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7.1 Anatomy

The vermiform (“worm-like”) appendix is a vestigial organ in the right iliac fossa. Although there is considerable variability in its length and position, the base of the appendix is always found attached to the posteromedial surface of the caecum, approximately 2 cm below the ileocaecal valve. The base is the only part of the appendix which is fixed, the remainder being free, thus accounting for the great variability in the position of the body and tip (Fig. 7.1). It is completely surrounded by peritoneum which is continuous with the mesentery of the small intestine, this connection being termed the mesoappendix. Again the size of the mesoappendix is variable, and the distal appendix may occasionally be

devoid of a mesenteric covering. As was stated, the position of the appendiceal base is constant, the surface landmark of this being one-third the way along a line drawn from the right anterior superior iliac spine to the umbilicus—*McBurney’s point*. Internally the base can be found by following the taeniae coli of the caecum to the base of the appendix where they converge to form a continuous appendiceal longitudinal muscle coat.

Histologically the appendiceal lumen is lined by colonic-type columnar epithelium with abundant lymphoid follicles (which decrease with age) in the submucosa. There are continuous circular and longitudinal muscle coats.

Lymphovascular drainage:

The appendix is supplied by terminal branches of the superior mesenteric artery and vein. Lymphatics drain to nodes in the mesoappendix, ileocolic nodes, and subsequently to superior mesenteric nodes.

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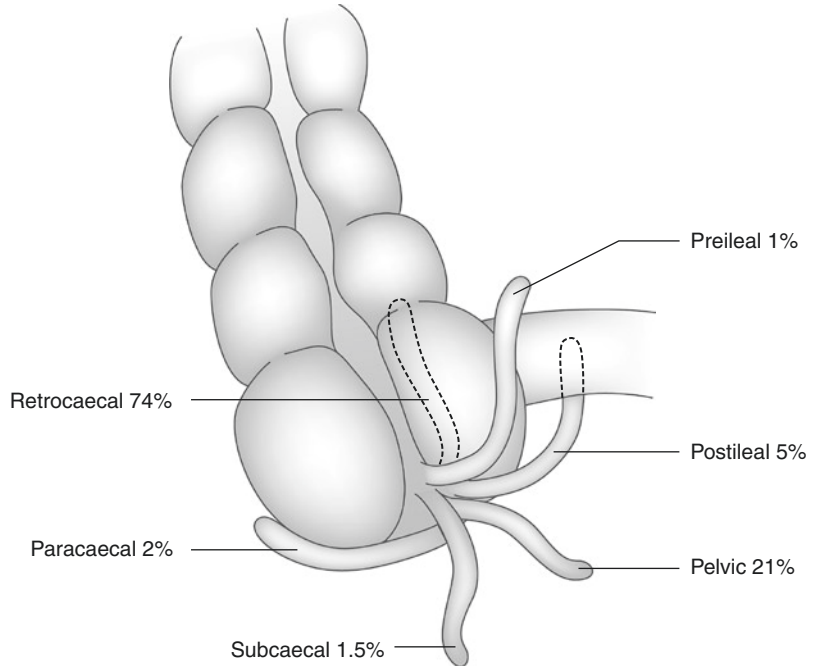
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7.2 Clinical Presentation

Acute appendicitis (and its complications) is among the most common surgical emergencies encountered. Classically it presents initially with vague, colicky, central abdominal (periumbilical) pain, which is associated with vomiting and anorexia. When the inflammation becomes transmural, a localized peritonitis is elicited and the

Fig. 7.1 The various positions of the appendix



pain becomes sharp in nature, localized in the right iliac fossa, and associated with pyrexia. Palpation reveals signs of localized peritonitis in the vicinity of *McBurney's point*.

As was stated above, the position of the body and tip of the appendix is variable and so the nature of the symptoms and signs will vary accordingly, e.g., flank pain and tenderness in retrocaecal appendicitis. Although perforation of the appendix usually remains localized (due to "walling off" by the greater omentum), occasionally it may lead to a generalized peritonitis.

