

# 19 Appendicitis

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## INTRODUCTION

Acute appendicitis is the most common cause of intra-abdominal infection in developed countries and appendicectomy is the most common emergency surgical operation. In the UK, 1.9 females per thousand have the operation each year compared with 1.5 males, and 1 in about 6 or 7 people eventually undergo the operation. Surprisingly, the incidence of appendicitis fell by about 50% between the 1960s and the 1980s.

Appendicitis can occur at any age but is most common below 40 years, especially between the ages of 8 and 14. It is very rare below the age of 2. Appendicitis is rare in rural parts of developing countries, but in the cities the incidence approaches that of the West. This different susceptibility in people of similar ethnic origin is probably related to a much reduced intake of dietary fibre in city-dwellers.

Acute appendicitis should be in the differential diagnosis of all patients presenting to hospital with abdominal pain. Even previous appendicectomy does not absolutely rule out the diagnosis. Despite lay impressions, a positive diagnosis is often difficult to make and this is partly because of the wide range of differential diagnoses. Sometimes a non-inflamed appendix is found at operation. The fact is that there is no definitive test for the confirmation or exclusion of appendicitis and thus a proportion of unnecessary appendicectomy operations is unavoidable. Diagnostic laparoscopy can improve diagnostic accuracy, particularly in young women, and can also be used therapeutically to remove an inflamed appendix.

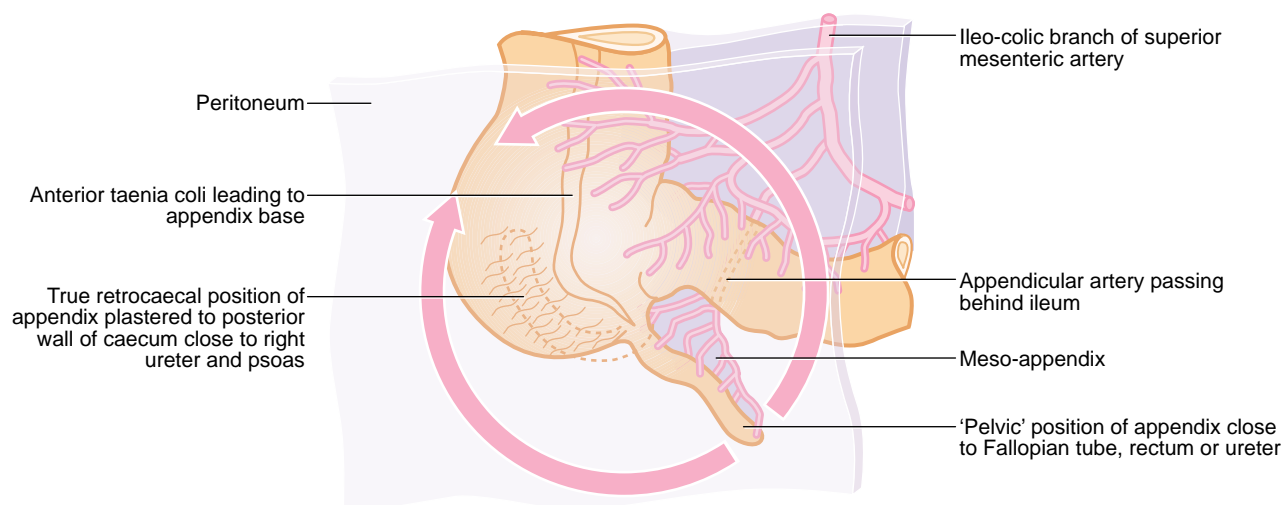
## ANATOMY OF THE APPENDIX

The appendix is a blind-ending tube arising from the caecum at the meeting point of the three taeniae coli, just

distal to the ileo-caecal junction. The base of the appendix thus lies in the right iliac fossa, close to **McBurney's point**. This is two-thirds of the way along a line drawn from the umbilicus to the anterior superior iliac spine (see Fig. 19.7, p. 272). In most cases, the appendix is mobile within the peritoneal cavity, suspended by its mesentery (**meso-appendix**) with the appendicular artery in its free edge. This is effectively an end-artery, with anastomotic connections only proximally.

The appendix has been described as lying in several 'classic' sites, but apart from the true retrocaecal appendix, the organ probably floats in a broad arc about its base (see Fig. 19.1). Only inflammation will fix it in a particular place. Its position will then determine the clinical presentation of the disease. In about 30% of appendicectomies, the appendix lies over the brim of the pelvis ('**pelvic appendix**'). This is adjacent to the bladder and rectum in males and to the uterus, Fallopian tubes and bladder in females. In some cases, the appendix lies retroperitoneally behind the caecum and is often plastered to it by fibrous bands. Thus, an inflamed retrocaecal appendix may irritate the right ureter and psoas muscle, and may even lie high enough to simulate gall-bladder pain.

Histologically, the appendix has the same basic structure as the large intestine. Its glandular mucosa is separated from a loose vascular submucosa by the delicate muscularis mucosa. External to the submucosa is the main muscular wall. The appendix is covered by a serosal layer (the visceral layer of peritoneum) which contains the large blood vessels and becomes continuous with the serosa of the mesoappendix. When the appendix lies retroperitoneally, there is no serosal covering. A prominent feature of the appendix is its collections of lymphoid tissue in the lamina propria. This lymphoid tissue often has germinal centres and is prominent in childhood but diminishes with increasing age.



