Small Intestine

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5.1 Anatomy

The small intestine is the longest part of the gastrointestinal tract and is divided into the duodenum (discussed previously), jejunum, and ileum (Fig. 5.1). It is primarily concerned with digestion and absorption of food. Together the jejunum and ileum measure approximately 6 m (jejunum 2.5 m/ileum 3.5 m) in the adult. The jejunum commences at the duodenojejunal junction (flexure) and the ileum ends at the ileo-cecal valve (two horizontal folds of mucosa that project around the orifice of the ileum as it joins the cecum). A fan-shaped fold of peritoneum (the small intestinal mesentery) attaches the small intestine to the posterior abdominal wall. The long edge of the mesentery completely encloses the intestine, allowing it to be mobile, while the short "root," which is attached to the posterior abdominal wall, admits blood vessels, lymphatics, and nerves which supply the intestine by traversing the mesentery.

Although there is a gradual change from jejunum to ileum, in general, the jejunum tends to be located in the upper part of the abdominal cavity, is thicker walled with more prominent *plicae circulares* (permanent mucosal folds), and has more numerous *Peyer's patches* (aggregations of lymphoid tissue).

Histologically the mucosa of the small intestine projects into the lumen in the form of finger-like structures covered by absorptive columnar

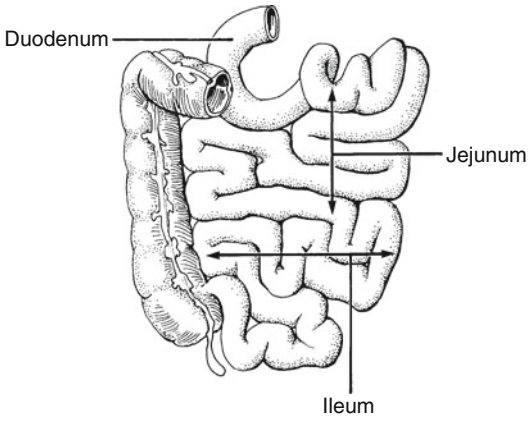

Fig. 5.1 Small intestine (Used with the permission of the Union for International Cancer Control (UICC), Geneva, Switzerland. The original source for this material is from Wittekind et al. (2005))

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epithelium. These projections are called *villi* and increase the surface area for absorption. The circular and longitudinal muscle layers are continuous.

Lymphovascular drainage:

The arterial supply of the jejunum and ileum is from the superior mesenteric artery. Numerous intestinal branches run in the mesentery and anastomose with one another to form "arterial arcades," which in turn supply the intestine. Venous drainage is via the superior mesenteric vein to the portal system. Lymphatics traverse through a series of mesenteric nodes and ultimately drain to the superior mesenteric nodes situated at the origin of the superior mesenteric artery.

5.2 Clinical Presentation

Patients with small intestinal disease may present with vague symptoms and signs such as poorly localized dull central (periumbilical) abdominal pain. If there is full thickness inflammation, the peritoneal somatic pain receptors are stimulated and the pain becomes more severe and localized. A patient with an obstructing lesion will classically present with vomiting, colicky abdominal pain (cramps), absolute constipation (i.e., neither flatulence nor feces passed per rectum), and abdominal distension.

Bleeding into the lumen of the small intestine may lead to hypovolemic shock and altered blood (melena) per rectum. Intussusception produces a mixture of blood and mucus – "redcurrant jelly stool," particularly in infants. Perforation, although rare (e.g., trauma, Meckel's diverticulum), will lead to a generalized peritonitis. A heart murmur or irregular pulse may provide a diagnostic clue in embolic small intestinal infarction.

The presentation of Crohn's disease may be insidious or acute, with symptoms including diarrhoea, anorexia, and weight loss. Various forms of fistulae (abnormal connection between two epithelial-lined structures) may occur including an enterovesical fistula (between small intestine and urinary bladder) which leads to gas in the urine (pneumaturia) and repeated urinary tract infections. Enterocolic and enteroenteric (between adjacent small bowel loops) fistulae may also occur. Enterocutaneous fistulae usually only happen after previous surgery. One of the differential diagnoses of a right iliac fossa mass is Crohn's disease with a peri-intestinal abscess around the distal ileum.

Several conditions, including Crohn's disease, may lead to a protein-losing enteropathy, resulting in generalized edema. Celiac disease presents in young children as a failure to thrive and in middle-aged adults with unexplained weight loss or iron-deficiency anemia. Melanin spots may be seen in the buccal mucosa and lips of those with Peutz–Jegher's syndrome.

