Appendicitis — Definition and Surgery

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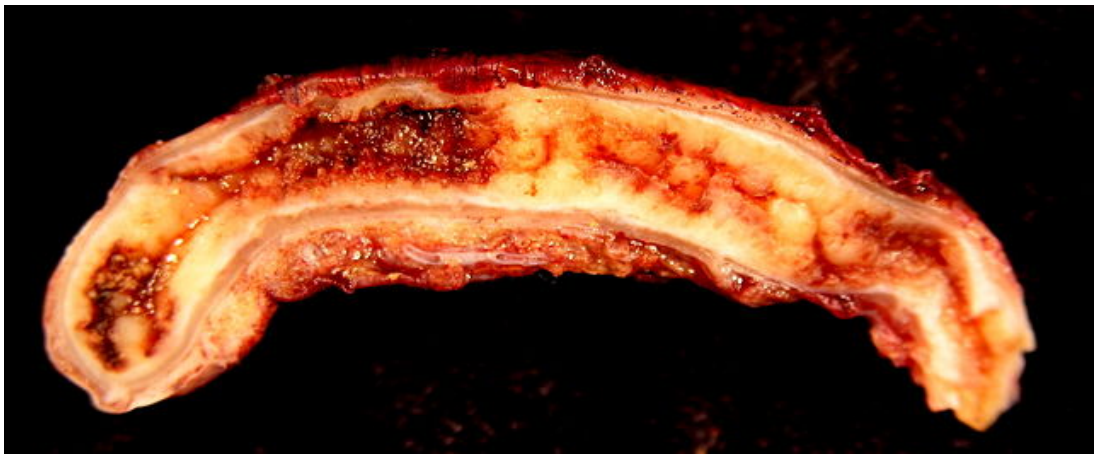
Appendicitis is a common and serious gastrointestinal disease that affects many people every year. It can have an acute and painful presentation and, if it is not treated quickly, can be fatal. We will explore the mechanics behind appendicitis, the causes, treatments, and complications that can arise.



Definition and Background

Appendix: The appendix is a small, blind-ended, hollow, finger-like extension located at the start of the large intestine (cecum). It is also known as the vermiform process: ‘vermiform’ which means ‘worm-like’ in Latin. It is 6–9 cm (2.3–3.5 in) long and 8 mm (0.3 in) wide although sizes may vary. The appendix has its own short triangular-shaped mesentery, the **mesoappendix,** and is supplied by the appendicular artery, which is a branch of the posterior cecal artery. The somatic nerve referral is to the periumbilical area.