**Fig. 19.1 Surgical anatomy of the appendix**

The appendix can be positioned anywhere on the circumference shown by the arrowed arc.

The mucosa contains a large number of cells of the gastrointestinal endocrine system (APUD system). These secrete mainly serotonin and were formerly known as **argentaffin cells**. Carcinoid tumours commonly occur in the appendix and arise from these cells.

### PATHOPHYSIOLOGY OF APPENDICITIS

Appendicitis is probably initiated by obstruction of the lumen by impacted faeces or a faecolith. This explanation fits with the epidemiological observation that appendicitis is associated with a low dietary fibre intake.

In the early stages of appendicitis, the mucosa becomes inflamed first. This inflammation eventually extends through the submucosa to involve the muscular and serosal (peritoneal) layers. A fibrinopurulent exudate forms on the serosal surface and extends to any adjacent peritoneal surface, e.g. bowel or abdominal wall, causing a localised peritonitis.

By this stage the necrotic glandular mucosa sloughs into the lumen, which becomes distended with pus. Finally, the end-arteries supplying the appendix become thrombosed and the infarcted appendix becomes necrotic or **gangrenous**. This usually occurs at the distal end and the appendix begins to disintegrate. Perforation soon follows and faecally contaminated appendiceal contents spread into the peritoneal cavity. If the spilled contents are enveloped by omentum or adherent small bowel, a localised abscess results; otherwise spreading peritonitis develops. The evolution of acute appendicitis is illustrated histologically in Figure 19.2.

### CLINICAL FEATURES OF APPENDICITIS

The pathophysiological evolution of appendicitis and the corresponding symptoms and signs are illustrated in Figure 19.3.

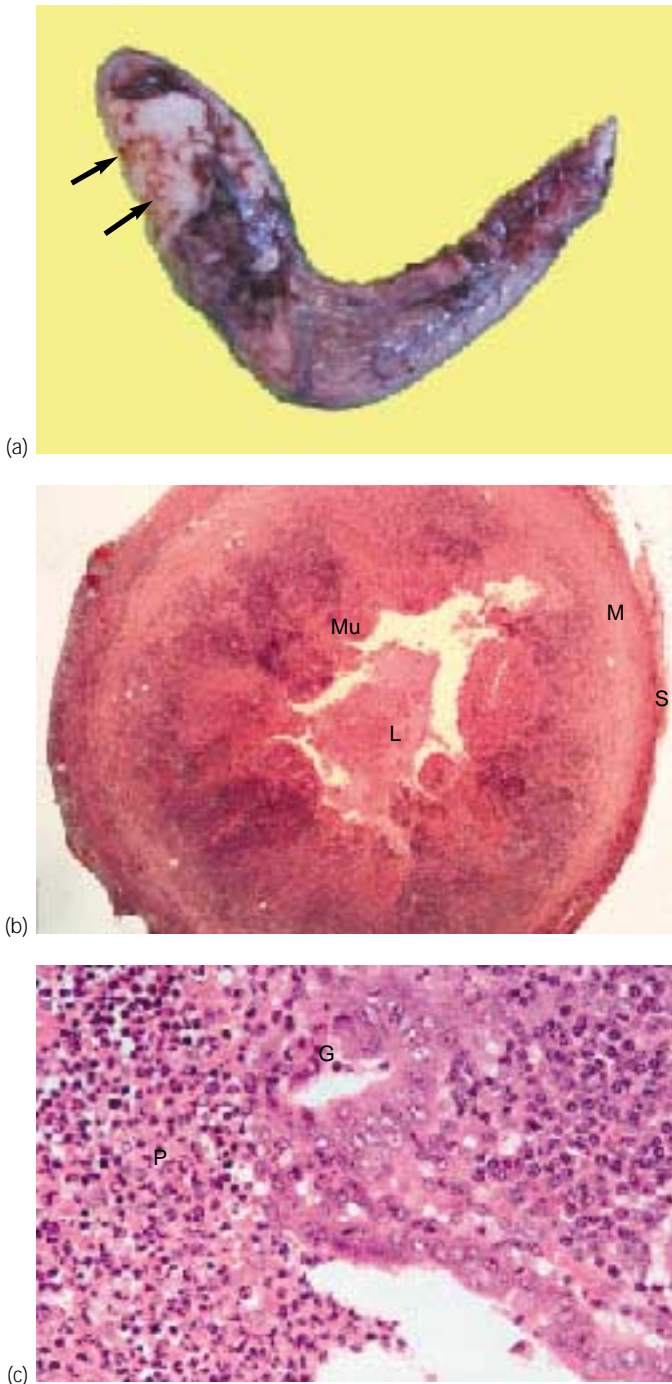
#### CLASSIC APPENDICITIS

Acute appendicitis classically begins with poorly localised, colicky central abdominal visceral pain; this results from smooth muscle spasm as a reaction to appendiceal obstruction. Anorexia and vomiting often accompany the pain at this stage.

As inflammation advances over the ensuing 12–24 hours, it progresses through the appendiceal wall to involve the parietal peritoneum (which is innervated somatically). At this stage the pain typically becomes localised to the right iliac fossa. Signs of local peritonitis, i.e. tenderness and guarding, can be elicited at this stage. This classic picture is seen in less than half of all cases, largely because the localising symptoms and signs vary with the anatomical relations of the inflamed appendix.