The list of differential diagnoses for acute appendicitis is myriad and includes ectopic pregnancy, torsion of an ovarian cyst, Meckel's diverticulitis, urinary tract infection, terminal ileitis, endometriosis, etc. An appendiceal abscess (which usually develops 3 days after a bout of acute appendicitis) can usually be palpated by a combination of abdominal and rectal examination. Differential diagnoses of an appendiceal mass also include carcinoma of the caecum, Crohn's terminal ileitis, and ovarian carcinoma.

7.3 Clinical Investigations

- FBP—white cell count will be elevated in >75% of cases of acute appendicitis.
- Pregnancy test—will be positive in an ectopic pregnancy.
- Urinalysis—to test for a urinary tract infection.
- USS—can demonstrate a swollen appendix and will detect a pelvic mass.
- CT scan—can delineate the nature of an "appendiceal mass."
- Laparoscopy—can be used to differentiate acute appendicitis from gynaecological conditions. It will also detect a small mass in the appendix, such as a mucocele, and may be used to biopsy suspected deposits of pseudomyxoma peritonei.

7.4 Pathological Conditions

The appendix may be resected incidentally as part of a radical cancer operation, e.g., right hemicolectomy for caecal carcinoma, or, oppor-

tunistically, at laparotomy for other reasons, e.g., Meckel's diverticulectomy or resection of ovarian malignancy (to exclude metastatic spread from a primary appendiceal neoplasm). However, the vast majority of appendices are removed because of clinically significant primary inflammation and a small minority for neoplasia.

7.4.1 Non-neoplastic Conditions

Appendicitis: Caused by epithelial ulceration, then infection by bowel bacteria, it may be precipitated by an underlying structural abnormality such as a diverticulum, or, more commonly, by luminal obstruction for one of various reasons (Table 7.1). It is characterized by transmural acute neutrophilic inflammation with the serosal component eliciting signs of peritonism. There is usually close correlation between the macroscopic and histological findings with acute appendicitis, resulting in serosal congestion, inflammatory exudate, and adherence of fat. Serious complications can arise from the resultant mural necrosis with wall thinning, gangrene, and perforation, potentially leading to generalized peritonitis, periappendicular abscess formation, portal vein pyaemia, and hepatic abscesses. In general, the high risk of morbidity and mortality serves to emphasize the crucial importance of early diagnosis and therapeutic appendicectomy. Chronic appendicitis is a more controversial entity, but in a minority of cases the inflammation may resolve, leaving only residual thickening of the tissues.

Other unusual causes of subacute appendicitis are: granulomatous appendicitis (Crohn's disease, sarcoidosis, TB, schistosomiasis, but usu-

ally isolated and idiopathic), measles, CMV, or secondary to ulcerative colitis. Periappendicitis or serosal inflammation without a mucosal or mural component should be noted as this may indicate inflammation emanating from another abdominopelvic organ, e.g., pelvic inflammatory disease (salpingitis) or colonic diverticulitis. In the older patient, such an exudate must also be closely scrutinized for evidence of peritoneal spread of carcinoma cells.

Fibroneural obliteration of the appendiceal tip and body is now regarded as an age-related physiological phenomenon rather than representing evidence of previous inflammation.

7.4.2 Neoplastic Conditions

Carcinoid (well-differentiated neuroendocrine tumour): Forming over 80% of appendiceal tumours, carcinoid tumour of classical type is usually small (<1 cm diameter) and found as an incidental finding at the appendiceal tip with or without associated appendicitis. It can be a histological finding only amidst the inflammation, or macroscopically discernible as a firm, pale-yellow mass replacing the lumen and wall. It has a variable nested and tubular pattern of uniform neuroendocrine cells that are positive with chromogranin A and synaptophysin antibodies. Despite showing transmural, serosal, and lymphovascular spread, appendicectomy is usually totally therapeutic and recurrence is only seen in a very small number of cases where the lesion is greater than 2 cm diameter or there is involvement of the appendiceal base, caecal wall, meso-appendix, or local lymph nodes. Conversely the much less common mucin-rich, goblet cell carcinoma (formerly adenocarcinoid/crypt cell carcinoma) more frequently involves the appendiceal base with potential for nodal metastases, local invasion of the caecal pouch, and transcoelomic peritoneal spread with ovarian metastases. Because of this, goblet cell carcinoid requires consideration for right hemicolectomy. Due to the difficulties in distinguishing between carcinoid tumour and inflammatory fibrotic reaction, the appendiceal tip and base are sampled and