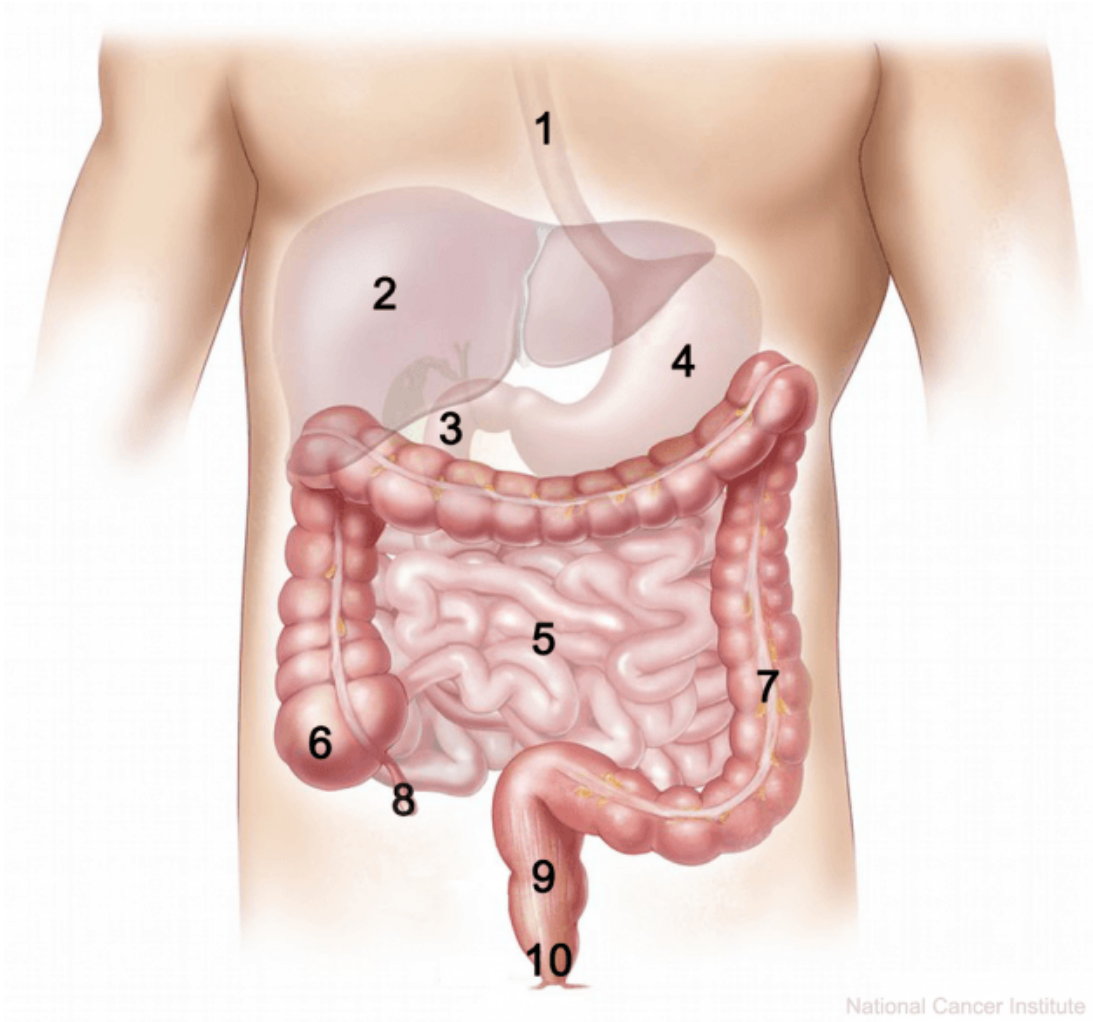


Image: Scheme of the human gastrointestinal tract with appendix (8). By William Crochot, License: CC BY-SA 4.0

Appendicitis: Appendicitis is the inflammation (-itis) of the appendix. The appendix is often inflamed when it becomes blocked and infected. There is gradual swelling as the appendix is filled with pus causing abdominal pain, vomiting, and acute illness. Since the appendix is a hollow structure, it can burst if left untreated. This perforation can rapidly lead to peritonitis and systemic sepsis, which are life-threatening.

Surface anatomy

The appendix is located at the right iliac fossa at a point called **McBurney's point** which lies at the lateral 1/3rd of the oblique line that joins the right anterior superior iliac spine to the umbilicus.

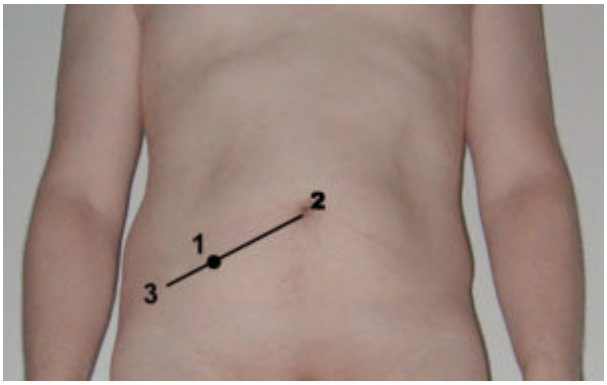


Image: Location of McBurney's point illustrated on the abdomen of a male subject. By Steven Fruitsmaak, License: CC BY-SA 3.0

Function

The appendix is considered a vestigial organ – meaning it has lost most of its original function. People can live normally without an appendix. However, some current theories suggest that the appendix may not be completely vestigial and its function is to maintain gut flora, and act as part of our immune system as it contains gut-associated lymphoid tissue (GALT).

Histology

Microscopy of a stained appendix slide reveals a very high density of GALT. The GALT-rich appendix harbors many immune cells (T cells, B cells, etc.) that protect the body from pathogens and are responsible for antigen detection. The crypts of Lieberkühn contain many goblet cells that are responsible for the production of mucus.