#### OTHER PRESENTATIONS OF ACUTE APPENDICITIS

If the appendix lies in the pelvis near the rectum, it may cause local irritation and diarrhoea. If it lies near the bladder or ureter, inflammation may cause urinary symptoms of frequency, dysuria and (microscopic) pyuria. These may readily be mistaken for urinary tract infection. An inflamed retrocaecal appendix produces none of the usual localising symptoms or signs, but may irritate the psoas muscle causing involuntary right hip



**Fig. 19.2 Acute appendicitis**

(a) Macroscopic photograph showing acutely inflamed appendix. The distended tip shows a purulent exudate on the serosal surface (arrowed). (b) Microscopy showing mucosal ulceration **Mu** with acute inflammatory cells within the lumen **L**. Inflammation extends through the muscle wall **M** to the serosal surface **S**. (c) High-power view showing acute inflammatory cells, mostly polymorphs **P**, destroying glands **G**.

flexion and pain on extension. A high retrocaecal appendix may cause pain and tenderness below the right costal margin. An inflamed appendix near the Fallopian tube

causes pelvic pain suggestive of an acute gynaecological disorder such as salpingitis or torsion of an ovarian cyst.

The early phase of poorly localised visceral pain typically lasts for a few hours until peritoneal inflammation produces somatic localising signs. If untreated, the inflamed appendix becomes gangrenous after 12–24 hours and perforates, causing spreading peritonitis unless sealed off by omentum. The whole abdomen becomes rigid and tender and there is marked systemic toxicity. Perforation is particularly common in children. Sometimes, the pathological sequence is extremely rapid and the patient presents with sudden peritonitis.

In older patients, a gangrenous or perforated appendix tends to be contained by omentum or loops of small bowel. This results in a palpable **appendix mass**. This may contain free pus and is then known as an appendiceal abscess. As with any significant abscess, there is a tachycardia and swinging pyrexia. An appendix mass usually resolves spontaneously over 2–6 weeks. In the elderly, a delayed diagnosis may produce an appendix abscess walled off by loops of small bowel. There may be no palpable mass and the symptoms and signs may not be recognisable as appendicitis. These include non-specific abdominal pain and features of small bowel obstruction due to localised paralytic ileus. Occasionally, appendicitis may present in a most unusual way. Examples include discharge of an appendix abscess into the Fallopian tube presenting as a purulent vaginal discharge, and inflammation of an appendix lying in an inguinal hernia presenting as an abscess in the groin.

### MAKING THE DIAGNOSIS OF APPENDICITIS

Acute appendicitis is a clinical diagnosis, relying almost entirely on the history and physical examination. Investigations are only useful in excluding other differential diagnoses. If possible, the diagnosis should be made and the appendix removed before it becomes gangrenous and perforates. On the other hand, unnecessary appendicectomies must be kept to a minimum.

Diagnosis of acute appendicitis poses little difficulty if the patient exhibits the classic symptoms and signs summarised in Box 19.1. The problem in appendicitis occurs when the symptoms and signs are not typical. The patient may present at a very early stage, or the signs may have some other pathological cause. At least two out of every three children admitted to hospital with suspected appendicitis do not have the condition.

If the evidence for acute appendicitis is insufficient and no other diagnosis can be made, the patient should be kept under observation, admitted to hospital if necessary and re-examined periodically. Eventually, the symptoms settle or the diagnosis becomes clear.