5.3 Clinical Investigations

- U&E – electrolyte imbalance due to malabsorption.
- LFTs/albumin – liver enzymes may be deranged in Crohn's disease and hypoalbuminemia will occur in protein-losing enteropathy.
- Folate, B12, and iron studies – pernicious anemia in Crohn's disease.
- Erect CXR – air under the diaphragm in a perforation.
- Erect and supine AXR – will detect gas shadows and fluid levels in distended loops of small intestine in obstruction.
- Small bowel series – radiological contrast is drunk and abdominal images are taken at regular intervals to outline the mucosal surface of the small intestine and to measure the transit time. This is particularly useful for obstructing lesions and Crohn's disease, and may also detect a Meckel's diverticulum.
- Barium enema – will demonstrate an ileocolic intussusception and may be used as a therapeutic procedure (see below).
- Sinogram/fistulogram – useful to delineate the extent of the complications of Crohn's disease.
- CT scan – useful in delineating an abdominal (e.g., right iliac fossa) mass.
- Radioisotope scanning – can be used in cases of repeated gastrointestinal hemorrhage of

unknown etiology and will localize heterotopic gastric mucosa in a Meckel's diverticulum. Radiolabeled red blood cells may show a site of active bleeding.
- Selective arteriography (superior mesenteric) – will aid identification of a site of small intestinal bleeding. This may detect angiodysplasia of the small intestine providing the bleeding rate is greater than 2 ml/min.
- Enteroscopy – allows direct visualization of small intestinal mucosa.
- Distal duodenal biopsy and serology (anti-endomysial (EMA) and tissue transglutaminase (tTG) antibodies) – in celiac disease.

5.4 Pathological Conditions

5.4.1 Non-neoplastic Conditions

Duodenitis and duodenal ulcer (DU): HP distal gastritis leads to hyperchlorhydria, duodenitis with surface gastric metaplasia, colonization by HP, and further duodenitis and ulceration. Occurring mainly in the cap and first part of the duodenum, DU is invariably benign and only rarely biopsied at laparotomy for perforation if its mucosal edges are irregular. DU is successfully treated by HP eradication – occasionally it is due to other causes, e.g., NSAIDs, Crohn's disease, or Zollinger–Ellison syndrome.

Celiac disease: Traditionally investigated by Crosby capsule biopsy of the proximal jejunum, it is now assessed by a combination of celiac serology and distal duodenal biopsies taken at flexible esophagogastroduodenoscopy (EGD). Cardinal features are an excess of surface intraepithelial lymphocytes, lamina propria inflammation, villous atrophy, and crypt hyperplasia. Diagnostic proof is by clinical improvement on a gluten-free diet and deterioration on subsequent rechallenge. Celiac disease involves the entire small intestine and can be complicated by malignant lymphoma (usually enteropathy-associated T-cell lymphoma, EATCL) or adenocarcinoma. Other conditions can produce similar histological changes, e.g., giardia lamblia infestation, lactose intolerance, or postinfective enteritis, but are not gluten sensitive. Giardia is a kite-shaped flagellate protozoon present in the intervillous mucus, causing diarrhoea with or without mucosal inflammation – it typically affects children or the elderly.

Crohn's disease (*regional enteritis*): a pangastrointestinal inflammatory condition of uncertain etiology, lesions can occur anywhere from the mouth to the anus. It is characterized by segmental, transmural chronic inflammation associated with linear and fissuring ulceration, and, in 40% of cases, non-caseating epithelioid and giant cell granulomas present either in the mucous membrane, bowel wall, or regional lymph nodes. The terminal ileum, ileum, and colon, or colon alone, are affected in decreasing order of frequency. Macroscopically the classical features are skip lesions comprising stenotic ring strictures and hosepipe segments, serosal fat encroachment (fat wrapping), fissure ulcers with fistulae to other organs, and abscess formation, and, ulceration that can be pinpoint (aphthous), linear, or contiguous. Perianal fissures or fistulae are also often present. Due to its segmental distribution, subsequent recurrence elsewhere in the gut is not infrequent. Complications can be gastrointestinal, e.g., adenocarcinoma or malignant lymphoma, or extraintestinal, such as liver disease, amyloidosis, or arthritis.

Other causes of ileitis include backwash ileitis in ulcerative colitis, ileo-cecal tuberculosis, or yersinial infection. Viral adenitis of the mesenteric lymph nodes can also mimic ileitis or appendicitis. Relatively common viral or bacterial gastroenteritis rarely provide histopathology material. Immunodeficency, e.g., AIDS predisposes to various opportunistic infections (giardia lamblia, mycobacterium avium intracellulare, CMV, etc.) and malignancies (malignant lymphoma, Kaposi's sarcoma) that need to be considered on duodenal or terminal ileal biopsy.

Meckel's diverticulum: In 2% of people, 2 in long, 2 ft from the ileo-cecal valve, and, "too" important to forget, this is a remnant of the fetal vitellointestinal duct comprising an outpouching of the ileal wall on its antemesenteric border with or without a fibrous cord attaching it to the

umbilicus. Its wall is continuous with the ileal muscle coat and the small intestinal lining not infrequently shows heterotopic gastric or pancreatic tissue. Complications (4% of cases) include peptic diverticulitis with ulceration, hemorrhage or perforation, intussusception, or rarely malignancy.