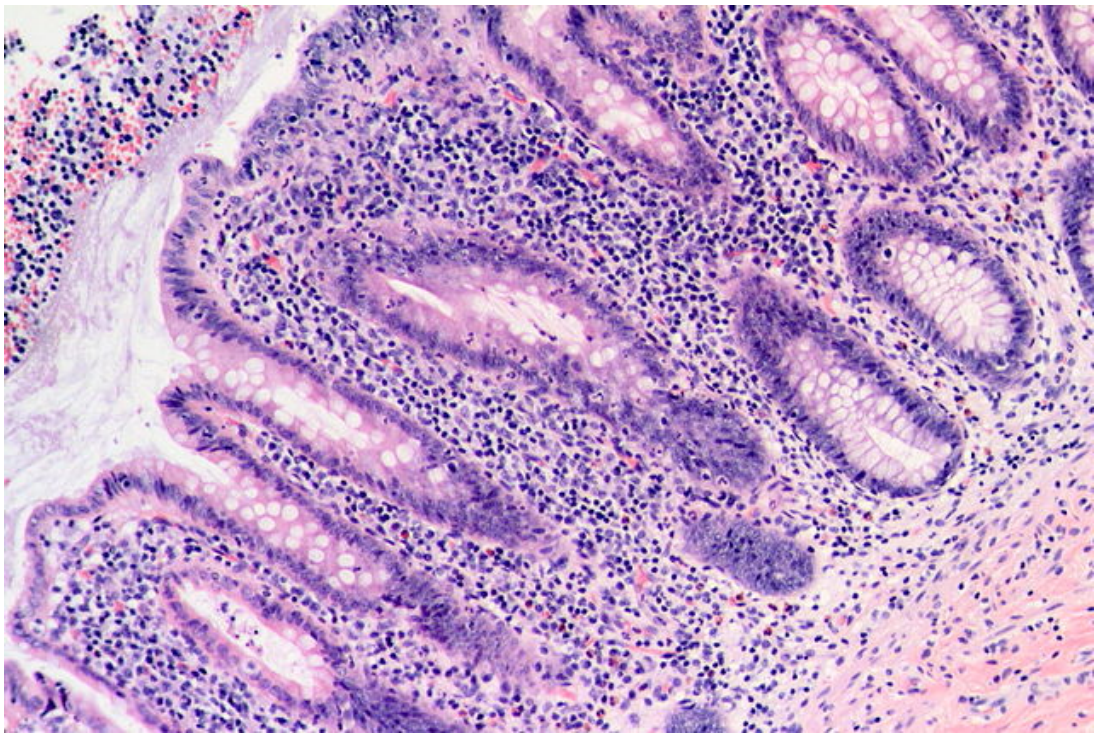


Image: Acute appendicitis. By Patho, Licence: CC BY-SA 3.0

Epidemiology

Appendicitis is 1 of the most common surgical emergencies worldwide but is more common in the West compared to the East (related to the typical low-fiber western diet). In 2013, there were 72,000 deaths globally from appendicitis. Appendicitis mostly affects teenagers and young adults but can occur at any age. It has a slight male predominance. The lifetime risk of appendicitis is around 6%.