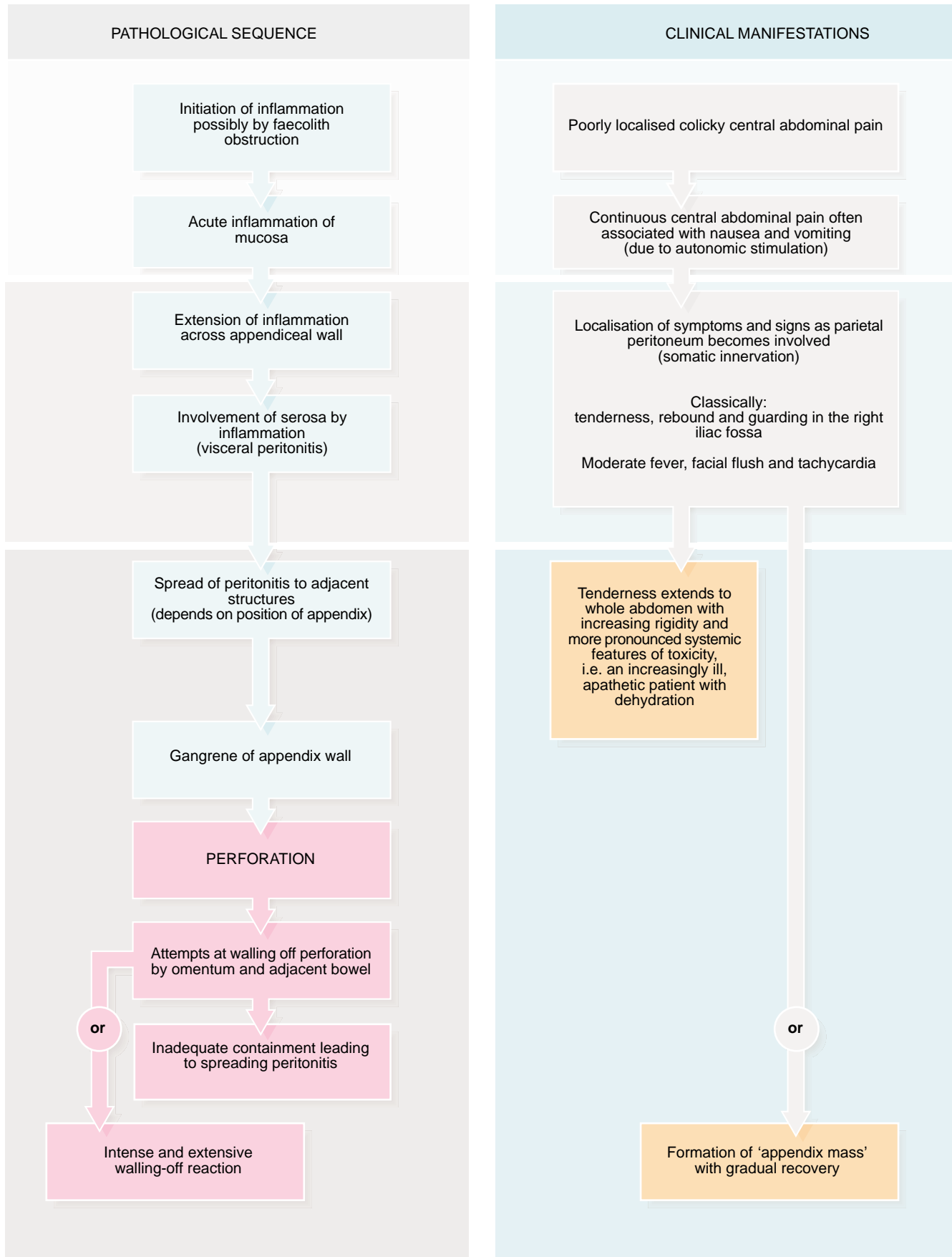


Fig. 19.3 Pathophysiology and clinical manifestations of acute appendicitis

**SUMMARY****Box 19.1 Cardinal features of acute appendicitis**

- Abdominal pain for less than 72 hours
- Vomiting 1–3 times
- Facial flush
- Tenderness concentrated on the right iliac fossa
- Anterior tenderness on rectal examination
- Fever between 37.3 and 38.5°C
- No evidence of urinary tract infection on urine microscopy

**SPECIAL POINTS IN THE HISTORY AND EXAMINATION**

Acute appendicitis typically runs a short course, between a few hours and about 3 days. If symptoms have been present for longer, appendicitis is unlikely unless an 'appendix mass' has developed. A recent or current sore throat or viral-type illness, particularly in children, favours the diagnosis of **mesenteric adenitis** (inflammation of the mesenteric lymph nodes analogous to viral tonsillitis). Urinary symptoms suggest **urinary tract infection** but may also occur with pelvic appendicitis.

The patient with appendicitis is typically quiet, apathetic and flushed; the lively child doing jigsaw puzzles almost never has appendicitis! Oral foetor may be present but is not a reliable sign of appendicitis. Cervical lymphadenopathy tends to suggest a viral origin for the abdominal pain. Mild tachycardia and pyrexia are typical of appendicitis but a temperature much over 38°C makes the diagnosis of acute viral illness or urinary tract infection more likely.

Signs of peritoneal inflammation in the right iliac fossa are often absent in the early stages of the illness. The patient should be asked to cough, blow the abdominal wall out and draw it in; all of these cause pain if the parietal peritoneum is inflamed. In children, it may be difficult to interpret apparent tenderness, especially if the child cries and refuses to cooperate. This can usually be overcome by distracting the child's attention whilst palpating the abdomen through the bedclothes or even with the child's own hand under the examiner's hand. Several signs (e.g. Rovsing's sign—pressure in the left iliac fossa causing pain in the right iliac fossa) have been described which are said to point to the diagnosis of appendicitis but these are all unreliable. One useful test is to ask the child to stand, then to hop on the right leg. If this can be achieved, there is unlikely to be any significant peritoneal inflammation.

**Rebound tenderness** can best be demonstrated by gentle percussion of the right iliac fossa. Pain on percussion is a reliable sign of local peritonitis. Anterior

peritoneal tenderness on rectal examination (i.e. pelvic peritonitis) supports the diagnosis of appendicitis, provided other signs are consistent. In pelvic appendicitis, it may be the only abdominal sign. Lack of rectal tenderness does not, however, exclude appendicitis.

**DIFFERENTIAL DIAGNOSIS**

The differential diagnosis of acute appendicitis theoretically includes all the causes of an acute abdomen shown earlier in Box 12.2. However, the main conditions of practical importance are summarised in Box 19.2, along with the main features distinguishing them from acute appendicitis. These other conditions rarely need operation. Certain uncommon conditions such as *Yersinia* ileitis and inflamed Meckel's diverticulum are not included in the list since they can only be distinguished from appendicitis at laparotomy.

**THE EQUIVOCAL DIAGNOSIS**

If acute appendicitis can be diagnosed confidently on clinical grounds, no further investigations other than those dictated by age are required unless there are secondary problems such as anaemia or dehydration. These require full blood count and electrolyte estimations. There are no diagnostic tests specific for appendicitis but certain investigations are useful where the diagnosis is in doubt.