Obstruction: Broadly, small intestinal obstruction is either due to loss of peristaltic bowel movement (paralytic ileus), or mechanical in nature. Ileus is commonly seen in the postoperative period of abdominal surgery and is self-limiting, although it is also encountered in various metabolic disturbances and can be difficult to manage – histopathology specimens are rarely provided. Mechanical obstruction is due to blockage of the bowel lumen or distortion of its wall. Common causes are primary or secondary malignancy, ulceration with ring stricture/diaphragm formation (Crohn's disease, NSAIDs), incarceration within a hernia, or extrinsic compression by postoperative adhesions or fibrous bands. The proximal bowel dilates, fills with fluid, and ultimately becomes atonic – sepsis or ischemia are possible complications. Particular forms of enteric obstruction are volvulus, where a loop of bowel twists around its mesenteric pedicle and, intussusception, where a lumenal or mural abnormality (e.g., tumor) acts as a nidus for peristalsis to propel a proximal segment (the intussusceptum) forward and inside a receiving distal segment (the intussuscipiens). The intussusception can be benign or malignant in nature and variable in site, e.g., ileal–ileal or ileal–cecal. Handling of all these specimens is targeted at determining the nature of the obstructing abnormality, its distribution and completeness of excision, and the presence and extent of secondary changes such as inflammation or ischemia.

Inflammatory fibroid polyp: An inflammatory mucosal pseudotumor of unknown etiology that can form the apex of an intussusception, it comprises edematous and inflamed fibrovascular granulation tissue with an infiltrate of eosinophils.

Diaphragm disease: Due to chronic ingestion of NSAIDs, it comprises multiple diaphragm-like mucosal ring strictures with variable lumen stenosis and intervening compartmentalization and sacculation. The strictures have a triangular cross-sectional profile of fibrovascular connective tissue and are probably partly ischemic in nature. Presentation is with subacute obstruction.

Ischemia: Acute, subacute, or chronic, depending on the nature, severity, and rapidity of onset of the cause. Acute ischemia is characterized by hemorrhagic necrosis of bowel wall that becomes paper-thin and gangrenous with subsequent electrolyte imbalance, sepsis, and shock. Chronic ischemia comprises ulcerated segments or strictures with replacement of bowel wall by fibrovascular connective tissue, evidence of secondary vascular thickening, and hemosiderin deposition. Examination of these specimens must include assessment of resection limit viability and any abnormality of the mesenteric vessels. Common causes are arterial, such as mesenteric artery embolism or thrombosis (particularly if superimposed on a low flow state due to mesenteric atheroma or cardiogenic hypotension), or venous thrombosis. The latter is usually due to obstruction of venous flow by bowel entrapment within a hernia or kinking of its mesentery by a fibrous band or adhesion resulting from previous surgery. Less usual causes of ischemia are systemic vasculitis (e.g., polyarteritis) or amyloid deposition which thickens and occludes mesenteric and mural vessels. Drugs must always be considered as a cause of isolated ulcers or chronic ischemic segments, especially NSAIDs.

Hernia: Herniation of the bowel can be either internal or external. Internal hernias are into anatomical spaces, e.g., the lesser omental sac or across fibrous bands, which can be acquired (postoperative) or congenital (e.g., persistent vitellointestinal duct). External hernias involve protrusion of the peritoneum ± bowel into the layers of the abdominal wall (particularly at the site of a previous surgical incision), groin, or femoral canal. They can be intermittent and reducible or irreducible with the risk of secondary ischemic changes. The surgical specimens are dealt with elsewhere (see Chap. 11).

Non-neoplastic polyps: In the duodenum these include gastric heterotopia, Brunner's gland hyperplasia/hamartoma, and pancreatic heterotopia. Small intestine is the commonest site for Peutz–Jegher's syndrome, which is autosomal

dominantly inherited, comprising oral pigmentation and pan-gastrointestinal polyposis – the polyps have a branching smooth muscle core and twisting of the polyp can produce glandular herniation into the submucosa and mimicry of adenocarcinoma. The terminal ileum can show mucosal nodular lymphoid hyperplasia which is usually of unknown etiology but occasionally linked to immunodeficiency. A protruberant ileocecal valve or fatty hyperplasia of its submucosa can simulate a tumor on radiological investigation, and, if not adequately investigated by colonoscopy and biopsy, can lead to unnecessary right hemicolectomy.

5.4.2 Neoplastic Conditions

Forming less than 10% of all bowel tumors, duodenal/jejunal lesions tend to be adenomas or adenocarcinoma, whereas carcinoid tumor and malignant lymphoma have a predilection for the ileum.