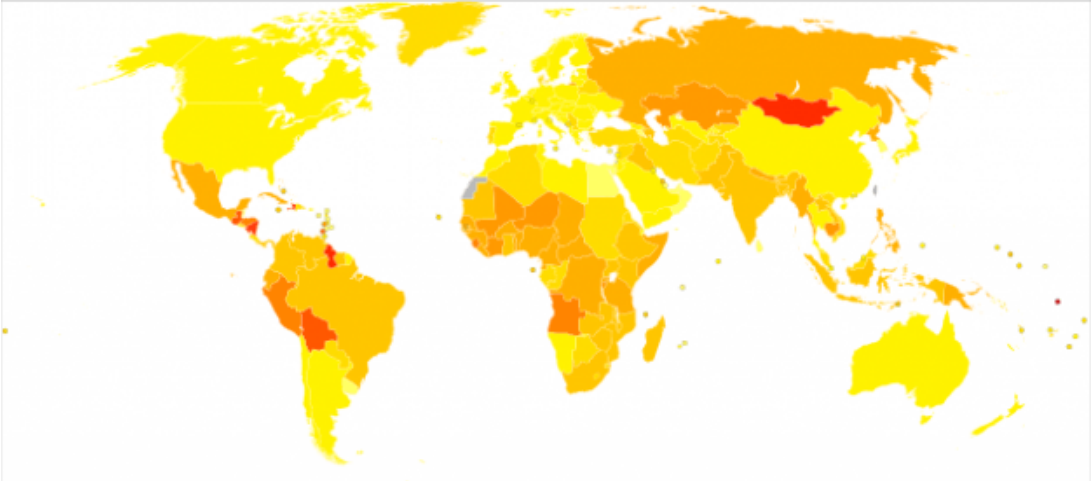


Image: Age-standardised disability-adjusted life year (DALY) rates from Appendicitis by country. By Lokal_Profil, License: CC BY-SA 2.5

Etiology

The majority of cases of appendicitis (50–80%) arise due to a primary obstruction. Usually, the muscles of the appendix wall push material back into the large intestines. If this fails, bacteria may thrive and cause an infection. (The appendix can also become inflamed and sterile when no bacteria are present.)

Obstructive agents include:

- *Fecaliths
- *Lymphoid hyperplasia – lymphadenopathy, infectious mononucleosis, measles, respiratory infection (*Streptococcal. spp*)
- Foreign bodies
- Intestinal worms
- Gallstones
- Tumors

(*Most common causes)

Common bacterial agents:

- *Escherichia coli*
- *Bacteroides fragilis*

(These bacteria are commonly found in the gut as part of the normal commensal flora.)

Hint: Appendicitis can also be caused by an infectious spread from lymphatic/hematogenous sources, e.g. *Streptococcus*-induced appendicitis following a respiratory tract infection causing mesenteric adenitis. It is, therefore, important to

inquire about recent infections. For example, the patient could present with concurrent pharyngeal infection with symptoms of appendicitis.

Pathophysiology

The obstruction of the appendix leads to a build-up of goblet cells, which continue to produce large amounts of mucus in spite of the obstruction. This causes abdominal pain in the **periumbilical area**. There is an inflammatory response consisting of swelling, and infection from bacterial overgrowth, leading to the accumulation of pus. Further, there is an invasion by neutrophils and activation of inflammatory mediators.

The infection and swelling cause further distension and increased intraluminal pressure. The pressure primarily occludes the venous drainage before occluding the arterioles. This leads to engorgement and congestion. At this point, the pain is **localized to the right iliac fossa** and surgical intervention will be needed as it rarely resolves after this point. At this point, systemic signs of illness, such as fever, tachycardia, nausea, and anorexia are characteristic.

If appendicitis continues untreated, the lack of blood supply leads to ischemia and eventually to necrosis. The walls of the appendix become weakened and pus begins to spread into the walls (muscular layer) forming focal abscesses (**acute suppurative appendicitis**). The pus contains dead lymphocytes from the inflammatory reaction, bacteria, cellular debris, and fluid. This can progress further with large hemorrhagic ulceration and gangrene covering the full thickness of the appendix to the serosa (**acute gangrenous appendicitis**).

If the appendix ruptures, the infection spreads to the abdominal cavity and causes an infection of the lining known as peritonitis (**suppurative peritonitis**). This widespread infection is very dangerous and can be fatal if it spreads to the bloodstream causing septic shock.

This is a general outline of the pathogenesis. However, note that there are variations depending on the causative agent, the presence of bacteria and whether appendicitis resolves or progresses.

The process can be summarized as follows:

- Obstruction
- Increase in intraluminal pressure
- Mucosal edema and ulceration
- Decreased lymphatic and venous drainage
- Thrombosis/occlusion of appendicular arteries
- Bacterial proliferation and inflammation
- Lymphadenopathy
- Abscess
- Gangrene
- Perforation (1–2 days)
- Peritonitis with our without sepsis

Symptoms

Acute appendicitis has a typical presentation of symptoms:

- Abdominal pain

- Nausea
- Vomiting
- Anorexia
- Constipation

Abdominal pain – usually **starts periumbilical** as the somatic nerve referral is to the periumbilical area (i.e., innervation of the appendix enters the spinal cord at the same point as the nerves of the umbilicus). The abdominal pain is typically very severe and colicky, keeping the patient awake. The pain is later localized to the **right lower quadrant** as the appendix irritates the parietal peritoneum.

Nausea and vomiting – Nausea is almost always present, whereas, vomiting is less common.