The white blood count is usually unhelpful, as a modest rise occurs in many conditions. If there is a great rise (to over 16 000), the clinical diagnosis of appendicitis is usually already clinically obvious, but it helps to exclude non-suppurative gynaecological pathology. Urine microscopy must be performed if there is any suggestion of a urinary tract infection.

Abdominal X-rays are not needed unless there is confusing evidence of abdominal pathology after a period of observation. The presence of a single fluid level in the right iliac fossa or even widespread small bowel dilatation (see Fig. 19.5a) suggests local adynamic obstruction due to appendicitis causing functional obstruction, but this is an uncommon finding. Even less commonly, a perforated appendix may allow sufficient free gas to escape to be revealed on plain X-rays (see Fig. 19.5b). In adults with an equivocal diagnosis of appendicitis, the plasma amylase should be measured because the early features of appendicitis and pancreatitis can be similar. There is no place for barium enema in the diagnosis of appendicitis. Abdominal ultrasound is largely unhelpful. CT scanning is claimed by some to be accurate but submits the patient to a high radiation dose and greatly increases the cost of investigation.

## KEY POINTS

**Box 19.2 Main differential diagnoses of acute appendicitis****Urinary tract infection** (cystitis or pyelonephritis)

- Unlikely if nitrites are absent from dipstick testing of the urine and can be excluded if there are not significant numbers of white blood cells or bacteria on urine microscopy

**Mesenteric adenitis**

- Inflammation and enlargement of the abdominal lymph nodes, probably viral in origin, and often associated with an upper respiratory infection or sore throat.
- Symptoms and signs may be similar to those of early appendicitis but without rectal tenderness
- Fever is typically higher than in appendicitis (i.e. greater than 38.5°C) and settles rapidly
- A firm diagnosis can only be made at laparotomy or laparoscopy

**Constipation**

- May cause colicky abdominal pain and iliac fossa tenderness
- There is no fever and the rectum is loaded with faeces

**Gynaecological disorders**

- The pain of ovulation about 14 days after the last menstrual period (**mittelschmerz**) may cause right iliac fossa pain. There is often a history of similar pain in the past. There are no signs of infection and the pain settles quickly
- Salpingitis (most commonly Chlamydial) causes lower abdominal pain, often with a vaginal discharge. Digital vaginal examination typically reveals adnexal tenderness, and moving the cervix from side to side induces pain ('cervical excitation')
- Torsion of, or haemorrhage into a right ovarian cyst may produce symptoms like appendicitis, but there is no fever. A tender mobile mass may be palpable in the right suprapubic region or on vaginal examination. This diagnosis can be confirmed with ultrasound

**Perforation of another abdominal viscus**

- A perforated Meckel's diverticulum (see Fig. 19.4) may present exactly like appendicitis
- Necrotic small bowel from strangulation usually presents with intestinal obstruction

**Acute pancreatitis**

- Pain is predominantly central
- If there is tenderness in the right iliac fossa, it will also be present in the epigastrium
- If in doubt, the serum amylase should be measured

**Non-specific abdominal upset**

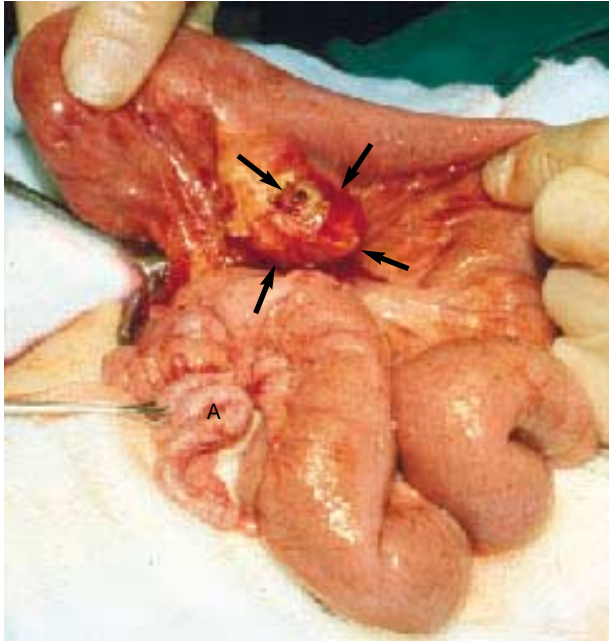
- Vague abdominal pain and tenderness which may be associated with vomiting and diarrhoea
- Usually improves steadily during a period of observation

**PROBLEMS IN DIAGNOSIS OF APPENDICITIS****THE VERY YOUNG**

Appendicitis is rarely seen below 2 years of age, but when it does occur, the 'typical' abdominal symptoms and signs are obscure or absent. An infant or toddler may display signs of sepsis without revealing the abdominal origin. Abdominal X-rays may demonstrate dilated loops of bowel and fluid levels. Generalised peritonitis supervenes rapidly in this age group because the abdominal defence mechanisms, in particular the 'wrapping' effect of the greater omentum, are rudimentary. Laparotomy is usually indicated in an ill infant with abdominal signs.