Adenoma: Relatively unusual in the small bowel but commoner in D2, particularly in FAP where there is a strong association with periampullary adenocarcinoma. Surgical removal is either by endoscopy or duodenotomy with thorough assessment of the ampullary region to exclude underlying tumor that would necessitate radical resection. Adenomas can also occur sporadically in the jejunum or ileum giving rise to adenocarcinoma.

Adenocarcinoma: Duodenal cancers (70% of cases) are often polypoid, while distal lesions are ulcerated and napkin-ring-like. Presentation is late, with regional lymph node metastases and serosal involvement due to the fluid content of the small bowel and consequent lack of symptoms. Prognosis is poor and incidence is increased in Crohn's disease and celiac disease.

Carcinoid (*well-differentiated neuroendocrine*) *tumor*: Single or multiple, carcinoid tumor is of intermediate grade malignancy metastatic potential relating to size (>1–2 cm), angioinvasion, invasion beyond the submucosa, and functionality. It produces vasoactive peptides, e.g., serotonin, that cause vascular thickening and elastotic stromal fibrosis which distorts the bowel wall and mesentery with characteristic spiculate CT appearances leading to subacute obstruction or intussusception. Metastatic deposits in the liver result in the peptides accessing the systemic venous circulation and carcinoid syndrome – facial flushing, asthma, and thickening of cardiac valves. Carcinoid tumors can be ulcerated or nodular, and are usually yellow. Other neuroendocrine lesions occur in the duodenum and include gastrinoma as part of Zollinger–Ellison syndrome, somatostatinoma, and gangliocytic paraganglioma, both of which may be associated with von Recklinghausen's syndrome (neurofibromatosis).

Malignant lymphoma: Solitary or multifocal, primary or secondary to systemic nodal disease, the vast majority are non-Hodgkin's in type. Established disease is ulcerated, segmental, and rubbery or fleshy in appearance. Many are MALT-derived of B cell character and variably low or high grade, prognosis relating to the grade and stage of disease. Unusual variants of malignant lymphoma include multiple lymphomatous polyposis (ileo-colonic nodular polyps of mantle cell lymphoma), ileo-cecal Burkitt's lymphoma in children and immunosuppressed patients, and EATCL. EATCL is strongly associated with celiac disease, either occult or clinically established of short or long duration. Presentation can be with perforated ulcerative jejunitis, a change in response to the gluten-free diet or with abdominal pain/mass.

Gastrointestinal mesenchymal or stromal tumors (*GISTs*): Spindle or epithelioid cell in type, a minority are leiomyomatous or neural, and a majority stromal (CD117 (ckit)/DOG-1 positive) in character derived from interstitial cells of Cajal, which regulate peristalsis. Malignancy cannot be accurately predicted but indicators are size (>2–5 cm), cellularity and atypia, tumor necrosis and hemorrhage, and infiltrative margins and mitotic activity (>5/50 high power fields). Small intestinal GISTs tend to behave more aggressively than their equivalent gastric counterparts with spread to the abdominal peritoneum and liver. The tumor can be polypoid, mural, or dumbbell-shaped with an extramural component. Occasionally they arise primarily in

the small bowel mesentery or retroperitoneum with no attachment to gastrointestinal wall.

Metastases: The small intestine is particularly prone to involvement by metastatic adenocarcinoma either from other abdominopelvic sites, e.g., stomach, pancreas, colorectum, and ovary, or due to distant spread, e.g., lung, breast, malignant melanoma. Deposits can be nodular, ulcerate or stricture the bowel wall mimicking a primary lesion – designation as a primary small intestinal adenocarcinoma therefore necessitates exclusion of spread from a more common site or evidence of a point of origin, e.g., an adjacent mucosal adenoma. Alternatively the deposits may be as diffuse peritoneal seedlings detected at CT scan or at laparoscopy. Malignant melanoma can be pigmented.

Prognosis: Small bowel adenocarcinoma is unusual being 50 times less common than colorectal cancers. Presentation is late, with poor prognosis (10–30% 5-year survival). Carcinoid tumor has an overall 5-year survival rate of 50–65% with smaller (<1–2 cm), early lesions, confined to the bowel wall being more favorable. Prognosis is better for low-grade B cell lymphomas (44–75% 5-year survival) than high-grade B or T cell lymphomas (25–35% 5-year survival) and is strongly grade and stage dependent. GISTs are of intermediate behavior, and unresectable/metastatic lesions respond to targeted therapy with the tyrosine kinase inhibitor imatinib (Glivec) leading to tumor shrinkage, cystic degeneration, and hyalinization. Neoadjuvant imatinib treatment may be considered to downstage a surgically unresectable GIST and permit resection.