Anorexia – Loss of appetite is common in acute appendicitis.

Bowel habit – The patient may also be constipated and may have reduced bowel movement. Diarrhea can also be present.

Note: If the appendix is located in the pelvis, it can cause urinary frequency, suprapubic pain, and diarrhea.

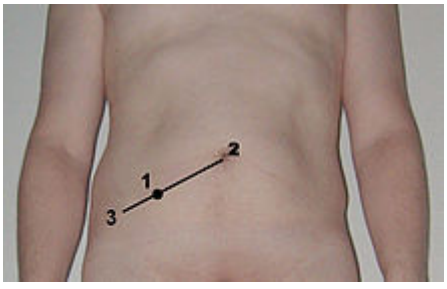
Signs of Appendicitis

Fever (initially mild)	Tachycardia
Furred tongue	Foetor (odor)
Flushing	Guarding and local tenderness
Rebound (Blumberg's sign)	Percussion tenderness
Abdominal swelling	Abdominal rigidity
Tender right iliac fossa mass may indicate the formation of an appendiceal mass	

Peritonitis

Reduced movement	Reduced breathing volume
Guarding	Rebound and percussion tenderness
Bowel sounds absent	Tympanitic (resonance)
Distended abdomen	
Dunphy's sign – Right lower quadrant pain when coughing	

Special Tests on Physical Examination



- Image: Location of McBurney's point illustrated on the abdomen of a male subject. By Steven Fruitsmaak, License: CC BY-SA 3.0

McBurney's sign – Deep tenderness at McBurney's point is a sign of acute appendicitis. As already discussed, McBurney's point is the point on the right lateral one-third of the distance between the anterior superior iliac spine and umbilicus. It is also used to locate the appendix in surgery as it is the site of the appendix base where it attaches to the cecum.

- **Rovsing's sign** – When pressure is applied to the **left** iliac fossa deeply and continuously, the patient with acute appendicitis feels pain in the **right** iliac fossa.
- **Obturator sign** – Pain on flexion and internal rotation of the right hip, due to the irritation from obturator internus.
- **Psoas sign** – pain when the right hip is passively extended/actively flexed. This movement relies on the iliopsoas muscle which may irritate the appendix or be inflamed itself.
- **Digital rectal examination** painful on the right – signs of the low-lying pelvic appendix. This may be present without abdominal rigidity.

Atypical Presentations

Atypical presentations of appendicitis may include:

- Lack of typical progression and may start with pain in the right lower quadrant.
- Flank or right upper quadrant pain and right-sided tenderness on digital rectal examination may be signs of retrocecal/retroperitonitis appendicitis (approx. 2–3%).
- Children can present with just generalized abdominal pain and anorexia.
- 0.1% of pregnant women experience appendicitis. Caution should be exercised as there is a higher risk of complications.
- Pain is localized to the left lower quadrant in 'situs inversus totalis'**.**

Diagnosis of Appendicitis

Diagnosis is usually based on a detailed history and physical examination, along with investigations such as blood tests and imaging. The diagnosis must be made quickly to prevent further progression. Some scoring systems may be useful for confirming diagnosis:

Alvarado scoring system (also called MANTRELS Score)

Symptoms	• Migration of pain to the right lower quadrant (+1) • Anorexia (+1) • Nausea or vomiting (+1)
Signs	• Tenderness in right lower quadrant (+2) • Rebound tenderness (+1) • Elevated temperature (above 37.7°C / 99.9°F) (+1)
Lab results	• Leukocytosis > 10,000 (+2) • Shift of WBCs to the left (Many immature leukocytes present) (+1)

- 0–3: Appendicitis less likely. The patient can be discharged without imaging.
- 4–6: Possible. CT evaluation is needed.
- 7–8: Probable. Surgical consultation
- 9–10: Very probable. Surgical consultation

Typical presentations can be confirmed using blood tests (revealing leukocytosis) and imaging if required. However, atypical presentations almost always require radiological investigations. The most common types of imaging that are used include ultrasound and CT.