**THE ELDERLY**

Appendicitis tends to develop more slowly in the elderly. The appendix wall becomes fibrotic with age and the area is more readily walled off by omentum and adherent small bowel. Many cases probably resolve spontaneously. In those who reach hospital, the history is often as long as 1 week. Symptoms and signs of obstruction may be present. These include vomiting, colicky abdominal pain and obstructed bowel sounds. A mass may be palpable if the patient is relaxed and not too tender but can often be palpated only under general anaesthesia. Abdominal X-rays may reveal fluid levels in the right iliac fossa.



**Fig. 19.4 Perforated Meckel's diverticulum**

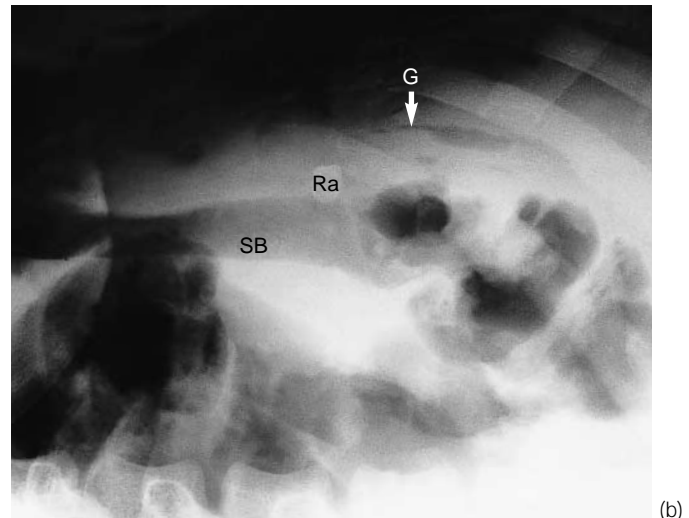
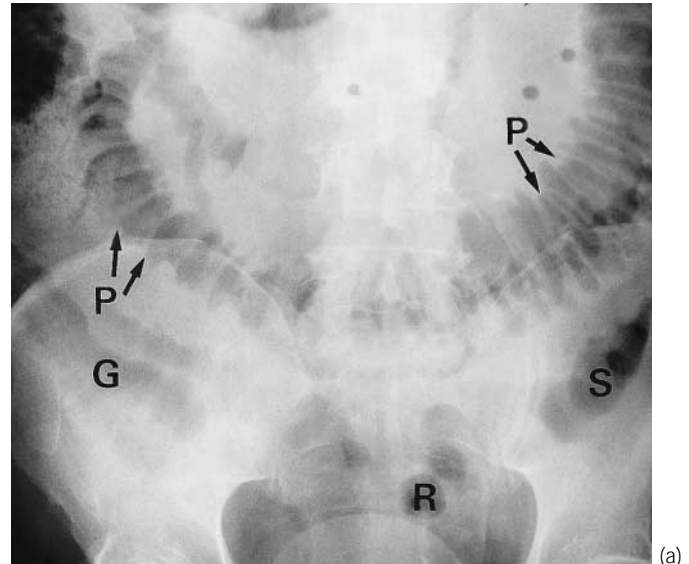
This man of 28 presented with a typical history and clinical findings of acute appendicitis. However, at operation he was found to have a normal appendix but a perforated Meckel's diverticulum (arrowed). The diverticulum was resected and the appendix also removed to prevent future confusion and the patient made a good recovery. On histological examination, the Meckel's was found to contain gastric mucosa.

### PREGNANCY

Appendicitis occurs at least as often during pregnancy as at other times but the diagnosis can be difficult. The appendix is displaced upwards by the enlarging uterus so that abdominal pain and tenderness are in a much higher position than usual. Diagnosis and management of the pregnant patient must be shared with an obstetrician. Laparoscopy may be indicated if the diagnosis is in doubt, but this becomes technically difficult beyond 26 weeks. Mortality from appendicitis for both mother and fetus rises as the pregnancy progresses; this is as high as 9% for the mother and 20% for the fetus in the third trimester.

### THE 'GRUMBLING' APPENDIX

Recurrent bouts of right iliac fossa pain occur in some children and are often labelled as 'grumbling appendix'. Appendicular pathology is probably the cause in very few of these cases. Persistent chronic inflammation of the appendix probably does not occur, but recurrent bouts of appendicular colic or low-grade acute appendicitis undoubtedly do. These children may have several abortive admissions for abdominal pain and it may eventually be justifiable to remove the appendix to allay parental



**Fig. 19.5 Perforated gangrenous sub-hepatic appendix**

This 12-year-old boy presented with 2 days' abdominal pain and vomiting. On examination, there was tenderness in the right side of the abdomen. There was also abdominal distension resonant to percussion and obstructed bowel sounds, which indicated possible small bowel obstruction. (a) Supine plain abdominal film showing grossly dilated small bowel filling the centre of the abdomen. The plicae semilunares **P** can be seen to cross the lumen completely, characterising dilated small bowel. There is a little gas in the rectum **R** and sigmoid colon **S**. These signs are diagnostic of small bowel obstruction. There is some free gas **G** visible in the right iliac fossa suggesting perforation. (b) A lateral decubitus plain abdominal film (right-side upwards) in another similar patient shows a featureless loop of small bowel **SB**, which is adynamic due to nearby inflammation. The radio-opacity **Ra** is a faecolith in the appendix (appendolith) and the linear radiolucency **G** is free gas under a Riedel's lobe of the liver. At operation, the appendix was found to be gangrenous and perforated, but was lying in a high position close to the liver.

anxiety. A non-inflamed appendix containing a faecolith or threadworms (assumed to have caused the pain) is often found.