5.5 Surgical Pathology Specimens: Clinical Aspects

5.5.1 Biopsy Specimens

Biopsy specimens can be obtained from the ileocecal valve and terminal ileum by colonoscopy, and from the duodenum by flexible EGD. They can also be obtained during laparotomy by either enteroscopy or wedge resection of a serosal lesion. In enteroscopy, an incision is made in the wall of the small intestine and an endoscope is passed along the small intestinal lumen to view the region of interest. The endoscope can also be introduced orally and the surgeon can guide it through the stomach and small intestine during a laparotomy.

5.5.2 Resection Specimens

Although small intestine may be resected as part of another procedure, e.g., right hemicolectomy, in primary small bowel resection, the goals of surgery are removal of the lesion and restoration of intestinal continuity. However, the exact procedure will depend on the type of lesion to be dealt with:

5.5.2.1 Neoplastic Conditions

Tumors: The type of resection will depend on the site of the tumor, e.g., a distal tumor will require a right hemicolectomy. For more proximal lesions, the operation of choice is a local resection with en bloc resection of a wedge of mesentery (Fig. 5.2). At least 5 cm of intestine on either side of the tumor should be removed with an

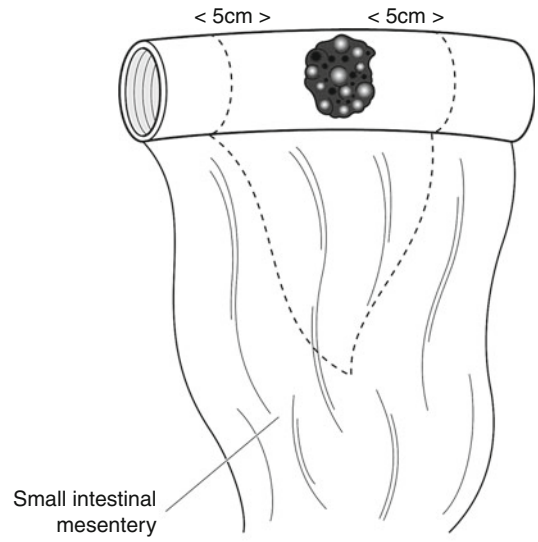

Fig. 5.2 Resection of tumor in small intestine (Reproduced, with permission, from Allen and Cameron (2004))

end-to-end anastomosis to reestablish continuity. Occasionally a hamartomatous polyp may be removed by making a longitudinal elliptical incision in the intestinal wall to include the base of the polyp. Closure should be done transversely to avoid luminal narrowing.

5.5.2.2 Non-neoplastic Conditions

Small intestinal resection in non-neoplastic conditions is essentially similar to that for neoplastic disease in that the affected length of intestine is resected with continuity being restored by a hand-sewn end-to-end anastomosis. Some specific conditions are discussed below:

Crohn's disease: Small bowel resection is usually reserved for those individuals for whom medical treatment has failed or who are suffering complications, e.g., obstruction (due to strictures), peri-intestinal abscess, fistula formation, or perforation. Essentially the extent of resection is limited to the macroscopically involved intestine as extensive resection does not reduce the risk of recurrent lesions and may lead to short bowel syndrome if subsequent resections are necessary.

If there are multiple areas of stricturing, these need not be resected in order to preserve intestinal length. Instead, a "widening procedure" called a stricturoplasty may be employed. In this procedure, the strictured region is incised longitudinally, the walls retracted, and the incision then sutured transversely (Fig. 5.3).

Infarction: At laparotomy, the infarcted intestine will appear dusky and should be resected until there is active bleeding from the ends that are going to form the anastomosis. A primary anastomosis may be fashioned or in cases of extensive intraperitoneal leakage or uncertain intestinal viability, an ileostomy (or jejunostomy) and distal mucus fistula can be fashioned. Essentially an ileostomy (or jejunostomy) is produced by bringing the cut opened end of the intestine out through an opening in the abdominal wall where it is sutured in place. A special ileostomy bag is then fitted to collect the effluent.

Meckel's diverticulum: They are usually only resected if symptomatic or found incidentally during another procedure. Essentially the diverticulum is excised with the opening in the intestinal wall closed in a transverse fashion to avoid luminal narrowing. If the diverticulum is large or broad based, a limited ileal resection may be required.

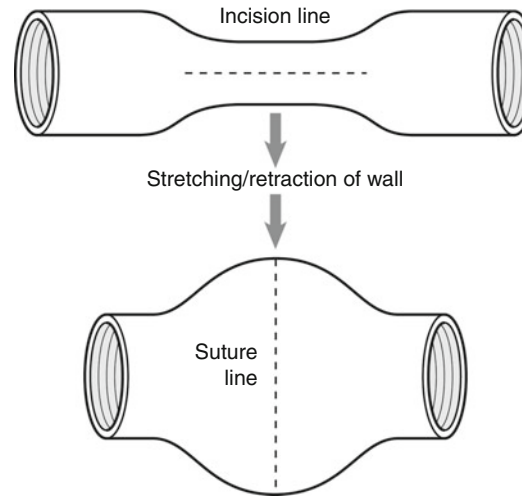

Fig. 5.3 Small-intestinal stricturoplasty (Reproduced, with permission, from Allen and Cameron (2004))

