infections, secondary malignancies (lymphoma and Kaposi's sarcoma) and typhlitis (inflammation of the caecum). There are no specific contraindications to operation.

Obese: Diagnosis and surgery may be a challenge due to high BMI. Laparoscopic appendicectomy is the preferred approach in obese patients to avoid large morbidity prone incisions of open surgery. It also affords better views and the other advantages mentioned earlier.

Conclusion

The diagnosis of appendicitis is a challenge for surgeons; however, recognizing the condition early is important to minimize the risks of complications and avoid mortality. A high index of suspicion should be maintained particularly in the atypical cases until a diagnosis is reached. Associated sepsis must be managed according to standard sepsis protocols. The definitive treatment for appendicitis is appendicectomy, which is often performed laparoscopically and when uncomplicated can be managed as a day case procedure. ◆

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Practice points

- The tip of the appendix can lie in variable locations and clinical presentation will reflect the anatomic position of the appendix
- Diagnosis of appendicitis is based on history, examination, blood tests including CRP supplemented with judicious use of radiological investigations in selected populations
- Appendicectomy remains the definitive treatment and laparoscopic appendicectomy is now the standard in the UK, offering advantages of shorter length of stay and lower wound infection rates than open operations
- Further studies are required to determine if non-operative management of appendicitis with antibiotics can be used as standard treatment in uncomplicated cases
- With increased use of diagnostic laparoscopy, it is desirable to achieve consensus on what to do with a normal-looking appendix. The selective use of appendicitis scoring systems in uncertain cases may help to reduce the negative appendicectomy rate