The management of suspected appendicitis is summarised in Figure 19.6.

## APPENDICECTOMY

The annual death rate from appendicitis has fallen dramatically since 1960. In 1934 there were 3193 deaths from appendicitis in the UK, whereas in 1982 there were 110 deaths. The improvement results from several factors including better general nutrition, earlier presentation, better preoperative preparation and better anaesthesia. Deaths that now occur are usually due to dehydration and electrolyte changes which are unrecognised or ineffectively treated before surgery. Infective complications of appendicitis have dramatically fallen since the 1970s because of the widespread use of prophylactic antibacterial agents.

## ANTIBIOTIC PROPHYLAXIS

In appendicitis, most intra-abdominal infective complications and wound infections occur in perforated or gangrenous appendicitis. The majority of the infecting organisms are anaerobic and the infections can largely be prevented by prophylactic metronidazole. Rectal suppositories are just as effective as intravenous metronidazole and are cheaper but need to be given 2 hours before operation. Aerobic organisms are involved in a smaller number of cases and some surgeons therefore advocate additional prophylaxis with an antibiotic such as a first- or second-generation cephalosporin.

## TECHNIQUE OF APPENDICECTOMY

The principal steps in appendicectomy are illustrated in Figure 19.7 and should be understood by any doctor

called upon to assist in the operation. Increasingly, laparotomy is being replaced by laparoscopic diagnosis and surgery but the principles are similar.

A low skin crease incision (**Lanz**) rather than the higher and more oblique one centred on McBurney's point is now favoured as it gives a better cosmetic result. The superficial fascia (well marked in children) is then incised and the three musculo-aponeurotic layers of the abdominal wall are split along the line of their fibres. This produces the '**gridiron**' incision, described as such because the fibres of external oblique and internal oblique run at right angles to each other. The peritoneum is then lifted and opened and may reveal pus or mucopurulent watery fluid; a swab of this is taken for microscopy and culture. The appendix is located digitally and delivered into the wound; further exploration may be needed if it does not lie in the immediate vicinity. A retrocaecal appendix will require mobilisation of the caecum by dividing the peritoneum along its lateral side.

Once the appendix has been delivered into the wound, its blood supply in the meso-appendix is divided between clips and ligated. The appendix base is crushed with a haemostat which is then reapplied more distally. An absorbable ligature is then tied around the crushed area. After this preparation, the appendix is then excised. A 'purse-string' suture is usually placed in the caecum near the appendix base, the appendix is inverted and the suture tied. If the appendix was perforated or gangrenous, or if pus was found, thorough peritoneal toilet is performed. A sump sucker is guided down into the pelvis with a finger to suck out any fluid, and the area is then gently swabbed out with gauze to remove any adherent infected material. Any pus or faecolith left in the pelvis predisposes to subsequent pelvic abscess.

The peritoneum, internal oblique and external oblique are each closed with two or three absorbable sutures. Drainage is not usually recommended unless there is a thick-walled abscess cavity which will not collapse.