Intussusception: Barium enema can be used both as a diagnostic procedure, and if the reservoir of barium is elevated 1 m above the abdomen, hydrostatic reduction under radiological screening can be attempted as a therapeutic procedure. Reduction is signified when barium flows freely to the proximal loops of ileum. If hydrostatic reduction fails, or there is evidence of perforation/peritonitis, operative management is indicated. In this reduction may be facilitated by squeezing the distal colon and pushing the intussuscepted intestine proximally. If this is unsuccessful, then resection of the affected segment should be carried out.

5.6 Surgical Pathology Specimens: Laboratory Protocols

5.6.1 Biopsy Specimens

See Chap. 1. Formal Crosby capsule jejunal biopsies are larger than flexible EGD distal duodenal samples. They are usually submitted on filter

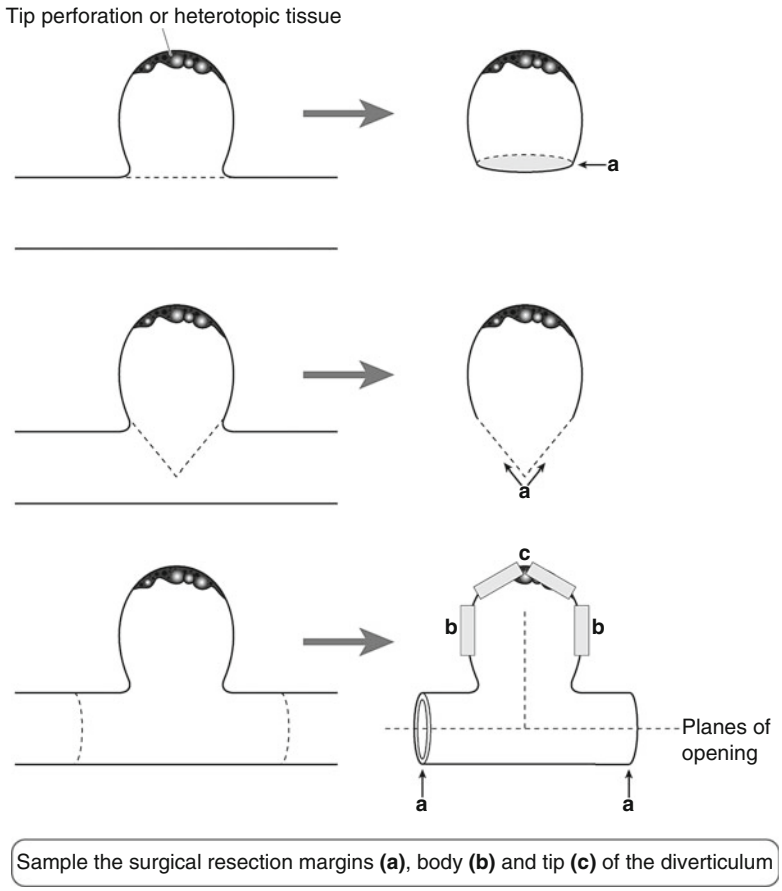

Fig. 5.4 Meckel's diverticulum – specimens (Reproduced, with permission, from Allen and Cameron (2004))

paper to allow orientation and inspection of the mucosal surface under a dissecting microscope and correlation with histology. Finger-like, cerebriform, and mosaic patterns correspond to normal, partially atrophic, and flat mucosae, respectively.

5.6.2 Resection Specimens

Specimen:

- Resection of small intestine can be for specific conditions such as Meckel's diverticulum or ischemia or, for obstruction due to various inflammatory, mechanical and neoplastic disorders.

5.6.2.1 Meckel's diverticulum:

- Measurements: Ileal base or segment – length × diameter (cm). Diverticulum – length × diameter (cm).
- Open the ileum longitudinally with blunt-ended scissors along its mesenteric border opposite the diverticulum, and then cut at right angles to this along the diverticulum toward its tip (Fig. 5.4). Photograph before and after dissection.
- Paint the external aspect of the diverticulum and fix by immersion in 10% formalin for 36–48 h.
- Inspect and describe the diverticulum (especially its tip), e.g., heterotopic mucosa, ulceration, perforation, abscess, fibrous bands, or tumor.
- Inspect and describe the ileal segment, e.g., inflammation, ischemia, or signs of intussusception.
- Transverse section the proximal and distal ileal limits of resection or ileal/diverticulum base.
- Sample normal appearing ileum, diverticulum, and its tip.

- Sample additional blocks as indicated by any macroscopic abnormalities present.