Investigations

Observations		If symptoms are acute, observe: temperature, heart rate, blood pressure, capillary refill, respiratory rate, and general appearance
Examinations		Full examination of the gastrointestinal system, including special tests
Blood		• Full blood count (check for signs of infection) • Neutrophil leukocytes (70–90% of cases) usually up to 10,000–20,000 cells/mm3 • Leukocyte left shift • Elevated inflammatory markers – C-reactive protein (marked increase indicates a gangrenous appendix)
Urinalysis		• Rule out pregnancy or ectopic pregnancy • Rule out urinary tract infection as a cause of abdominal pain
Imaging	Ultrasound	Ultrasound scan may be useful (preferred in children and pregnant women as it is radiation-free). Useful in the assessment of an appendiceal mass or abscess.
	CT scan	Higher diagnostic accuracy and useful if the diagnosis is uncertain. More sensitive and specific than ultrasound. Predictive signs on CT scan – enlarged appendix, appendiceal wall thickening, and enhancement and fat stranding around the appendix.
	MRI	Complicated cases where you wish to avoid radiation and where ultrasound is insufficient (pregnancy and children).
	Laparoscopy	Diagnostic laparoscopy can be considered, but there is an increased risk of complications such as perforation

Differential Diagnosis

False-positive diagnoses can occur and normal appendices can occasionally be removed. This can be partially avoided with the use of imaging. The following conditions should be considered when the diagnosis is not certain:

- **Pseudoappendicitis** – mesenteric adenitis (lymphadenitis caused by *Yersinia enterocolitica* often preceded by a sore throat) is mostly seen in children. It typically mimics appendicitis.
- **Infections** – gastroenteritis, urinary tract infection, lobar pneumonia, and systemic viral infection
- **Gynecological conditions** – testicular torsion, urinary tract infection, ectopic pregnancy, ovarian torsion, salpingitis (pelvic inflammatory disease), endometriosis
- **Other bowel conditions –** New-onset inflammatory bowel disease (Crohn, Ulcerative colitis), Meckel diverticulitis, diverticulitis, intussusception, intestinal obstruction, colonic carcinoma
- **Other appendix conditions –** carcinoid tumor, adenocarcinoma
- **Other –** abdominal trauma, renal colic, pancreatitis, peptic ulcer perforation, cholecystitis

Therapy/Treatment

All suspected cases require hospital admission

- If a patient presents in an **emergency** scenario, **life support pathways** should be followed: airway, breathing, circulation, (A B C, etc.) to stabilize the patient.
- **Supportive treatments**: IV fluids, opiate analgesia (morphine), perioperative IV antibiotics (reduce infective complications.)
- **IV Antibiotics:** For example, metronidazole and cefuroxime should be administered immediately if sepsis is suspected, and perioperatively with IV hydration.
- **Active observation:** Can be useful if the diagnosis is uncertain.
- **Appendectomy:** Surgery is the gold standard treatment for appendicitis offering a rapid improvement in symptoms, low recurrence rate, and evasion of the life-threatening complications of appendicitis more than any other treatment option. It is important that surgery is performed as soon as possible. It can be conducted via open surgery or laparoscopically.