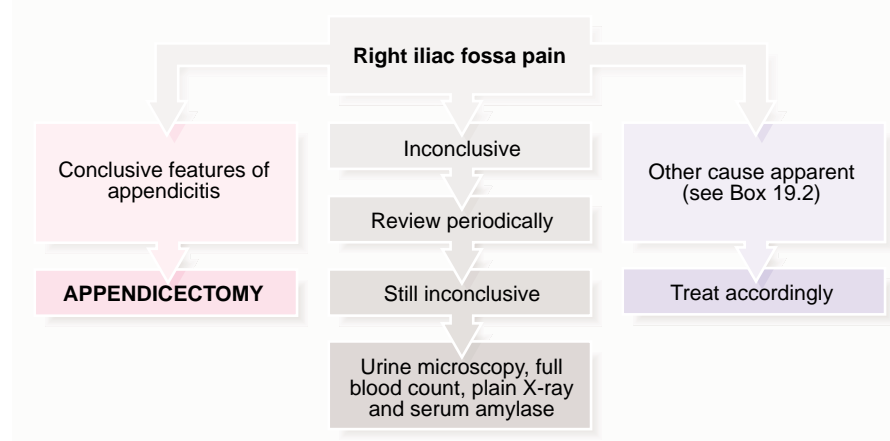


Fig. 19.6 Summary—management of suspected appendicitis

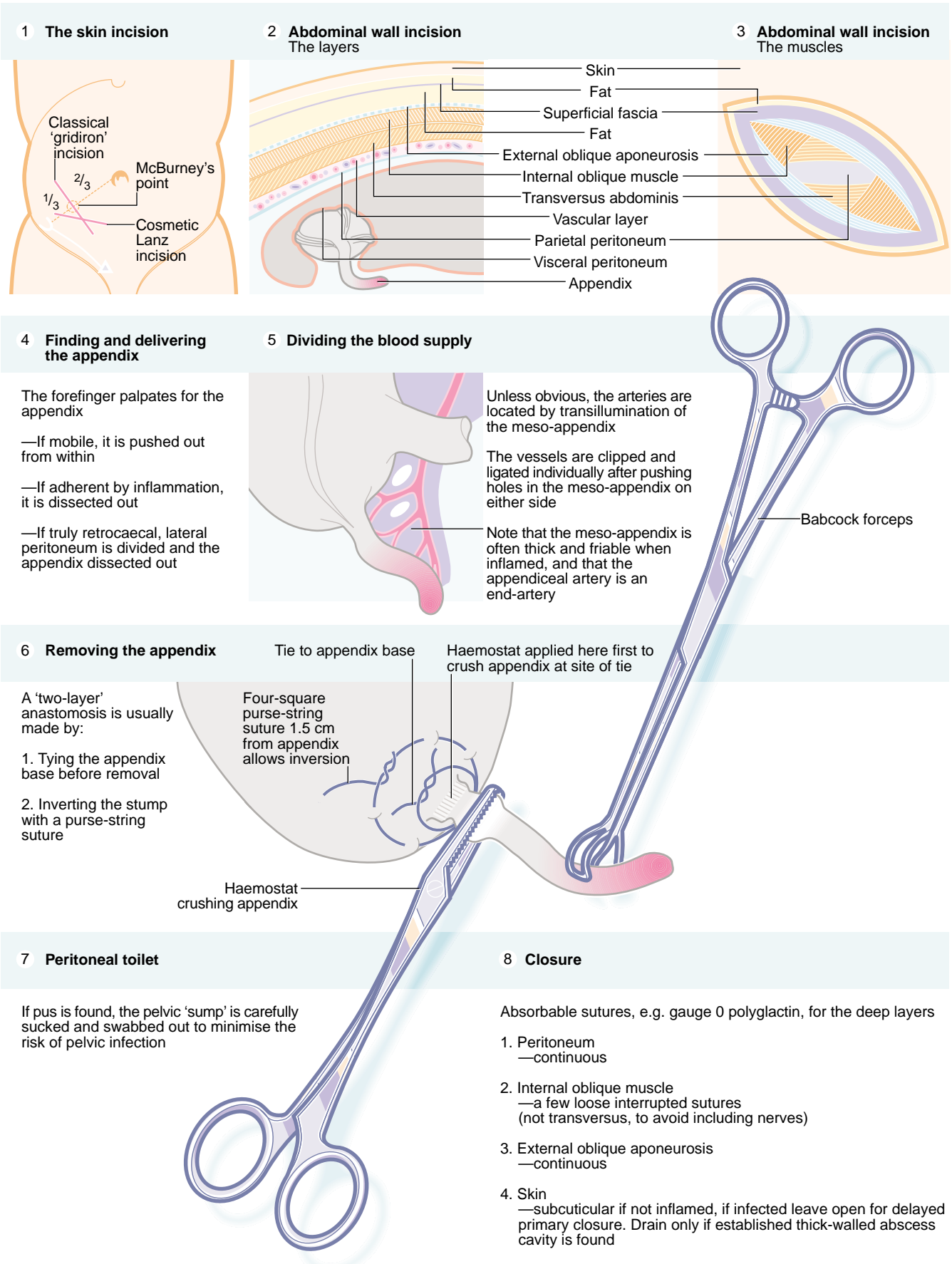


Fig. 19.7 Appendicectomy—operative technique

After operation, oral fluids followed by solids are gradually increased over a few days unless vomiting or other complications occur.

### Laparoscopic appendicectomy

Laparoscopy allows the appendix to be found wherever it may lie. The principles and techniques are similar to the open operation; the appendix can be visualised and appendicectomy performed if it is abnormal. Laparoscopic removal gives a lower wound infection rate and may allow an earlier return to normal activities. However, it is a more technically demanding operation.

### THE 'LILY-WHITE' APPENDIX

If the appendix is found not to be inflamed at open operation (colloquially termed 'lily-white'), it should always be removed because an appendicectomy scar would lead doctors in future to assume that the appendix has been removed. The abdomen is explored as allowed by the incision to search for a cause for the symptoms:

- **Mesenteric lymph nodes** in children may be grossly enlarged by mesenteric adenitis—this is probably viral in origin
- **The terminal ileum** may be thickened and reddened by Crohn's disease or by *Yersinia* ileitis—the appendix is removed but the bowel is left alone. If possible, an enlarged mesenteric node is removed for histological examination
- **An inflamed Meckel's diverticulum** may be found within 30 cm of the ileocaecal valve—if inflamed, this is removed but a wide-mouthed non-inflamed diverticulum is usually left alone
- **Both ovaries can usually be palpated**—ovaries may be twisted, inflamed or enlarged or an inflamed Fallopian tube may be seen
- **Cholecystitis, hydronephrosis or a leaking aneurysm**—these are rarely found

### THE APPENDIX MASS

A vigorous response to appendicitis may result in a mass in the right iliac fossa, often with fever. Usually the patient has few systemic symptoms or signs of ill health. A conservative regime followed by interval appendicectomy 6 weeks later (**Ochsner–Sherren regimen**) was advocated in pre-antibiotic days but is now less favoured. Early operation under antibiotic cover is now performed more frequently.

### YERSINIA ILEITIS

Acute inflammation of the ileum by the organism *Yersinia pseudotuberculosis* is an uncommon cause of right iliac fossa pain which is clinically identical to acute appendicitis. The diagnosis is made at operation, when the terminal ileum is seen to be bright red and thickened by the inflammatory process. Sometimes the appearance may be difficult to distinguish from Crohn's disease. *Yersinia* ileitis is a self-limiting condition and requires no treatment.