5.6.2.2 Ischemia:

- Measurements: Small bowel segment – length and maximum diameter (cm). Mesentery – length × depth (cm).
- Inspect and describe: hyperemia/duskiness of the serosa, perforation, constriction bands across the bowel or mesentery.
- Open longitudinally with blunt-ended scissors along the mesenteric border – inspect for mucosal thinning, ulceration, hemorrhage, necrosis, perforation, stricture formation, or any underlying tumor that might have precipitated volvulus or intussusception.
- Fix by immersion in 10% formalin for 36–48 h.
- Transverse section the proximal and distal limits of resection.
- Sample (two blocks minimum) representative macroscopically normal and abnormal areas as indicated (Fig. 5.5).
- Sample mesentery with constituent vessels.
- Sample mesenteric lymph nodes.

5.6.2.3 Obstructive enteropathy:

- The resection specimen is dictated by the site and nature of the abnormality and extent of any complications that are present. For example, jejunal ring diaphragm disease results in resection of the radiologically and macroscopically involved segment, whereas Crohn's terminal ileitis produces a limited right hemicolectomy. Intussusception complicated by ischemia needs a more extensive resection than would be otherwise necessary. A cancer operation will necessitate more radical dissection of mesentery and regional lymph nodes. In some instances, it is not possible clinically or macroscopically to distinguish between inflammatory and neoplastic ulcers or strictures – handling of the specimen must therefore cover these various options pending histopathological assessment.
  Initial procedure:
- Open longitudinally with blunt-ended scissors along the mesenteric border, avoiding any obvious areas of tumor or perforation.
- Measurements:

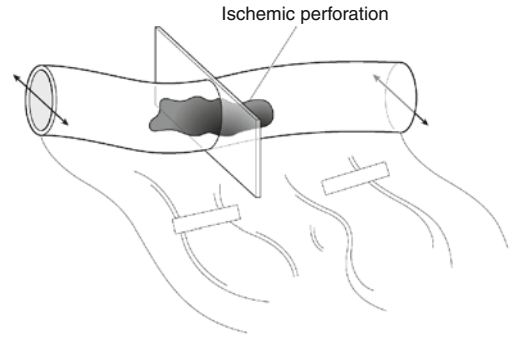

Fig. 5.5 Small bowel ischemia (Reproduced, with permission, from Allen and Cameron (2004))

  Lengths and maximum diameter (cm) of the parts present – duodenum, jejunum, ileum, cecum, ascending colon, and appendix.
  Lengths (cm) of ischemic, strictured, or hosepipe segments, intussusception.
  Maximum dimensions (cm) of any perforation(s), ulcer(s), polyp(s), and tumor(s).
  Distances (cm) of the abnormality from the proximal and distal resection limits.
- Photograph.
- Gently pack the bowel lumen with formalin-soaked lint and fix by immersion in 10% formalin for 48 h.
  Description:
- Tumor
  - Site: duodenal/jejunal/ileal/ileo-cecal valve. Lumenal/mural/extramural/mesenteric.
    Size: length × width × depth (cm) or maximum dimension (cm).
  - Appearance:Polypoid/nodular–inflammatory fibroid polyp, carcinoid, malignant melanoma, adenoma, carcinoma, multiple lymphomatous polyposis, GIST.
    Ulcerated/stricture – carcinoma, carcinoid, malignant lymphoma, metastatic carcinoma.
    Fleshy/rubbery – GIST, malignant lymphoma.
    Multifocal – metastases (carcinoma, melanoma), carcinoid, malignant lymphoma.
    Adjacent atrophic mucosa – EATCL
  - Edge: circumscribed/irregular.
- Crohn's disease: cobblestone mucosa/ulceration (aphthous, linear, confluent)/ring strictures/

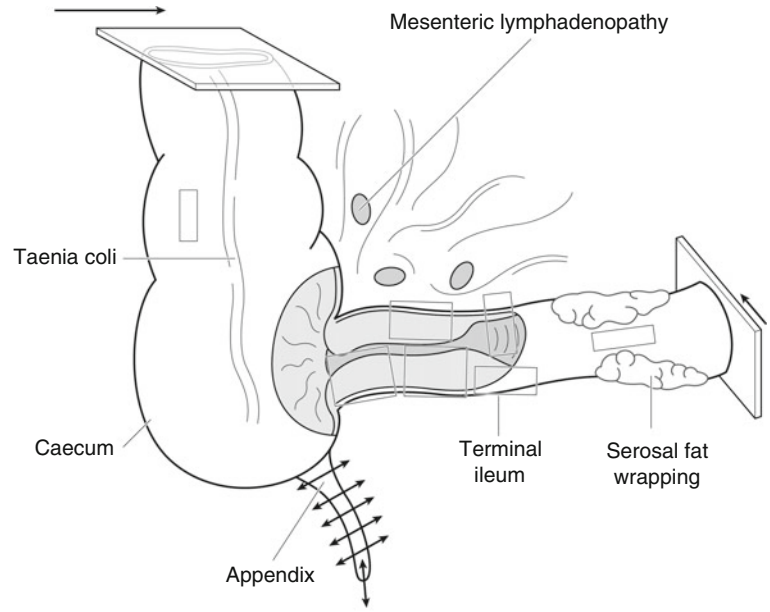

Fig. 5.6 Right hemicolectomy for Crohn's disease (Reproduced, with permission, from Allen and Cameron (2004))