Table 7.1 Obstructive causes of appendicitis

Faecolith	Hardened, impacted faecal debris
Foreign body	Vegetable matter, fruit pips
Tumour	Carcinoid, adenocarcinoma appendix or caecal base
Mucosal lymphoid hyperplasia	Mesenteric adenitis, infectious monocleosis, yersinia
Endometriosis	enterocolitica infection

separately identified as part of the routine blocking procedure to assess adequacy of tumour excision if present.

Polyps: Hyperplastic polyps; sessile serrated lesions; tubular, tubulo-villous or villous adenomas; adenomas are more often sessile than polypoid comprising low- or high-grade dysplastic epithelium. All these lesions may be associated with synchronous/metachronous polyps or tumours elsewhere in the colorectum, adenomas with FAP, mucocele (see below) or adenocarcinoma of the appendix or adjacent caecal pouch. Diagnosis of any appendiceal polyp within an appendectomy specimen should therefore trigger consideration of follow-up colonoscopy.

Adenocarcinoma: A relatively unusual lesion that may be mucinous and cystic, secondary involvement of the proximal appendix from the caecal pouch is more common than a primary appendiceal lesion. Signet ring cell variant adenocarcinomas may arise from underlying goblet cell carcinoid and demonstrate overt (MANEC, mixed adenoneuroendocrine carcinoma) or only subtle neuroendocrine differentiation. Other cancers metastatic to the appendix are from ovary, stomach, breast, and lung.

Mucocele: Macroscopic distension of the appendiceal lumen by abundant mucus often with marked thinning of the wall. Obstructed or non-obstructed in character the former represents a retention cyst lined by attenuated and atrophic but non-dysplastic mucosa. Non-obstructed mucocele is due to oversecretion of mucus by an abnormal mucosal lining that can be either hyperplastic, adenomatous (LAMN—low-grade appendiceal mucinous neoplasm—if there is destruction of the muscularis mucosae) or frankly adenocarcinomatous in nature. Extrusion of mucus through the wall to the serosa results in pseudomyxoma peritonei which is localized to the periappendiceal tissues or generalized in the peritoneal cavity. The latter can be refractory to surgical debridement with reaccumulation over a prolonged time course of months to years resulting in bowel obstruction and death. It is due to spillage of either atypical or frankly malignant appendiceal epithelium into the peritoneal cavity, whereas mucocele due to benign hyperplastic or

adenomatous epithelium that is limited to the appendix more often results in a self-limited localized reaction.

It is now recognized that there is a strong association between generalized pseudomyxoma peritonei, appendiceal mucinous tumours, and bilateral ovarian mucinous borderline tumours with the latter regarded as either implantation deposits or metastases from the appendiceal lesion.

Prognosis: Carcinoid tumours less than 2 cm diameter are generally adequately treated by local appendectomy. Those that are larger, involve the base or mesoappendix or are of goblet cell type may require right hemicolectomy. Prognosis of mucocele depends on the nature of the underlying mucosal epithelium and degree of spillage of epithelium into the peritoneal cavity. Adenocarcinoma treated by appendectomy alone does worse (20% 5-year survival) than when right hemicolectomy is performed (60–65% 5-year survival)—outlook is tumour grade and stage dependent.

7.5 Surgical Pathology Specimens: Clinical Aspects

7.5.1 Biopsy Specimens

Not applicable.