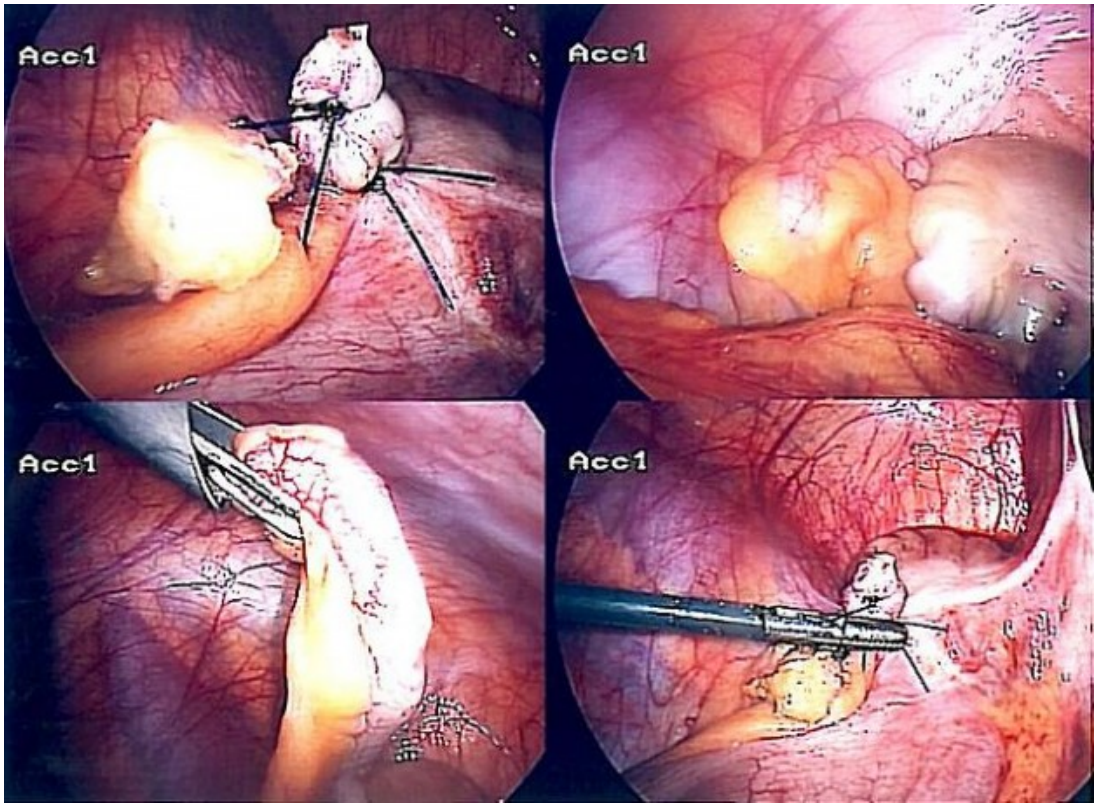


Image: Appendectomy. By Life-of-hannes.de, License: Public domain

Spontaneous resolution can occur, but, without surgery, there is an increased risk of readmission. The procedure is usually performed as an emergency procedure. Laparoscopic surgery offers reduced scarring and quicker recovery time. Hence, it is preferred over open surgery. An incision is usually made over McBurney's point (as discussed earlier), which represents the appendix base.

The procedure was performed over 300,000 times in the United States alone (2011) and represented over 2% of all procedures.

Contraindications: Inflammatory bowel disease; postoperative healing response is

impaired; therefore, treat with DMARDs (disease-modifying anti-rheumatoid drugs).

Sepsis: If suspected: The sepsis pathway should be followed immediately.

- High-flow oxygen
- Blood cultures
- IV antibiotics
- Fluid challenge
- Measure lactate
- Measure urine output

Recovery – hospital stays usually last a few days after surgery. However, if a complication arises, it can be extended to a few weeks. It also depends on whether the appendix has ruptured, as this is an indication of severity. It is advised that the patient rests and avoids physical activity (some movement is encouraged). Full recovery takes 4–8 weeks depending on severity.

Complications

- **Perforation** – Between 16–30% of cases involve perforation (higher in the extremes of age and when a fecalith is a cause).
- **Peritonitis** – Spread of infection from a perforated appendix can cause peritonitis. It is very serious and can be fatal if the infection spreads to the bloodstream, causing septic shock. Rapid treatment is essential. Signs of peritonitis include increasingly severe abdominal pain, nausea, and vomiting, anorexia, fever, and oliguria/anuria.
- **Appendiceal mass** – Presentation is usually fever with a palpable mass. The mass is formed when the small bowel and omentum cover the inflamed appendix. Surgery is an option, along with initial conservative management (nil by mouth with antibiotics). It is important to rule out other causes of such masses like colonic cancer.
- **Appendiceal abscess** – Can result from an unresolved appendiceal mass that becomes enlarged. Ultrasound and CT scans can reveal abscesses that can usually be treated by drainage during open appendectomy or percutaneously with radiological guidance.
- **Wound infection** – Risk depends on the severity of the case. Perioperative antibiotics reduce the risk.

Prognosis

The surgical procedure is relatively safe with a mortality of 0.8 in 1000 for non-perforated cases and 5 in 1000 for perforated cases. Early detection, management, and rapid surgical treatment are needed to avoid further complications.

If the patient presents with severe appendicitis accompanied by perforation, the prognosis is significantly worse as there is a risk of life-threatening peritonitis and sepsis.

Prevention

There is no way to prevent appendicitis. However, there is a lower occurrence in people with a fiber-rich diet. Early detection and treatment are essentially a cure and prevent further progression of the disease.

References

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Notes