1. Transverse section the surgical limits
2. Process the appendix as usual
3. Sample normal ileum and colon
4. Sample representative blocks of the hose pipe segment, any ulceration and adjacent mucosa.
5. Sample mesenteric lymph nodes

hosepipe segments/fat wrapping/fistula/polyps or tumor/lymphadenopathy/sharp demarcation at the ileo-cecal valve/cecal or colonic disease/adhesions/abscess formation.

- Diaphragm disease: ring strictures – number, width, lumen aperture, intervening sacculation, mucosal ulceration.
- Extrinsic compression: constriction band/extrinsic tumor/lumen stenosis/mucosal ulceration/proximal dilatation.
- Intussusception: apex (inflammatory fibroid polyp, tumor, Meckel's, mesenteric lymphadenopathy)/ischemia/perforation/ileo-ileal/ileo-cecal.

Blocks for histology (Fig. 5.6):

Non-neoplastic conditions

- Sample by circumferential transverse sections the proximal and distal limits of resection.
- Sample macroscopically normal bowel.
- Sample representative blocks (a minimum of five) of any abnormality that is present to include its edge and junction with the adjacent mucosa, e.g., ulceration, stricture, fistula, perforation, serosal adhesions or constriction band, intussusception apex. These can be taken transversely or longitudinally depending on the anatomy and the abnormality present.
- Sample mesenteric lymph nodes and any adjacent structures, e.g., cecum, appendix, or ileocecal valve.

Neoplastic conditions

- Sample the nearest longitudinal resection margin if tumor is present to within <2 cm of it.
- Sample macroscopically normal bowel – usually one section but several if a multifocal condition, e.g., FAP or EATCL, is suspected.

- Serially section the bulk of the tumor transversely at 3–4 mm intervals.
- Lay the slices out in sequence and photograph.
- Sample (four blocks minimum) tumor and wall to show the deepest point of circumferential invasion. With tumors <1 cm diameter, fewer blocks will be possible. Include adjacent mucosa where feasible.
- Count and sample all lymph nodes – identify a suture tie limit node.
- Sample multifocal serosal tumor seedlings as indicated by inspection and palpation.

Histopathology report:

- Ischemia
  Necrosis – mucosal/transmural/gangrenous
  Resection limits – ischemic/viable
  Mesenteric vessels – thrombosis/embolism/vasculitis
  Miscellaneous – constriction band/volvulus/intussusception/stricture

- Crohn's disease
  Chronic transmural inflammation/granulomas/fissures/fistulae/abscess formation/ileal confined/ileo-cecal/appendiceal or resection limit disease/malignancy

- Intussusception
  Apex/secondary ulceration, stricture, ischemia or perforation/site (ileo-ileal/ileo-cecal).

- Neoplastic conditions
- Tumor type – adenocarcinoma/malignant lymphoma/GIST
- Tumor differentiation
  - Adenocarcinoma – well/moderate/poor
  - Malignant lymphoma – MALToma/mantle cell/follicular/Burkitt's/other, low grade/high grade
  - GIST – spindle cell/epithelioid cellularity/atypia/necrosis/mitoses/margins/size
- Tumor edge – pushing/infiltrative/lymphoid response.
- Extent of local tumor spread (for carcinoma).

pTis	Carcinoma in situ
pT1	Tumor invades lamina propria (pT1a) or submucosa (pT1b)
pT2	Tumor invades muscularis propria
pT3	Tumor invades through the wall into subserosa or perimuscular connective tissues (mesentery or retroperitoneum) with extension ≤2 cm
pT4	Tumor perforates the serosa or invades other organs/structures, e.g., mesentery >2 cm, small bowel loops, abdominal wall

- Lymphovascular invasion – present/not present.
- Regional lymph nodes: A regional lymphadenectomy will ordinarily include 6 or more lymph nodes.
  Duodenum: pancreatioduodenal, pyloric, hepatic, superior mesenteric nodes.
  Ileum/jejunum: mesenteric.
  Terminal ileum: ileo-colic, posterior cecal.

pN0	No regional lymph node metastasis
pN1	Metastasis in 1–3 regional lymph node(s)
pN2	Metastasis in 4 or more regional lymph nodes

- Excision margins
  Proximal, distal, and mesenteric limits of tumor clearance (cm).
- Other pathology
  FAP, Peutz-Jegher's, Crohn's disease, celiac disease, EATCL.

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