7.5.2 Resection Specimens

7.5.2.1 Appendectomy

Although the appendix may be removed laparoscopically or in the course of other procedures for diagnostic and/or staging purposes (e.g., suspected ovarian malignancy), the operation of choice in acute appendicitis is open appendectomy. In the case of an “uncomplicated appendicitis,” a muscle-splitting *Gridiron* oblique incision centred over McBurney’s point is used. The caecum is delivered into the wound and the taeniae coli are followed to the base of the appendix. The appendicular vessels in the mesoappendix are divided and ligated. The appendiceal base

is crushed and ligated, and the appendix is divided distal to the ligation.

If appendiceal perforation with generalized peritonitis is present preoperatively, a midline incision may be employed to facilitate better access to the abdominal cavity. This will allow an adequate laparotomy examination and peritoneal lavage to be carried out and so will lessen the risk of postoperative abscess formation.

In the case of an appendiceal abscess, the patient may be initially treated conservatively with antibiotics and close clinical supervision, followed by an interval appendectomy at a later date. However, if there is diagnostic doubt or worsening symptomatology (e.g., increasing pyrexia), early operative intervention is indicated. Although a simple appendectomy may suffice, a right hemicolectomy may be needed if a large mass is present.

7.5.2.2 Right Hemicolectomy

The technique of right hemicolectomy (removal of the terminal ileum, caecum, and proximal ascending colon) is described in detail elsewhere (see Chap. 6).

As well as for a large appendiceal mass, other lesions of the appendix requiring a right hemicolectomy include primary adenocarcinoma and, as previously discussed, a minority of carcinoid tumours.

7.6 Surgical Pathology Specimens: Laboratory Protocols

7.6.1 Resection Specimens

Specimen:

- Handle similarly whether as part of a radical cancer resection specimen or a simple appendectomy. The former will require sampling of adjacent structures and locoregional lymph nodes (see Chap. 6).
- Some appendectomies are submitted in several pieces due to difficulties in surgical excision. This precludes assessment of the base unless a surgical clamp mark is visible.

Initial procedure:

- Orientate the tip (rounded end) and the base (clamp marked).
- Measurements:
Appendix—length (cm) × maximum diameter (cm).
Mesoappendix—maximum dimension (cm).
Exudate (serofibrinous/mucin)/perforation/mucocele/tumour—maximum dimension (cm) and distances (cm) from the tip and base.
- Photograph before and after blocking as appropriate.
- Fix in 10% formalin for 24–36 h.

Description:

- Tumour
 - Nodular/yellow: carcinoid
 - Cystic: cystadenoma/adenocarcinoma
 - Ulcerated/stricture/polypoid: adenocarcinoma/goblet cell carcinoid
- Wall
 - Tumour confined to mucous membrane, in the wall or through the wall
- Mesoappendix
 - Maximum dimension (cm) of abscess/tumour/mucin deposits
- Mucocele
 - Maximum diameter (cm)/intact or ruptured/mucin coating (location and extent)
- Diverticulum
 - Maximum diameter (cm) and location
- Appendicitis
 - Exudate/perforation/gangrene: location and extent

Blocks for histology (Fig. 7.2):

- Trim off any excess mesenteric fat and only process that which appears abnormal.
- Process in one cassette a 1–1.5 cm longitudinal slice from the tip along with a transverse section from the base.
- Serially section the rest of the appendix transversely at 3 mm intervals with a sharp scalpel.
- Sample five to six slices, approximately one slice per 1–1.5 cm length and process in a separate cassette from that of the tip/base.
- Sample any area of mural thinning or focal lesion as indicated by gross inspection.

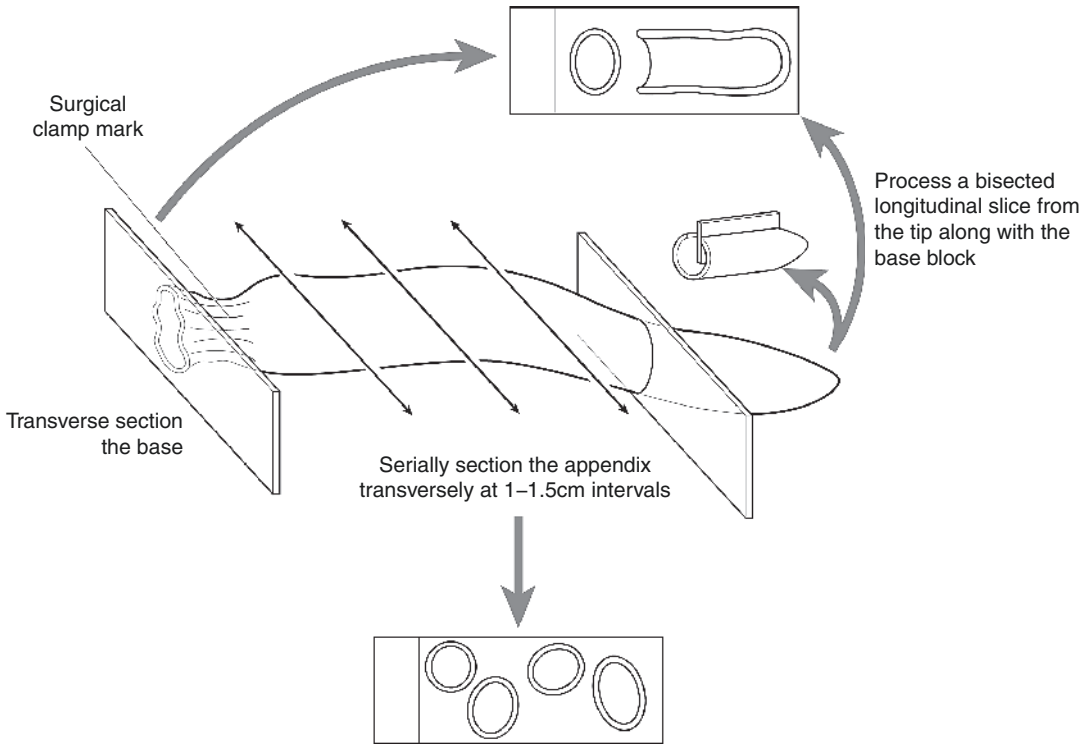


Fig. 7.2 Appendectomy specimen (Reproduced, with permission, from Allen and Cameron (2013))

- If part of a formal cancer resection specimen, e.g., right hemicolectomy, dissect and sample as previously described (see Chap. 6).
Histopathology report:
- Appendicitis
 - Cause: faecolith, tumour, diverticulum, endometriosis
 - Type: acute (transmural/gangrenous/perforation/abscess), granulomatous, peri-appendicular
- Mucocele
 - Obstructed/non-obstructed
 - Intact/ruptured
 - Mucosal hyperplasia/adenoma(LAMN)/adenocarcinoma
 - Pseudomyxoma: localized/generalized/presence and nature of the epithelium present
- Carcinoid tumour
 - Type: classical/goblet cell
 - Size: \leq or $>$ 2 cm: TNM 8 for well differentiated neuroendocrine tumours—pT1 \leq 2 cm, pT2 $>$ 2 cm and \leq 4 cm, pT3 $>$ 4 cm or into subserosa/mesoappendix, and, pT4 into peritoneum or adjacent organs/structures other than by direct mural extension e.g. abdominal wall.
- pN1 regional lymph node(s) involved.
- Spread: mesoappendix, peritoneum, appendiceal base (R0/R1).
- Adenocarcinoma
 - See Chap. 6. In TNM 8 appendiceal adenocarcinoma and goblet cell carcinoid are staged similarly to colorectal carcinoma. Adenocarcinomas are also classified as mucinous or non-mucinous for grading purposes.
 - pT1 submucosa, pT2 muscularis propria, pT3 subserosa/mesoappendix, pT4 visceral peritoneum (including mucinous peritoneal tumour or acellular serosal mucin) or other organs/adjacent structures.
 - pN1 1–3 nodes, pN2 \geq 4 nodes. A regional lymphadenectomy will ordinarily include 12 or more lymph nodes.

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